Simulation and Student Transition in Restorative Dentistry

by

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Abstract

Simulation in the shape of the “phantom head” is an essential part of every dental training programme. It is used to provide the student with practice before he/she is allowed to carry out restorative dental procedures on patients. In theory, this practice promotes patient safety. However, the learning process lacks clarity, and we do not understand fully how well learned skills transfer to clinical activity. This study asks whether in fact the pre-clinical course is a reliable guarantor of patient safety.

It does so by examining four facets of the simulation process: purpose, learning, fidelity and transition, using a mixture of research methods, including comparison of pre-clinical and clinical assessment grades, focus groups with students, one-to-one interviews with their teachers and a questionnaire.

The results of these investigations indicate a complex inter-relationship between purpose, learning, fidelity and transition. They also suggest that success in simulated restorative dentistry is a poor predictor of clinical ability, a limitation that needs careful consideration in the light of patient safety.

The study recommends changes to increase the complexity and authenticity of the pre-clinical course, and suggests that the student transition needs detailed management, perhaps through a blend of pre-clinical and clinical activity.

Dedication & acknowledgements

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- And above all, I acknowledge the assistance of my wife for proof reading the finished work and pointing out errors of grammar and punctuation, for providing cups of tea on a regular basis, and for putting up with years of neglect while I worked on this thesis. I dedicate it to you.

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CHAPTER 1 – INTRODUCTION

> *"Students must provide patient care only when they have demonstrated adequate knowledge and skills. For clinical procedures, the student should be assessed as competent in the relevant skills at the levels required in the pre-clinical environments prior to treating patients"*
>
> The General Dental Council, Standards for Education, Standard 1 November 2012

Restorative dentistry is the branch of the dental profession which undertakes the filling of teeth, the making of crowns and bridges, and similar techniques for treating teeth damaged by disease, with the aim of restoring them to full function. Perhaps the most significant part of any training in restorative dentistry is supervised clinical practice on volunteer patients, an approach designated throughout this study as "the patient care model" of dental education. However, it is inappropriate to allow the student of dentistry to carry out irreversible restorative dentistry on patients without first gaining some experience. As well as being unethical, this is specifically mandated against by the General Dental Council. There is no alternative to gaining that experience through simulation. In principle the student then graduates to patient care with enough expertise to treat the patient safely.

What does the student need to learn prior to beginning patient care, how does the teacher decide when the student can safely begin treating patients and what are the relationships between simulation, learning and patient safety? This study explores such questions in the context of restorative dentistry.

DEFINITIONS

In the United Kingdom, the teaching and learning of restorative dentistry is a component of two undergraduate training programmes: that leading to a diploma or degree in dental therapy (designated in this study by the abbreviations DipDT or BSc), and that leading to a degree in dental surgery (designated by the abbreviation BDS). Because this study involves students on both of these programmes, the terms "student(s)" or "student(s) of dentistry", unless otherwise indicated, should be taken to mean students on either programme. Where specific designation is required the terms dental therapy students and dental students is the most common usage.

All individuals who took part in this study were students or staff at Cardiff University School of Dentistry. Unless otherwise indicated, the term "school" refers specifically to this institution.

Simulation plays an increasing role in the pre-clinical training of many professions and, without further definition, the term can lead to confusion. In educational settings it most commonly describes a representation of a real situation. It is used to permit a participant to carry out some activity, often for learning purposes, which reproduces a similar activity that might be carried out in the real situation. In both situation and activity this representation is partial, sometimes by design and sometimes because of the limitations of the simulation. This document discusses this meaning of simulation in many different settings. A purpose of this study is to understand the use of simulation in the teaching and learning of restorative dentistry. Where it uses the terms "phantom head", pre-clinical, or dental pre-clinical simulation, it refers to the specific use of simulation, known as the "phantom head".

The simulation used to prepare students for restorative dentistry originated with Oswald Fergus in 1894 (Mason, 2006). His "dental phantom" consisted of a facsimile upper and lower jaw in which were embedded extracted teeth for student practice. Although Fergus' very basic arrangement has evolved into a slightly more realistic plastic mannequin head, the basic principle is still the same. Dental simulation still uses teeth attached to artificial jaws to teach the basic skills required for restorative dentistry, though the teeth are more likely to be plastic facsimiles. The dental pre-clinical laboratory contains mannequin heads affixed to laboratory benches, in a manner that allows adjustment of position to allow the student to work in a seated position as he/she would in a clinical setting. The heads also have a rubber sheet which provides an approximation of the patient's cheeks and mouth opening (See appendix 1 for photographs of the "phantom head"). It is customary to call the mannequin heads "phantom heads", hence the use of the term "phantom head laboratory" for the pre-clinical laboratory. In this study when the word "simulation" is used in an unqualified way, it refers to the "phantom head" simulation.

The "phantom head" simulation fulfils a need in the teaching and learning of restorative dentistry, but the nature of that need is not as well defined as it might be. Some of the advantages suggested are that it teaches motor control and precision, that it teaches essential technical skills and that it gives students the confidence to treat patients. It also allows assessment of student restorative skills prior to patient contact, providing some assurance of patient safety. This assessment typically takes the form of a practical cavity preparation exercise, or series of exercises, carried out on the "phantom head".

The “phantom head” also alleviates ethical concerns associated with the patient care model, though of course this is only valid until the transition to patient care. In terms of longevity, it has a successful track record of more than 100 years of use since Fergus’ “dental phantom”. Every dentist and dental therapist currently practicing in the UK will have taken part in an undergraduate pre-clinical course, and it is difficult to imagine dentistry without it.

Learning restorative dentistry involves students in one or more periods of pre-clinical simulation. Dental therapy students will typically undertake a pre-clinical course during the first year of their training, moving on to patient care in the second year. Dental students will typically spend time in the pre-clinical laboratory during the second year of their training. Dental students can expect to return there from time to time later in their programme in order to practise advanced endodontic and crown and bridge skills. Advanced restorative skill development does not form part of this investigation.

TRANSITION TO RESTORATIVE CLINICAL PRACTICE

At some point the student leaves the “phantom head” behind and transfers to patient care. This is also a learning environment, but one which has the burden, for both student and teacher, of ensuring patient safety. In theory, the pre-clinical course continues until the student is considered safe to begin patient care. In practice, the timing of the transition tends to be regulated more by the requirements of the academic timetable.

The learning of restorative dentistry does not take place in isolation from other aspects of clinical learning. Of particular relevance is that the transition to clinical activity typically begins within a context of dental examination and dental hygiene care,

activities which do not involve irreversible changes to the patient's dentition. In the school both dental and dental therapy programmes arrange for students to encounter patients concurrently with the restorative pre-clinical course. As a result the transition from restorative pre-clinical simulation to patient care is not a sharp divide. It is nevertheless a significant moment in the student's early professional development. It is the point at which the student first carries out irreversible dental treatment on a patient.

In order to further facilitate the student's transition, early clinical practice is managed so that the student initially encounters only simpler types of cavity preparation. At the same time, the student will benefit from favourable staff/student ratios, the clinical teacher providing the student with one-to-one teaching. Equally important, he/she is also present to prevent harm to the patient. I mention these conditions to emphasise that the clinical practice setting is still also a learning one, and the transition to restorative clinical practice is not considered the end of student learning.

However, the relationship between the pre-clinical simulation and clinical reality is not clear. The purpose of pre-clinical simulation is ostensibly to prepare the student for supervised clinical practice. Yet, there is little detailed and specific understanding of how and what the student learns in pre-clinical simulation, nor of what he/she most needs to learn to be prepared for clinical reality.

FIDELITY, PURPOSE AND TRANSFER IN PRE-CLINICAL DENTISTRY

Preparing the student for clinical activity demands appropriate learning and assessment in the pre-clinical setting, and appropriate transfer of that learning to the clinical setting. Pre-clinical courses regularly comes in for criticism for their inability

to provide these. I introduce some of these criticisms, from students and teachers, as a background to the study. Most can be categorised into one or more of three areas: fidelity, purpose and transfer.

The issue which surfaces most regularly is a concern over the physical fidelity of the simulation. Changes in cultural and healthcare practice have meant the extraction of fewer teeth, and the Human Tissue Act (2008) has effectively restricted the availability of extracted teeth (in the UK) for educational and research purposes. This forces most pre-clinical courses to use plastic alternatives. Students complain that these do not look like real teeth, do not reproduce the anatomical reality of contact points or occlusion and, most important, do not feel like real teeth when cut by the dental handpiece. Students learn by preparing idealised tooth cavity shapes, perhaps because these are easier to assess reliably. However, when they transfer to clinical activity, they also comment that real tooth cavity shapes are defined by the extent of the dental caries and rarely resemble the ideal shapes of the "phantom head" cavity. They complain that they have little opportunity to experience this reality in the pre-clinical laboratory. Students also note that the "phantom head" provides a very limited simulation of the reality of clinical practice because it lacks the interaction of patient care.

The purpose of the pre-clinical course is underdefined. While most teachers appear to agree over the basic purpose of motor skill development, there is much confusion over what other benefits the student gains from the process. While the dental literature holds many examples of ways of improving the fidelity of pre-clinical simulation

(Sukotjo et al., 2007, p1070) (Leblanc et al., 2004, p378), there is little discussion about the purpose or learning goals of these proposals.

Also of concern is the transfer of pre-clinical skills to the clinical setting. Contrary to the expectations of pre-clinical teachers, the general assumption of clinical teachers appears to be that such transfer is automatic, and they

often do not demonstrate understanding of the difficulties experienced by the student. Possibly every student has been told at some time by a clinical teacher *"but you learned that in phantom head, you should know it",* implying some dereliction of knowledge or duty on the part of the student. Perhaps pre-clinical teachers better understand the limitations of pre-clinical simulation, and the differences between simulation and reality. Transfer is a complex construct, and the student transition needs facilitating just as much as other aspects of dental education. A recent personal example, in which a student struggled to smooth a filling in a difficult-to-access area of the mouth, illustrates this complexity. I suggested using a particular dental bur, which was not immediately available, and had to be brought from elsewhere within the building. The student's response was interesting:

"*As soon as you said that, I thought 'of course, why didn't I think of that? If the bur had been there I would have picked it up straight away, but because it wasn't I didn't think of it'*."

Thus far, fidelity purpose and transfer provide a helpful structure. But purpose, fidelity and transfer are all inextricably bound up with learning, so that learning also becomes an important component of this framework. The structure used in this study is that of

purpose, learning, fidelity and transfer as these relate to pre-clinical restorative dentistry, and the student's transition to patient care.

AIMS AND JUSTIFICATION OF THIS RESEARCH

By intention, pre-clinical restorative dentistry prepares the student for patient care. It uses simulation to teach and to assess. This is done primarily for ethical reasons, because it matters less if the student makes mistakes on a "phantom head". Understanding of how learning takes place is limited. Neither do we know how successful the pre-clinical course is, nor how well learned skills transfer to clinical activity. In other words, does the fact that the student has passed the pre-clinical course guarantee good clinical skills and patient safety? These questions, and their answers, are relevant to a number of stakeholders including the student, the patient, the educational establishment and the regulatory body.

The purpose of this investigation is to examine the student transition between simulation and patient care. The primary research method used is qualitative, and seeks to understand transition from both staff and student viewpoints. It is hoped that better understanding will lead to improvement, providing both a better learning experience for the student and more assurance of safety for the patient. Specific research questions are developed in chapter three, using the resources provided by a review of relevant literature in chapter two.

Although patient treatment is an important component of dental training programmes, dental educators recognise the ethical issues associated with the patient care model for student learning. In the future dental training programmes can expect increasing

pressure, both from within and without the profession, to rely more on simulation, and to use it more effectively. We need to better understand the role and the limitations of dental pre-clinical simulation.

A PERSONAL CONTEXT

This study has a personal context. Although little experienced in pre-clinical teaching, I am a clinical teacher. I teach clinical restorative dentistry to both dental and dental therapy students. I have spent significant amounts of time teaching students in years two and three of the BDS programme, and in years one and two of the Dental Therapy programme. In each case I teach students in the process of transition from pre-clinical to clinical dental practice and have seen how they struggle to function in the unfamiliar clinical setting. I understand the effort that it takes for them to learn how to manage patient care. I have reflected on pre-clinical learning and its transfer to the clinical setting, and asked myself whether pre-clinical learning could better prepare the student. The present study is an outcome of that reflection. In recent years, I have taught, along with colleagues from both pre-clinical and clinical settings, a course which blends pre-clinical exercises with simple clinical activity. For the purposes of the study, I have referred to this blended learning activity as a "managed transition". Student feedback from this initiative also forms part of the study.

A BRIEF INTRODUCTION TO THE RESEARCH METHODS USED IN THE STUDY

The study used a mixture of methods.

It collected and compared student performance figures from both pre-clinical and clinical activity, in order evaluate the predictive nature of pre-clinical assessment.

It also used a questionnaire to evaluate the managed transition to patient care.

It has a qualitative element in the form of focus groups with students and one-to-one interviews with a number of staff. The focus groups involved students from both Dental and Dental Therapy programmes. Their purpose was to understand the student transition to clinical activity both prospectively and retrospectively. Interviews with staff involved in pre-clinical teaching, clinical teaching and both, provided an understanding of student transition from the teacher perspective.

Ethical approval for the study was given by Birmingham University School of Education research ethics committee (Birmingham REC) and Cardiff University School of Dentistry research ethics committee (Cardiff REC). The only exception to this is the third component of the data collection – a student evaluation of a blended transition programme. I was asked to undertake this at a later date by Cardiff University School of Dentistry. Ethical approval for this component was sought only from Cardiff REC.

AN OUTLINE OF THIS REPORT

This report contains six further chapters.

- Chapter two is an indicative review of the literature on simulation: it provides an overview of the purposes of simulation, learning, motivation and assessment in the dental pre-clinical setting, the role of simulation fidelity in both learning and transfer, and skill transfer from simulation to reality.
- Chapter three uses this overview to articulate research questions for this study.

- Chapter four details and defends the research methods used, as appropriate to the questions that the study is attempting to answer. It also discusses the ethical implications of the research methods, and the steps taken to ensure an ethical approach to the study.
- Chapter five reports the results of the study, in four sections: a comparison of student pre-clinical and clinical performance, student focus groups, staff focus groups and the student evaluation.
- Chapter six comments on these results, and proposes changes to practice. It returns to the framework of purpose, learning, fidelity and transfer, and uses it to link the findings described in the results chapter to available literature.
- Chapter seven makes some concluding remarks on the current state and future development of pre-clinical restorative simulation. It also comments on the limits of this study and suggests further areas for investigation.

CHAPTER 2 – INDICATIVE LITERATURE REVIEW

INTRODUCTION

Patient care provision is a major component of student learning in restorative dentistry. For reasons explored below, the student needs careful preparation before undertaking it and simulation has a significant role in this preparation. However, the role is not clearly understood. The primary purpose of this review is to provide a theoretical framework for improving our understanding of that role and, therefore, shaping the research questions of this study in chapter three.

Sources for this discussion are varied. Literature from the field of dentistry addresses a range of issues surrounding student learning in the simulated environment such as measurement of skill acquisition (Quinn et al., 2003, p13) and simulation as a teaching modality (Buchanan, 2001, p1225; Pohlenz et al., 2010, p560). It rarely addresses purpose, however, or learning as a theoretical construct, or the role of fidelity or skill transfer. The discussion draws upon literature from other healthcare domains, especially surgery, anaesthesiology and nursing where simulation is also studied. It also touches on literature from aviation, the military and human resources, all of which are domains which make extensive use of simulation for training purposes. An underlying assumption is that discussion of purpose, fidelity and transfer present in these literatures can, to some extent, be extrapolated into pre-clinical restorative dentistry.

In chapter one I noted some of the (anecdotal) concerns that both teachers and students of dentistry have concerning learning and transfer: lack of sufficient clarity as to the purpose of pre-clinical dentistry, lack of fidelity and its effect on learning, and concern

over the way in which pre-clinical learning transfers to the clinical setting. Because purpose, fidelity, learning and transfer appear so important to the users of pre-clinical simulation, they form the structure of this chapter.

- Section one introduces the concepts of simulation fidelity and skill transfer. This early introduction is important because fidelity and transfer need some definition as they permeate the discussion of learning and purpose in pre-clinical dentistry.
- Section two explores the purposes of simulation found in the general simulation literature and applies these to a discussion of its purposes of pre-clinical dentistry.
- Section three considers learning in simulation, suggesting a theoretical framework for understanding pre-clinical dentistry. It also includes what is inevitably a brief glimpse into the extensive literature on motivation.
- Section four discusses the effect of the fidelity of the dental "phantom head" on student learning.
- Section five brings together purpose learning and fidelity in a discussion of skill transfer to the clinical setting.

A summary of each section is available in chapter three, as part of the process of identifying research questions for this study.

SECTION ONE – AN INTRODUCTION TO FIDELITY AND TRANSFER

This section briefly introduces fidelity and transfer and their relevance to pre-clinical dentistry. Some issues are highlighted for further discussion in sections three and beyond.

A commonly stated definition of simulation fidelity is "the degree to which the simulation replicates the reality it is intended to represent". Authors on the subject, at least in the field of healthcare education, commonly categorise fidelity into "high" and "low" based on the physical resemblance to reality and on the ability of the simulation to *"… convince users they are, in fact, using something that resembles what they would encounter in real life"* (Seropian et al., 2004, p165). This classification appears somewhat limited, mainly because it appears to addresses only the physical aspects of simulation. Alinier (2007, p e243) identifies a need for more precision in our use of the language of simulation and offers a six point typology of simulation based on the complexity of the technology used. I agree that a more complex understanding of fidelity is needed. But, as I will suggest in section four of this chapter, this should involve more than physical representation and the complexity of the technology used.

I observe that many individuals, at least in western cultures, respond positively to simulation involving high physical fidelity[1], and consider it desirable. Teachers appear ever ready to spend money on the latest generation of IT-based simulations. Students report face validity and learner satisfaction as significant to clinical confidence (Suvinen et al., 1998, p30; Rodgers, 2007, p55). I note at the outset of this study that the dental "phantom head" does not offer high physical fidelity and, although students complain about its absence, there is some evidence that it absence does not necessarily affect learning.

[1] It would be more accurate to say most people appear to gain satisfaction from interaction with computer driven virtual simulations, as witnessed by the computer gaming industry. As a species we appear to like the possibilities offered by virtual reality. I suggest that this bias is one of the more interesting aspects to the use of simulation, but one which I have not found discussed in the healthcare education literature.

Skill transfer is a complex phenomenon and there is an extensive debate over its nature and existence. I will explore this debate in section five of this chapter. According to Simons (1999, p577) transfer is taking place *"… whenever previously learned knowledge and skills affect the way in which new knowledge and skills are learned and performed."* Much relevant work has taken place in the fields of human resources (Foxon, 1993 passim), around the transfer of training to the workplace, in aviation in the study of flight simulator training (Liu et al., 2009 passim), and in the military where simulation is used extensively to study strategy and tactics (Sharma et al., 2007 passim), and to prepare the soldier for the battlefield.

Studies of transfer do exist in the healthcare education literature. As I will demonstrate, these have generated little empirical evidence for the construct. In spite of this lack of evidence there is a general supposition in healthcare education that "… *the skills acquired in simulated settings are directly transferable to the operative setting*" (Sturm et al., 2008, p166). This supposition requires careful examination because it has potential to affect patient safety as the student transfers from pre-clinical to clinical settings.

In fact there is some slight evidence for a **lack** of transfer between pre-clinical and clinical restorative dentistry, as measured by a comparison of student performance across the two settings (Chambers, 1987, passim; Curtis et al., 2007, p370). Why this should be is uncertain. Although both articles note the phenomenon, in neither case do the authors investigate possible causes. In his article Chambers speculates that lack of transfer may be at due to *"… differences in the mix of skills required in the two contexts, failure to teach for transfer of skills to new settings, and laboratory education practices that create clinically dysfunctional habits"*(p 238).

SECTION TWO – THE PURPOSE OF SIMULATION IN DENTISTRY

In this section, I attempt to clarify the purpose of simulation in dentistry by applying discussion of purpose in other areas to pre-clinical dentistry. This discussion exists in a variety of domains, including aviation (Moroney and Lilienthal, 2009 passim; Thompson et al., 2009 passim), healthcare (Fanning and Gaba, 2009 passim; Blum et al., 2010, passim) and sport (Hoffman, 2006 passim). The main purposes identified in this literature are those of control through standardisation, safety, simplification, skill development and confidence. As there are problems applying these to pre-clinical dentistry, this section attempts little more than identification of the issues, which are taken up again in the sections dealing with learning, fidelity and transfer.

STANDARDISATION

One purpose of simulation is standardisation, creating a controlled environment for learning and assessment. Students learn restorative skills by carrying out standardised tooth cavity preparations to precise measurements. The process has the advantage of teaching control of the dental handpiece, because a high degree of precision is demanded of the student, and because teacher and student can detect errors relatively easily.

As Zeitsman et al. (2011) point out, however, standardisation of cavity preparation does not transplant easily to the clinical setting where cavity preparations are undertaken to eliminate dental caries and, therefore, are tailored to the extent of the disease. They cannot consist of predefined, standardised measurements, although there is regular comment from clinical teachers that students frequently attempt this. Usually this

results in inadequate removal of dental caries, and sometimes damages the tooth unnecessarily.

A second purpose for standardisation is to improve assessment reliability. Standardised cavity shapes are easier to assess reliably, being based on a series of measurable features (Schiff et al., 1975, p93). However, standardised assessment is also not tenable in a clinical setting. Not only does clinical caries removal require non-standardised cavity shapes, but because clinical performance is multidimensional, its assessment needs a more sophisticated approach.

Safety

Patient safety is the most significant driver behind the development of medical simulation (Gordon et al., 2001, p472; Maran and Glavin, 2003, p22). Patient safety also provides the most widely accepted definition of purpose for dental pre-clinical simulation. It allows the student to practice restorative skills prior to carrying them out on patients. It also provides various stakeholders with some assurance of clinical ability prior to the first encounter with patients. These stake holders include the patient, the educational establishment, the student him/herself and the registering body.

In the United Kingdom, that registering body is the General Dental Council (GDC). Pre-clinical simulation has been referred to by the GDC as the "*gateway to clinical practice*" (General Dental Council, 2002). Later GDC documentation becomes increasingly specific, requiring for example that students "*demonstrate[d] to the education/training provider that they are clinically competent where the outcomes required this* (General Dental Council,

2011, p8), or that *"Students must provide patient care only when they have demonstrated adequate knowledge and skills."* (The General Dental Council, 2012, p2).

Underlying the gateway concept are the following assumptions: that learning in pre-clinical simulation is appropriate to clinical restorative activity, that assessment is adequate to ensure patient safety, and that pre-clinical learning transfers in a straightforward way to the clinical setting.

SKILL DEVELOPMENT

Irrespective of GDC "gateway" requirements, no dental school would consider allowing the student of dentistry to carry out restorative clinical activity without prior experience in a simulated setting. Pre-clinical restorative dentistry is credited with developing perceptual- motor skills, procedural knowledge and knowledge of relevant materials. Although it provides only a simplified version of clinical reality, preventing the student from developing all of the skills required for clinical activity, it cannot be denied that skills such as perceptual-motor skills are important to restorative dentistry. An often quoted reason for standardisation in cavity preparations is that it teaches the student to manipulate a dental handpiece with precision.

Skill development and practice

There is ample evidence that simulation results in learning (Nestel et al., 2011, pS13). There is also some evidence that practice is an important component of that learning (McGaghie et al., 2011, passim). Learning through practice is established by tradition and enshrined in the phrase "practice makes perfect". Ericsson (2004 passim , 2008 passim) provides evidence for the tradition in his concept of deliberate practice. The

"deliberate practice" school asserts that expertise is a result, not of innate ability, but of "effortful practice" characterised by a driving motivation, attention to small task components in order to perfect them, immediate feedback and multiple repetitions. Wulf et al. (2010, p75) identify a number of factors which have *"both informational and motivational influences on learning"*. These include observation of practice by others, a focus of attention on the object, rather than on the body movement required to perform it, appropriate immediate feedback, and practice which is controlled by the learner instead of being timetabled by the teacher. There is evidence from neurology that human brains have (at least) two different, competing learning systems: a verbal explicit system situated in the frontal lobe of the brain that *"uses logical reasoning and depends on working memory and executive attention"* and a procedural system, which is largely automatic, situated in the basal ganglia, that *"learns in a slow incremental fashion and is highly dependent on reliable and immediate feedback"* (Ashby and Valentin, 2005, p548). If this is the case, it would go some way to explain the need for time and practice in the learning of manual skills.

Pre-clinical simulation allows the student to practice, does not require the presence of a patient, and allows the student to make mistakes in safety. On the other hand, the pre-clinical course is only one part of a busy curriculum. Personal experience suggests that students rarely have the luxury of extensive self-directed practice simulation. Another issue with pre-clinical dentistry is that of demonstration. Surveys (for example that of Shanks et al., 2010 passim) suggest that students benefit from demonstration in the simulation setting as much as the clinical one; yet the individual nature of the pre-

clinical course limits opportunities for observation of peers or teachers. How do a lack of practice and demonstration affect student preparation for clinical activity?

Skill development and simplification

A significant feature of all simulation is that it confronts the learner with a subcomponent or subset of components abstracted from the complexity of the whole (Beaubien and Baker, 2004 passim; Sinz, 2004 passim). Cognitive load theorists (Sweller, 1998, p261) suggest that learning sequentially rather than simultaneously reduces the student's cognitive load to a manageable level. The phenomenon is deliberately used in the "partial task trainer" concept, in which simulation contains only one or two aspects of the whole. It is suggested (Hahn, 2010) that this results in better learning and transfer. For example, Tichon and Wallis (2010, p464) found that partial task trainers resulted in improved learning for train drivers dealing with stressful scenarios. In pre-clinical dentistry, the "phantom head" is a partial task trainer, allowing the student to focus on procedural and motor skills in isolation from the complexities of the clinical environment.

At the same time, and for many of the same reasons, simplification has disadvantages. Other skills also need development if the student is to provide safe patient care. Reflection would suggest that these include, as a minimum, patient interaction, intraoral examination and a variety of contextual patient administrative skills. They also include team skills, such as working with a dental nurse. The "phantom head" teaches very little of these, and students commonly transfer to clinical practice with little understanding of holistic patient care. Dental schools are aware of this, and most ensure that the pre-clinical course is only part of the student's preparation for restorative clinical practice.

Students will usually experience a gradual introduction to patient care through clinical observation. In many schools they also undertake hygiene clinical practice prior to beginning restorative clinical practice, helping to develop essential patient interaction skills. And when the student does eventually begin restorative patient care, the clinical setting is also a learning one, in which clinical teachers provide one-to-one contextualised teaching.

CLINICAL CONFIDENCE

A frequent comment from students and teachers is that the early stages of clinical patient contact can be stressful, and that simulation is one of the factors in enhancing student confidence. With relatively few exceptions (Brannan et al., 2008, p498), studies report increased student confidence as an outcome of simulation (Peteani, 2004 passim; Bambini et al., 2009 passim; Wagner et al., 2009 passim; Blum et al., 2010 passim). Lasater relates simulation to clinical confidence and clinical judgement (2007). Problems with this study, however, include sample size and the unusual composition of the focus group (all participants were "*older than 25 or male or had a previous degree or of a racial/ethnic minority"* (p271)*)* compared with most nursing students. The author herself recognises that *"… the non-traditional composition of the final focus group potentially biases the findings."* (p272)

Student confidence is an important simulation outcome, because some degree of confidence is important to clinical functioning. On the other hand, overconfidence is potentially dangerous. But why does simulation affect student confidence, and why is confidence an important simulation outcome? It may simply be that simulation provides

the student with a window into the relevant clinical task, and reduces fear of the unknown. It may relate to more informed self-assessment gained through the simulation.

It might be supposed that the relationship between confidence and performance transfers from the pre-clinical to the clinical settings. If so, we could reasonably expect subsequent clinical performance to reflect confidence shown in the simulated setting. However, there is some empirical evidence that it does not, at least for medical students in an anaesthesiology placement (Morgan and Cleave-Hogg, 2002, p537).

I have already mentioned, in section one of this chapter, evidence for a lack of correlation between pre-clinical and clinical performance in dentistry. Of course, this lack of correlation may be due to factors other than student confidence, such as teamwork, patient interaction and patient variation, which are not available to the student in the pre-clinical setting but are of huge importance in the clinical one. Does this lack of "phantom head" fidelity in these areas affect the student's transfer to the clinical setting? I will return to this discussion in later sections under the headings of fidelity and transfer.

SECTION THREE – LEARNING AND ASSESSMENT IN PRE-CLINICAL SIMULATION

Learning is studied by both educationalists and by neurologists. While educationalists debate whether learning is individual or social, contextual or context independent, neurologists map functional organisation of the brain. This sub-symbolic explanation of learning may not provide descriptions and theories of use to the teacher, but it does

remind us that, at the most basic level, learning depends on neural representations. To this extent, learning is personal and individual.

A useful account of pre-clinical learning in dentistry must explain a number of things:

- the acquisition of perceptual-motor and procedural skills which, are an important outcome of the pre-clinical course,
- the place of observation, practice, teaching and peer input into the acquisition of these skills,
- the distinction between explicit and implicit learning, because implicit learning is significant in learning restorative dental skills, and
- it must also suggest ways to promote transfer of learning to clinical activity.

In this section, I address learning and assessment processes within the "phantom head" simulation.

Simulation literature is relatively atheoretical on the subject of learning; where it exists, the most common theoretical framework is that of experiential learning. Zigmont et al. (2011, passim) provide one example among a number which adopt this approach. Other theoretical underpinnings include situated learning, for example (Kneebone, 2005 passim; Paige and Daley, 2009 passim; Onda, 2011 passim), and adult learning (Clapper, 2010 passim). In this section, pre-clinical learning is assessed through the lens of each of these paradigms.

The basic concept of experiential learning has given rise to apprenticeship, problem-based learning, action learning, school field trips, and other learning contexts with a common thread of immersion of the student in an applied setting; ideas so large and diverse that Roberts (2012, p8) states *"It is simply not possible to draw a neat genealogy of the field…"*

As far as the simulation literature is concerned, the primary interpretation is based on the learning cycle popularised by Kolb (Kolb and Fry 1975 passim; Kolb 1984 passim). Part of a popular "reflective constructivist" stream of experiential learning, this model proposes a circular (or more often conceived as spiral) learning process whose components are concrete experience, reflection, abstract theorising and experimentation. In the simulation literature the tendency is to focus on experience and reflection with the other two stages rarely discussed.

Reflection and concrete experience are both important learning activities in pre-clinical dentistry. Concrete experience allows the development of perceptual-motor and procedural skills which depend heavily on non-verbal learning processes. Learning about them theoretically or by observation is helpful, but helpful primarily if interpreted through the lens of experience. Reflection is important in that there is a significant body of literature to support the idea of reflection following activity. This is particularly the case when that activity did not give a desired, or less than perfect, result (Schon, 1983 passim; Boud et al. 1985, p9). Lieberman et al. (2002 p214) claim a neurological distinction between the stream of consciousness and reflective awareness. This latter appears analogous to the educationalists meaning of "reflection on action" They also identify an "alarm" system, which may be analogous to the concept of "reflection in

action", and suggest that this is mediated by the anterior cingulate and monitors the stream of consciousness for discrepancies between desired and actual conditions. This theory may describe neurologically how reflection allows the individual to identify errors and isolate the cause. In the context of restorative dentistry, it may also be the reason that a wide experience is helpful, because it allows the operator to recognise desired endpoint in the context of clinical variation, and identify divergence from it. The skill of reflection is a requirement in a profession whose practitioners commonly have no external referent of good practice.

The Kolb cycle offers a partial explanation of simulation learning. It addresses perceptual-motor and procedural skill learning as a process of multiple practice/reflection episodes, allowing the student to learn tacitly. But there are a number of points that need clarification in relation to restorative dentistry.

Firstly, with its focus on individual reflective construction, the Kolb learning cycle holds little explanation for the role of socialisation in learning. Neither does it allow for context, or personal motivation. Its concept of learning as dependent on reflective constructivism alone has some validity, but is two dimensional and *"… clings to binaries drawn between complex blends of doing/learning, implicit/explicit, active/passive, life experience/instructional experience, reflection/action"* (Fenwick, 2001). It requires a learning environment which is stable and reliably predictive, otherwise the learners experience cannot lead to new learning. Such a world is not usually part of human learning even within the standardised environment of the dental pre-clinical laboratory and certainly not part of the dental clinical environment.

Secondly, in spite of its focus on reflection, the concept of reflection it promotes is nebulous. The student of dentistry is encouraged to be a "reflective practitioner", but there is no precision as to the nature of reflective learning held within the theory, a lack which leaves us with questions such as which type of reflection is important? Does learning stem from reflecting tacitly "in action" (as described in Lieberman's alarm system) or reflection "on action" (as described in Lieberman's "C" system) (ibid 2002). It also leaves us asking whether reflection is an individual process, a social one, or both.

Thirdly, although the Kolb cycle recognises the role of experimentation, it does not adequately address the role of mistakes in learning, or their effects on the student. In the simulation literature, error is only discussed in relation to patient safety. Yet mistakes are an inevitable accompaniment to learning and while they have a place within the Kolb cycle, their role is a relatively narrow one, seen in cognitive terms, as the student reflects on and corrects mistakes. The freedom to make mistakes is one of the benefits of simulation, but is never thought of in positive terms by student or teacher. Instead, mistakes can be very costly to the student in terms of self-esteem, socially and eventually in terms of progression. This is particularly true in the transfer to the clinical setting, where mistakes can cause harm to the patient, and teachers can often criticise harshly. As I noted above in the discussion on clinical confidence, poor performance and undue criticism are likely to affect learning. The Kolb learning cycle does not offer suggestions on how the pre-clinical course might be constructed to best promote student reflection, nor how feedback might be incorporated into reflection without damaging student learning.

Finally, the Kolb learning cycle assumes a process of theorising integrated into the student's practical experience. Theorising and experimentation might offer possible mechanisms for learners to link theoretical knowledge to restorative practice. Yet, in spite of the opportunity to do so, it is a common observation that students do not easily make such links. Why this might be is a subject for discussion in section five below, the point I make here is simply that the Kolb learning cycle makes a prediction that is difficult to establish empirically in the simulation setting.

SITUATED LEARNING

Cognitive models of learning, such as the Kolb learning cycle, tend to minimise the role of context and motivation. In the situated learning paradigm, activity and context become central to knowledge itself, not just its application. In other words, knowledge does not exist outside context, and *"situations… co-produce knowledge through activity"* (Brown et al., 1989, p32).

Situated learning, the individual and the community

Robbins and Aydede (2009 p7) suggest that literature on situated learning falls into two broad categories. The first conceives of learning as taking place in interactions between the individual and the immediate physical and social environment. In this paradigm, dental pre-clinical simulation can be seen as a physical context, using the tools of restorative dentistry and carrying out treatment on a "phantom head" or on a patient. It can also be seen as a social context, in which students learn through interaction with each other and with the pre-clinical or clinical teacher.

The second of Robbins' categories describes learning at a more organisational level. It takes place as part of the individual's relationship to, and participation in, a larger social/organisational/cultural context. Examples of this include the legitimate peripheral participation model of Lave and Wenger (Lave and Wenger 1990, passim), and the concept of communities of practice (CoP)[2].

In dentistry, the CoP concept can be applied to the individuals' relationship with the larger dental community. The community provides the student with a sense of identity through the use of a shared language, shared practices and a sharing of patient care between members. It provides a mechanism for the sharing of knowledge that is otherwise held tacitly by individuals (Duguid, 2005, passim). Engagement with the dental community begins in the pre-clinical setting, so that as students make their transition to clinical activity, they have already acquired an embryonic dental identity. But it is not a one-way relationship. In return, the community demands a degree of conformity from its members. The pressure to conform is overt in the form of General Dental Council regulation, but also exists in the form of peer pressure. Conformity provides the individual with security (in both the emotional and the legal sense), and the community with a sense of control. It is used in the dental undergraduate curriculum as a method of instilling professional values. For qualified dentists, it is a linchpin in the self-regulation of the profession, and the protection of patients.

[2] Lave and Wenger's earliest description of the community of practice was intended to explain the process by which individuals, peripheral to a professional grouping, took on identity as members. The change of focus to an organisational management one was a later development. See Li, L., Grimshaw, J., Nielsen, C., et al. (2009, p11).

Situated learning and authenticity

According to Onda, *"The development of clinical competency necessitates hands-on practice in an authentic clinical environment."* (Onda, 2011, p e273) Clinical restorative dentistry provides the student of dentistry with a supposedly authentic clinical environment. The role of simulation is to provide the student with an alternative learning environment when, for reasons of patient safety, patient availability, cost etc., patient care is unavailable. But what constitutes an authentic setting, and does the "phantom head" provide authenticity with simulation?

Simulation, by definition, can only provide a partial representation of clinical reality. Yet for learning to be situated it must represent reality and not a subset. Situated learning theory would appear to present a fundamental inconsistency. How are opposing concepts of authenticity and simulation to be reconciled? This question is key to understanding the role of simulation, and will be taken up again in section four as part of a discussion on simulation fidelity.

ADULT LEARNING

The third theoretical learning paradigm in the simulation literature is that of adult learning. Malcolm Knowles, in a series of contributions (1978, passim; 1980 passim) suggested that adults are autonomous, practical and self-directed in their learning, characteristics that differentiate them from children.

While this view has attracted significant criticism, our purpose is to assess how well the model advances our understanding of learning in simulation? Clapper's (2010, passim) contribution on this topic is somewhat confusing, as it tries to run through most of the

field of learning theory in a single short paper, but his significant contribution is the identification of motivation and emotion as key to simulation learning.

Apart from highlighting the importance of motivation and emotion, does andragogy contribute to our understanding of simulation learning? It has a further point worth noting in its recognition of the substantial experience that adults bring to the learning process, compared with children. This is often beneficial, but not, of course, in every case. Some students bring destructive personal experiences, which colour their whole approach to learning, and understanding these influences is helpful in teaching the individual.

OTHER FACTORS AFFECTING LEARNING IN RESTORATIVE DENTISTRY

At this point I wish to introduce two concepts that did not feature in the informal discussions with staff or students that were related in chapter one: those of implicit learning and motivation. Their introduction here is justified because both have already surfaced during the preceding discussion on learning in simulation.

Implicit learning

The notion of implicit learning is present in both experiential and situated learning paradigms. It is the observation that much learning, and especially skill learning, takes place without the benefit of words (Berry and Broadbent, 1984, p261). The ability to acquire and hold knowledge without it being verbally explicit would appear important to skill learning.

There is a tendency for the term implicit to be identified with knowledge which is used practically or has been learned experientially. Ryle (1949, p16) refers to this as

procedural knowledge. There is a corresponding tendency for theoretical knowledge to be thought of as wholly explicit and language-based, which Ryle refers to as propositional. Reber suggests that such polarisations may, in any case, be false, and that "they should properly be viewed as interactive components or cooperative processes, processes that are engaged in *"a 'synergistic' relationship"* (Reber, 1993, p23). In this way both theoretical and practical activity can be expected to have both explicit and tacit components (Polanyi, 1964, p139).

Arriving at an understanding of implicit learning and implicit knowledge has proved difficult. As Gourlay points out (2006, p61), *"Many regard it as personal, private knowledge, thus appropriately treated only at the individual level. Others refer to collective or organizational tacit knowledge linking this with organizational capabilities, routines, and procedures."*

Ignoring the complexities of this debate, "implicit" and "tacit" are used interchangeably in this study to explain individual learning which requires observation and practice. A related concept equally important to skill learning is the development of automatic skilled performance. Chein and Schneider (2012, p79) identify three different levels of control architecture in the brain whose contributions to activity vary as that activity becomes more skilled and requires less attention and conscious decision making. The concept of skilled automaticity is intuitively appealing to explain performance of fine motor movements, such as those involved in the manipulation of a dental handpiece. There is also a possibility that this automaticity is actually a more important outcome of pre-clinical simulation than learning how to prepare tooth cavities.

The notions of implicit learning and automaticity impose significant changes on teaching practice (Fugill, 2012, p3). They suggest a reduced role for propositional learning and an increased emphasis on practice, calling into question the practice of insisting on teaching "theory before practice". They also hint at a possible explanation for the transfer conundrum, as the learner struggles to match verbal explanation with non-verbal learning. Because implicit learning is at least partially non-verbal, it also requires a different approach to teaching, in that the teacher is no longer just concerned with the teaching of codified explicit knowledge, but must unpack and verbalise his/her own tacit knowledge (Fugill, 2012 ibid).

Understanding the implicit nature of skill learning helps explain the importance of experience and both experiential and situated learning paradigms provide helpful explanations for the learning of perceptual-motor and procedural skills. It is key to understanding the role of pre-clinical simulation in dentistry.

Motivation and learning

There is a tendency to think of students of dentistry as motivated by their choice of career and by the career and financial rewards offered (Baharvand et al., 2011, p1492). Although this might be true at some higher level, does it necessarily apply to pre-clinical simulation? A relationship between motivation and learning has already suggested itself through andragogy, as has the concept of motivation as dependent on a range of personal factors. Later sections of this chapter also hint at links between motivation and fidelity, and motivation and transfer. It can be argued that patient safety is dependent on student motivation, and hence student learning during the pre-clinical course, so that this subject merits some consideration.

As Robison and Watson (2013, p41) identify *"In order for learners to process energetically and learn deeply, they must choose to engage."* If motivation enhances learning, it is in the best interests of all stakeholders in pre-clinical dentistry to promote it. Csíkszentmihályi (1975 p182) describes motivation as "flow", a state in which the individual is absorbed in an activity to the extent that they can *"forget personal problems, lose their sense of time and of themselves, feel competent and in control, and have a sense of harmony and union with their surrounding"*, but is the attainment of such an ideal state possible or necessary in the pre-clinical course? The experience of computer gaming suggest that it is possible for players to lose all sense of time. There is also evidence that computer games promote learning (Garris et al., 2002 p443; Gee, 2007 passim; Meluso et al., 2012, passim), although the concept is contested (Whitton 2007, p1064), and there is some evidence that the link, if it exists, is a complex, multifactorial one (Tychsen et al., 2008 p63). Nevertheless, the observation has stimulated significant interest in computer games as educational tools. A component of that link is often cited as the learner's "willingness to suspend disbelief", or "willingness to engage", though the exact meaning of either phrase in terms of motivation and learning is far from clear. Both appear to relate to the game's ability to absorb the interest of the player. Also discussed in the same context are the roles of fidelity and authenticity. Although the relationship between these two constructs is unclear, it seems reasonable to postulate a relationship between them and the player's willingness to engage.

In the more prosaic field of pre-clinical dentistry, how can student motivation be promoted? Teachers have traditionally appealed to the classic distinction between extrinsic and intrinsic motivation, citing assessment as the primary motivator. But the

classic definitions appear to develop more complexity on closer examination (Ryan and Deci, 2000 passim). In the arena of pre-clinical dentistry students can expect to experience both personal challenge and extrinsic motivation driven by assessment, progression and peer pressure. Separating individual strands from this mix of motivations appears difficult. Keller (1987, p2) uses a different approach, looking at outcomes of attention, relevance, confidence and satisfaction. Although this approach ignores underlying psychological state and student history, it helps us to understand how the pre-clinical course might be made more engaging to students.

- Engagement is also increased by stimulating the student's attention, making the simulation difficult but not too difficult, and increasing that difficulty as the student gains expertise, in order to continue to challenge the student. Also relevant may be the fidelity and/or the authenticity of the simulation. Does the pre-clinical course engage students?
- Boredom is characteristic of repetitive activity, but boredom can be reduced by activity that stimulates the student's attention, and demonstrates relevance. Does the pre-clinical course appear relevant to students?
- Does the pre-clinical course increase the student's confidence in their ability both to manage cavity preparation in the pre-clinical setting, and to transfer that ability to patient care?
- Motivation is also observed to improve with achievement and the satisfaction that comes with it. This suggests a need for goal setting within the pre-clinical course.

As I suggested at the beginning of this section, a useful account of pre-clinical learning must account for the learning of procedural and perceptual motor skills. It must explain the various roles of observation, practice, teaching and peer input. It must also distinguish between explicit and implicit learning and it must also suggest ways to promote the transfer of that learning to clinical activity.

This section has addressed four different stories of learning, and their application to pre-clinical simulation. The situated learning paradigm provides a more complete understanding of the role of social interaction (Paige and Daley, 2009 passim; Onda, 2011 passim), but pre-clinical dentistry lacks authenticity implied in a situated learning environment. However, implicit learning, engagement, practice and social context combine well in the concept of apprenticeship. The focus of apprenticeship is the expert/novice dyad, with the student gaining experience under the supervision of the expert. This type of learning relationship is so significant in both the pre-clinical and the clinical setting, to the extent that dental education can justifiably be called an apprenticeship. As important to apprenticeship seems to be the role of informal learning (Chin et al., 1999 passim; Chin et al. 2004 passim). Boud and Middleton (2003 p200), in a study on workplace learning, identify a variety of types of learning networks, both formal and informal. They mention the work of Engeström (2001 p153), whose notion of expansive learning draws attention to "*…. horizontal or sideways learning"* in which problem solving occurs essentially through interactions among peers without resort to a conventional knowledge hierarchy. Dentistry takes place in confined spaces and has significant tacit elements, limiting to some extent the opportunities for learning

by observation. Nevertheless, social interaction outside of the dental surgery context allows for peer learning. According to Collins, such interaction helps learners construct understanding, providing feedback and motivation. *"… Among other things, this encourages them to view learning as an incrementally staged process, while providing them with concrete benchmarks for their own progress"* (Collins et al., 1989, p457). Until the opening of dental schools in the early 19th century, almost all dental training took place in apprenticeship settings (Bishop et al. 2002a, passim).

Classical apprenticeship, however, has been criticised as haphazard, as the exploitation of learners for cheap labour. It has also been accused of promoting practical skill at the expense of underpinning academic knowledge (Clarke and Winch, 2004 p513). Indeed, to a large degree, public unease at the informality of dental education was the driver for the development of UK dental schools during the 19th century (Aldrich, 1999 p20; Bishop et al., 2002b p684). A more structured alternative, combining experience with academic learning, is provided by the concept of cognitive apprenticeship (Collins et al., 1989 Chapter 14 passim). The model as originally described was intended to facilitate the learning of reading, writing and mathematics by externalizing the cognitive processes involved in their learning. But it also explains the social and experiential. In particular, the teaching tools defined in the model (modelling, coaching, scaffolding/fading, reflection/articulation and exploration) have been explored extensively in domains where practical skills have a significant cognitive element, such as nursing. Many of them are familiar from other contexts. In fact many are already familiar to clinical teachers of dentistry, though I suggest that they usually lack any coherent theoretical framework within which they are used. Cognitive apprenticeship

helps to explain learning in both pre-clinical and clinical dentistry education as experiential, social and (at least partially) tacit. Unless otherwise stated, though frequent reference will be made to individual concepts such as implicit, situated, experiential and the expert/novice dyad in subsequent pages, these are to be understood within the framework of cognitive apprenticeship.

The central questions of this study are concerned, not simply with pre-clinical or clinical dentistry, but with the transfer between them. If cognitive apprenticeship is helpful in our understanding of both pre-clinical and clinical dentistry, can it also help understand the transfer process? This is the only aspect of pre-clinical learning not adequately provided for in cognitive apprenticeship theory.

Assessment

Pre-clinical assessment is used to decide whether the student has gained skills appropriate for safe patient care provision. This makes it important, and a mandatory part of all pre-clinical courses in the UK.

The pre-clinical assessment in the Cardiff school consists of the preparation of a series of cavities of different types under assessment conditions. Criteria for assessing these are the same as those used in the learning process, i.e. they are based on standard cavity features and dimensions. While this makes for a reliable assessment process, it lacks important clinical elements. The student is not tested, for example, on the skills of patient management and clinical decision making, or on caries management in the real setting. This raises questions over the validity of pre-clinical assessment.

I have already noted in section one articles by Chambers and Curtis, pointing out the lack of correlation between pre-clinical and clinical performance (Chambers, 1987 p241; Curtis et al., 2007 p370). The two studies are limited in scope, but the suggestion is a matter of concern in view of the use of pre-clinical simulation as a "gateway" to clinical activity. The GDC expects students in the clinical setting to work under supervision, so it clearly recognises that simulation and its assessment have limits in ensuring patient safety in the clinical setting.

The lack of correlation between pre-clinical and clinical performance remains to be confirmed in this study, but if the studies by Chambers and by Curtis et al. (both studies cited above) are confirmed, they will form an interesting contrast with the claim frequently made by pre-clinical teachers that they can identify with a high degree of confidence, at an early stage, the student who will do well clinically. The discrepancy between formal assessment and teacher informal judgement is alarming. Yet Chambers et al. provide some empirical evidence for the accuracy of the informal judgment (1997, passim). How should we interpret this evidence? Is informal/individual judgement a more accurate predictor of future clinical achievement than formal assessment? Are pre-clinical teachers deluding themselves? Optimal decisions, arrived at by explicit and/or tacit consideration of a number of different treatment pathways, are characteristic of clinical activity. It is possible that what teachers are doing is applying this type of heuristic process to student assessment, in sharp contrast to the more academically acceptable standardised assessment process.

SECTION FOUR – THE ROLE OF FIDELITY IN PRE-CLINICAL LEARNING

High physical fidelity is generally well received by learners, but pre-clinical dentistry is not a high fidelity simulation. While there is some evidence to support the use of "partial task trainers" with low physical fidelity, it is this aspect that students of dentistry comment on most. For example, they identify the poor physical characteristics of plastic teeth, comment that cavity preparation is standardised and unrealistic, and that the working conditions in the oral cavity are not realistic. In this section, I will explore the effects of this lack of fidelity on pre-clinical learning and transfer.

DEFINING SIMULATION FIDELITY

I begin by attempting a definition of the concept. Previous attempts at defining fidelity have resulted in a proliferation of distinctions. As Lane and Alluisi (1992 p5) pointed out 2 decades ago *"at least 22 different definitions have been used in the literature"* with the most common extant in the medical and nursing literature a measure of physical resemblance between simulation and reality. It is from this concept that we derive the distinction between "high" and "low" fidelity.

Though disputed by some (Alessi, 1988 p47; Reder and Klatzky, 1994 p19), there is an assumption underlying much of the healthcare literature that increased physical fidelity increases both learning and transfer. The origins of this belief may lie in the "identical elements" theory of Thorndike (1913), who suggested that commonality of features between simulation and reality facilitates transfer between them (see section 5 below). Judd's (1908) "general principles" theory is also based on commonality, proposing that the same general principles underlie different activities in different contexts.

Fidelity contributes in a number of ways to learning a complex skill set but our understanding of it has changed over time (Dahl et al., 2010 p12) to include cognitive processes, as well as physical settings and commonality. Also of note in this context are contributions from Rehmann et al. (1995 p11) and Kozlowski and Deshon (2004 p4). Singley and Anderson (1989, p25) identified a belief in "general cognitive skills" as a resource in knowledge transfer. For Wilson et al. (2009, p9-9), it is important for learners in simulated settings to "… *progress through the same cognitive processes as would be required to complete the task in the real world."*

Fidelity and motivation appear linked in that literature from the field of medical simulation suggests a role for emotional realism in engagement and learning. Beaubien and Baker suggest that without emotional involvement, the student is "*unlikely to behave … as they would in the real world*" (Beaubien and Baker, 2004, p i52). In other words fidelity is, at least partly *"the degree to which the simulation captures key psychological processes of the performance domain"* (Dahl et al., 2010, p15). Immersive simulation is certainly used to good effect in training for medical emergencies (Wilkerson et al., 2008 passim). In a meta-analysis of simulation learning, Oskarsson, Nahlinder and Svensson (2010, p2422) felt able to comment that *"A feeling of involvement in the simulation influences the training in the simulator, which in turn has a positive influence on the transfer of training to real world performance."* Although the reliability of this assertion is limited because the meta-analysis only involved four articles, it is supported by evidence from other simulations, particularly the computer gaming industry. As Gee (2007 (abstract p1)) comments, computer game designers have generally succeded in getting *"… people, often young people, to learn and master something that is long and challenging--and enjoy it."*

While the physical, the cognitive and the emotional all appear to be significant components of fidelity (AGARD, 1980 p1; Rehmann et al., 1995 p8; Estock et al., 2006 p4), they do not provide a complete description. For example Dahl et al. (2010 p15) also identify *"human perception, attention, decision-making, memory, and action"* as factors. They do not identify in what way these are important, though we can, for example, observe the effect of attention and fatigue on learning in the dental pre-clinical laboratory. Nor is it likely that individual components can be isolated and investigated separately, as considerable overlap of function and effect can be expected (Hochmitz and Yuviler-Gavish, 2011 p490).

EXPLORING FIDELITY IN THE "PHANTOM HEAD" CONTEXT

The general trend of "phantom head" development is towards physical fidelity in cavity cutting. In the past decade computer technology has allowed what are essentially the first developments since Fergus' invention of the "dental phantom". The first of these was represented by the DentSim© (Buchanan, 2001, passim; Lackey, 2004, passim), the basic purpose of which was to monitor student cavity cutting and detect deviation from a pre-programmed shape. However, it proved so complicated to maintain, that it has generally fallen out of use. The second generation is currently in use in a few dental schools. It introduces virtual reality to the "phantom head" simulation, along with haptic feedback (Curnier, 2010, passim; Konukseven et al., 2010, passim). Although this system still uses pre-programmed cavity shapes to develop handpiece control, the addition of tactile feedback is provides addition learning necessary to motor skill development (Schmidt and Wrisberg, 2008, Chapter 10 passim). The third generation is currently represented by a robotic patient "Hanako", creation of the Japanese company TMSUK

(Tanzawa et al., 2011, passim). It is only in this generation that we start to see features other than standardised cavity cutting added to the "phantom head"; the Hanako robot offers some elements of patient interaction.

Decision making and attention are also important to clinical practice at all levels. "High fidelity" in medical simulation is most frequently understood in terms of the patient mannequin. This represents a patient in both anatomical and physiological detail and learning on such mannequins usually involves decision making about some aspect of treatment. In the dental setting, standardised cavity preparation largely eliminates such decision making. Clinical practice requires attention to many aspects, not just to the cavity preparation. For example, the clinician must reassure the patient, manage soft tissues, control patient saliva and work with a dental nurse. Juggling these multiple demands is also a skill that the student needs to learn and the ability to increase the complexity of the learning environment is one attraction of "high-fidelity" simulation. The logic behind this is that the more "real" the simulation, the more authentic (in the situated learning sense of the term) it will be as a learning environment.

Authenticity and fidelity

However, the relationship between authenticity and fidelity is not clear. Does increasing the fidelity of the "phantom head" increase its authenticity? What is authenticity, and how much fidelity does it require, always assuming that fidelity can be quantified? And which components of the simulation are crucial to authenticity: physical similarity, cognitive elements such as attention and decision making, or motivational ones such as involvement and emotion? These questions are important to understanding simulation

as a situated learning setting, and an important context in which to set current drives toward increased fidelity.

Available literature seems to relate authenticity not to simulation fidelity, but to activity (Lombardi 2007, p2). It holds elements of relevance and involvement; in simulation terms "the willingness to suspend disbelief". Reeves et al. (2002, p563) set a number of criteria for an authentic learning setting. In their view, authenticity sees learning taking place through complex activity that has value to real life, is of personal relevance, and requires reflection, integration and collaboration. Goals of such activity are typically fluid with a number of satisfactory completion pathways, requiring the learner to assess competing solutions and make critical decisions.

This is not a description of pre-clinical dentistry, whose tasks are not cognitively complex and do not require much decision making. The "phantom head" does not include elements of emotional fidelity such as attention, decision making or motivation. It provides a limited degree of physical fidelity in that students cut cavities, but into plastic teeth which do not have the same haptic qualities as real ones. Because outcomes are standardised, the student has only a single measure of success. What is the effect of this lack of authenticity on student learning? In medical simulation some authors feel able to argue that the increasing sophistication of simulation promotes authenticity (Kneebone, R. et al., 2004, p1096). Would an increasingly sophisticated "phantom head" better promote student learning? I suggest that it depends on the aim of the pre-clinical course. If its only aim is to develop perceptual motor skills, then a partial task trainer may be an adequate tool. On the other hand, if the need is to develop student clinical

skills to a safe and competent operating level, then authenticity may promote appropriate student learning.

In fact there is growing recognition that the current generation "phantom head" is not sufficient, and many schools are looking for ways to improve its authenticity.

Increasing "phantom head" authenticity

Could working in a clinical environment provide more authenticity? The clinical environment is where the student will see patients and we might expect some degree of identification with it. Clancy et al. compared practical work carried out in a laboratory setting with that carried out in a patient mannequin in a dental chair. The authors commented that *"Students with more bench top experience scored better on the bench top, and students with more manikin experience scored equally in both environments"* (2002, p1331). The opposite was found by Green and Klausner (1984, p665) whose study suggests that the setting does not significantly improve cavity preparations. Clinical restorative dentistry is not just about cavity preparations, and the authors do point out that *"Enthusiasm, motivation, satisfaction, operator comfort, long-term productivity, and exposure to the clinical environment prior to patient treatment are important dimensions of the pre-clinical experience."* Would these perhaps contribute to the authenticity of the learning environment? It is unfortunate that they did not form part of this study.

In spite of this conflicting evidence, a number of dental schools are now making use of the clinical setting to increase authenticity. The most favoured approach appears to be a blended learning one, in which students spend some time in a teaching clinic in parallel with the "phantom head" exercises.

The student engages in clinical activity in a number of ways:

- He/she practises on a "phantom" head placed in a dental chair, working with an assistant to practise teamworking aspects of dentistry.
- He/she practises a limited range of procedures on student colleagues, such as intraoral examination, dental charting. The range of such treatments is obviously limited for ethical reasons.
- He/she also see patients, undertaking a limited range of reversible procedures, working with an assistant to practise teamworking aspects of dentistry.

The limitations of simulation authenticity

This is perhaps an appropriate place to reflect on the theoretical limitations of simulation. One definition is that of a "subset of reality". Simulation can never be a replacement reality. The degree to which it approaches reality is ultimately limited by the student's willingness to *"suspend disbelief"* in order to *"fully engage in learning scenarios based on authentic tasks"* (Herrington et al., 2003). In other words, a willingness to engage is an essential component of authenticity. The challenge is to encourage the student to engage in the "phantom head" simulation. Engagement may be a key to understanding the relationship between fidelity and authenticity. Whether it be physical, psychological, emotional or other important component, fidelity appears to be important in promoting involvement, as witnessed by the computer gaming industry. This relationship between fidelity and authenticity is key to understanding simulation. It is one that needs further study. (Long et al., 1997, p133).

SECTION FIVE – TRANSFER TO CLINICAL ACTIVITY

Transfer of learning from the pre-clinical setting to the clinical is critical to patient safety. But to what degree does it take place and how are we to understand it theoretically? This section begins with a brief theoretical consideration of transfer, then addresses the issue of evidence for transfer in both general and healthcare literature, concluding that there is relatively little. It then propose an alternative understanding of transfer as boundary crossing and explores some of the implications of this for pre-clinical restorative dentistry.

As previously noted, perceptual-motor skill is not the only component of clinical practice. Although the different components may differ in terms of transfer from simulation, I have explored these differences only superficially, largely by noting their absence from the pre-clinical setting. During the following discussion I have used the term knowledge in its widest sense, encompassing all components of professional activity.

A BRIEF THEORETICAL CONSIDERATION OF TRANSFER

Clinical restorative dentistry requires transfer in two ways. It requires the fusion of propositional and procedural knowledge, and it requires their joint application to clinical practice. Neither is straightforward, but this difficulty is not unique to restorative dentistry (Renkl et al., 1996, p115). Healthcare literature contains numerous examples of educational methods or techniques trying to bridge the gap between academic and clinical knowledge (Higgs 2001, p526; Smith 1998, p257). It also contains a similar number of comments on skill transfer between contexts (McKeachie, 1987

passim; Merriam and Leahy, 2005 passim). This sub-section provides an overview of the complex field of transfer theories.

Two transfer paradigms

As Säljö (2003, p311) points out the term transfer is essentially a label to describe how something learned in one task or context is applied in another task or context but an adequate explanation of the phenomenon has proved elusive.

The two main "classical" approaches, the "identical elements" theory of Thorndike and Woodworth (1901; Thorndike 1913), and the "general principles" theory of Judd (1908), still resonate in current thinking. According to Beach these two traditions are particularly powerful *"… because they are affirmed by the structure of many aspects of our education system"* (Beach 1999, p103). Their influence can be traced in current views of simulation practice. For example, the desire for high physical fidelity stems, to some degree, from the belief that fidelity provides "identical elements", and that these allow the student to link the simulation to the reality. We see the echo of Judd's "general principles" theory in the way in which "*Beliefs about transfer often accompany the claim that it is better to 'educate' people broadly than simply to 'train' them to perform particular tasks.*" (Bransford and Schwartz, 1999, p61) and in a persistent belief that learning takes place from the general to the particular.

Common to both explanations is a cognitive understanding of knowledge as a context independent, transferable commodity. This view of knowledge, of course, is disputed. Historical development of the transfer construct has largely paralleled development in learning theory resulting in both cognitive and situated schools. For the cognitive school transfer is *"learned intelligent behaviour"* and *"successful transfer occurs when the problem*

solver is able to recognise the requirements of the new problem, select previously learned specific and general skills that apply to the problem" (Tuomi-Gröhn and Engeström, 2003, p23). Cognitive explanations by and large require pre-existing knowledge to provide a baseline for new learning. In this they resonate with theories of learning that put dependence on previously existing knowledge, such as that of Ausubel (1968), and Vygotsky's "Zone of Proximal Development" (1978).

As we might expect, criticism of cognitive transfer centres round the role of context (Lave, 1988, p68). Situated explanations tend to de-emphasise the idea of knowledge as an independent, transferable commodity. A variety of conceptions are proposed, loosely categorised as situated *"patterns of participatory processes across situations"* (Tuömi-Grohn and Engeström, 2003, p24), socio-cultural *"relations between persons and activities"* or activity-based *"transition between activity systems"* (Guile and Young, 2003, p63). Transfer becomes, in effect, *"a self-perpetuating cycle of continuous development and reconstruction of meaning and practises"* (Lauder et al., 1999, p481). Some go further, questioning the existence of a transfer construct in any currently recognised form (Beach, 1999 p110; Hager and Hodkinson, 2009, passim). Lobato (Lobato, 2006, p432) highlights the dilemma inherent in both camps, suggesting that *"If one rejects the idea of transfer… then the notion that new learning is constructed from previous learning seems to be denied… if one accepts transfer, then questionable beliefs* [i.e. the identification of knowledge as a context independent commodity] *about knowledge seemed to be endorsed.*"

If the theoretical construct is doubtful, is there any concrete evidence to support it? In other words, is there evidence for transfer? Although there is ample evidence of learning in simulation, without transfer to clinical activity, this is of little use; here I briefly explore the evidence available in the simulation literature.

Studies from military and commercial aviation sources appear to demonstrate transfer, but conclusions tend to be complicated by methodological difficulties.

Most studies fall into one (or more) of the following four categories (Hahn, 2010, p2):

- pre- and post-testing of learning arising from a single simulated task in the same or similar simulated environment;
- comparison of a number of different learning methods, using post-testing as a measure of transfer;
- post-testing of learning in a higher fidelity simulated environment;
- measurement of transfer by comparison of performance in simulated with that in real settings.

The first two categories are straightforward to undertake, but have the obvious limitation of measuring learning within the simulated environment only; they do not measure transfer to real settings. Examples of these from the healthcare literature include Muresan et al. (2010, p537), Schwid et al. (1999, p821), Zeitsman et al. (2011), and Ruggenberg (2008, p81). The third approach undoubtedly has higher face validity but there is still concern that a different type of simulation may actually measure different factors. Lane and Rollnick (2007) provide a systematic review and discussion of this approach. They

also conclude that *"A number of methodological weaknesses make concrete conclusions difficult to draw"* (p13). The fourth type of study, comparing simulated and real settings, would appear to provide the most reliable evidence but suffers from the limitation that the activity may have legal, ethical, cost or safety implications that make the experiment much more difficult to stage. To add further layers of complexity, the term simulation covers such a wide field, both of training settings and of simulations used, that it is difficult to make universal statements about transfer. Given these difficulties, it is not surprising that evidence on transfer is poor.

The question of transfer to the clinical setting features regularly in the surgical and nursing literature. Here there is some limited evidence in favour of the construct but also a degree of uncertainty. Skills transfer very well to the clinical setting according to Domuracki and colleagues (2009, passim), though their study only looked at a single skill (cricoid pressure during CPR). Other authors find a more confusing picture. For example, Patel and Cranton (1983), studying transfer between medical rotations among final year medical students, concluded that *"Results indicated that learning was discipline-specific as well as specific to the learning domain studied"* (p126). Put differently, transfer did not take place between one training rotation and the next. As exemplified by these two studies, variations in the complexity of the simulated task and in the contribution of simulation to the learning process, make comparison difficult. Sturm et al., in their systematic review of transfer of surgical skills to the operating theatre note that *"Little evidence has focussed on correlating simulated performance with actual surgical performance"* (2008, p166). The authors were able to conclude that *"Skills acquired by simulation-based training seem to be transferable to the operative setting."* However, this

general assertion is problematic, given that the studies they examined focus on only two surgical procedures, and only one of the 11 studies examined provided a direct comparison between simulation-based training and patient care provision. Nestel et al. (2011, p S10), in a larger review of 81 studies, found more conclusive evidence that "*simulation usually leads to improved knowledge and skills"*. It is of note, though, that this statement carefully avoids the word transfer, the authors only able to add that *"A small number* [of studies] *support the transfer of simulation learning to clinical practice."*

TRANSFER AS BOUNDARY CROSSING

In view of the weakness of any direct evidence for transfer, how are we to understand the use of previously acquired knowledge in new contexts? Is it even appropriate to ask questions about previously acquired knowledge? In this sub-section I examine the notion of boundary crossing, which may offer an alternative understanding of transfer.

Conceptually, boundaries are markers of separation and difference, used for denoting categories and roles (Lamont and Molnar, 2002, p169). They can also be markers of continuity in the sense that they represent places where two different domains are in contact. They also represent achievement as learners advance from one domain to another. In other words, the concept of boundary can be seen as a metaphor for barriers to, and opportunities for, learning.

The concept is developed in particular through Engeström's (1995, passim) expansive learning theory and Wenger's (Wenger, 1999, passim) communities of practice. According to Akkerman and Bakker (2011, p132), it is also a response to increasing specialisation resulting in ever more fragmentation of knowledge. It has two central

elements: boundary crossing and boundary objects. Suchman (1993, p25) defines the term boundary crossing as the way in which we *"… enter… onto territory in which we are unfamiliar and, to some significant extent therefore unqualified."* On crossing boundaries the learner faces *"… the challenge of negotiating and combining ingredients from different contexts to achieve hybrid situations"* (Engeström et al., 1995, p319). On close examination, boundaries appear a regular feature of clinical practice. One example is the "theory practice gap" so often seen as students struggle to apply academic knowledge to clinical settings (Rolfe, 1993, p173). Another is the development of team practice at an organisational level (Kerosuo and Engeström, 2003, passim). Is each of these boundaries fundamentally different, or do they represent different examples of a common underlying human activity? And does the concept of boundaries and boundary crossing contribute to understanding transfer from simulated to actual contexts?

Professional wisdom as boundary crossing

The most relevant example of boundary crossing in dental clinical learning is the need to metamorphose pre-clinical skill into professional wisdom. Kinsella and Pitman (2012, p7) identify professional wisdom with the Aristotelian concept of phronesis *"the virtue that enables us to judge what it is we should do in any given situation".* Eraut (2009, p2) calls it *"knowledge in use"* and suggests that it involves *"know-how in the form of skills and practises, memories of episodes and events, self-knowledge, attitudes and emotions"*. He further proposes that each one of us has both public and personal versions, an idea which recalls the distinction between "*espoused theory*" and "*theory in use*" proposed by Argyris and Schön (1974, p6). Haggerty and Grace (2008, p235) suggest three components: "*balancing and providing for the good of another and the common good, the*

use of intellect and affect in problem solving, and the demonstration of experience-based tacit knowing in problematic situations".

Examination of knowledge conditions on either side of the boundary identifies some of the characteristics of clinical wisdom and gives an idea of the scope of change that the student has to undertake. On one side of the boundary is knowledge (including skill, in as much as skill can be codified) that is codified in order to facilitate its transmission from teacher to student. The personal ethos of the student is oriented towards his/her own learning. Knowledge tends to be derived deductively, because it is the fruit of dental research in an evidence-based culture. Because it is "best evidence" the student is expected to impose it onto his/her clinical practice. The result tends to be inflexible because it is "*based on exact principles and explicit rules*" (Tanggaard, 2007, p455). Rule-based knowledge has limited use in the clinical setting and can occasionally be dangerous, as when the student attempts to manage dental caries through standardised cavity preparation. It must be sifted, adapted and applied in context. On the other side of the boundary is clinical wisdom. It requires a mix of knowledge and skill, but both are generally more tacit in nature, because it is used personally. Codification only becomes necessary when the clinician is required to explain a disease process or its management to the patient and then it usually needs further modification in order to be understandable to patients with no pre-existing knowledge. Professional standards require the student to focus on the patient, not on his/her own needs. Clinical wisdom is also different because it is inductive. Rather than being applied to practice, it is derived from it.

The development of professional wisdom would appear very demanding for the student of dentistry:

- in terms of language, because the learner is not equipped with an adequate vocabulary with which to express him/herself. In fact the learner has to learn two languages: the first need is to communicate with colleagues, but the technical vocabulary required for this is unsuitable for communicating with patients so a separate language is required for this;
- in terms of learning because the learner is equipped initially only with explicit, codified clinical knowledge, and personally oriented standards, and is at significant disadvantage in the clinical environment;
- in terms of unlearning because many of the practices learned in the pre-clinical setting are not appropriate for the clinical one. As we have previously discussed, the need for standardised assessment is at least partly responsible for inappropriate learning;
- in terms of transfer because transferring and adapting academic knowledge requires significant learning over and above the minimum required to deal with the new clinical environment and
- in terms of identity because transformation requires that familiar *"beliefs, attitudes, norms and roles"* (Hung and Chen, 2007, p148) be adapted to the needs of the patient and the profession.

Carlile (2004, p557) describes a boundary crossing approach to organisational management. While this involves primarily knowledge transfer between members of a team, it has some application to personal knowledge transfer from pre-clinical to clinical restorative dentistry. He identifies the cost to the student of unlearning; for example when skills learned with difficulty in the pre-clinical setting are suddenly found

inappropriate in the clinical one. In his "3T framework" he argues for the idea that knowledge management across boundaries is not only a matter of transfer, but also of translation and transformation. This framework may help understand the student transfer from a pre-clinical setting to a clinical one and it confirms the suggestion that transfer is not a single process (Down, 2011, passim), offering an alternative in which transfer is one component of a larger redefinition of individually acquired knowledge. This would also explain why little evidence is found for transfer as a separate entity.

Redefinition of transfer as a multicomponent phenomenon is helpful to understanding the development of student clinical ability. It includes at least skill transfer, knowledge transformation and new learning fused together in a developmental process that changes a student into a clinician. In order to differentiate this complex process from that of transfer alone, the term transition will be used for the rest of this report, on the grounds that this larger concept better represents the scale of change required of the student.

BOUNDARY OBJECTS IN THE TRANSITION TO CLINICAL ACTIVITY

If we consider transition as having many components, we can also theorise that some of these will promote while others may hinder the transition. Implicit in theories of boundary crossing (Young et al., 2003 passim) is the idea of boundary objects; a "boundary object" being an artefact that fulfils a bridging function across the boundary. Perhaps the concept can be used to describe the various components of the transition process. This sub-section explores the notion of boundary objects in both pre-clinical and clinical environments to see how they contribute.

Boundary objects and barriers

Akkerman and Bakker (2011), in a meta-analysis of boundary literature, identify a range of boundary objects which, they consider, promote learning:

- Identification is the process of recognising a change in practice by *"defining one practice in light of another, delineating how it differs from the other practice"* (p142). This is an activity that can only occur retrospectively, as the learner encounters new practice.
- Coordination facilitates *"boundary permeability so that one is not even aware of different practices simply because actions and interactions run smoothly*" (p144).
- Reflection and articulation have a role in the boundary crossing metaphor, as in many other explanation of learning. In this context reflection is a process of *"… coming to realize and explicate differences between practices and thus to learn something new about their own … practices"* (p144). This too is a process that can only take place in the clinical setting.
- Transformation is the process of practice change, giving rise potentially to *"the creation of a new, in-between practice, sometimes called a boundary practice"* (p146). Perhaps the managed transition, blending laboratory and clinical activity, can be considered a boundary practice?

In section two, I discussed the conceptualisation of pre-clinical dentistry as cognitive apprenticeship, and asked the question "How can cognitive apprenticeship usefully contribute to understanding the student transition to clinical activity?" I suggest that the student/teacher dyad, central to cognitive apprenticeship, can justifiably be

interpreted as a boundary object. There are hints of this in Akkerman & Bakker's (2011 ibid) description of identification and coordination. Cognitive apprenticeship is aimed primarily at teaching the processes that expert use to handle complex tasks. Modelling, coaching, scaffolding/fading, reflection/articulation and exploration are typical of the interactions taking place within the dyad as the student is learning how to translate pre-clinical skills into clinical ones.

The boundary object concept can also provide a metaphor for elements that hinder learning, in other words a barrier. There appear to be at least two of these in the context of restorative dentistry.

- The first is chronological distance. Time constraints on dental programmes frequently mean that pre-clinical simulation and patient care are separated in time, to the extent that the student loses skills learned during simulation.
- The second is psychological distance. Although students of dentistry and their teachers are members of the same profession, the distance (Vaughn and Baker, 2004, passim) between them in terms of status can affect the boundary crossing process, particularly if the student does not feel able to ask questions or challenge the teacher (Fugill, 2003).

TRANSFER AS A RETROSPECTIVE ACTIVITY

What seems to emerge from this discussion is an image of transfer as retrospective. The concept implied by both the "identical elements" theory of Thorndike (1913), and the "general principles" theory of Judd (1908), is that of the student carrying forward to a new context, a headful knowledge previously acquired. Yet Akkerman and Bakker's

(2011 ibid) concept of promoters of learning appear to require a real, not a simulated, environment. In dentistry, this means require clinical experience. The metaphor of transformation includes the picture of the student looking backwards through the boundary and retrieving knowledge which has suddenly been recognised as relevant. It is unfortunate then, that there appears to be little help for the student of dentistry in the development of clinical wisdom. There is almost no theoretical discussion of transfer in the dental education literature. Personal observation suggests that the development of clinical wisdom is left very much to the individual student.

For Judd, the transfer process required that "… *teachers … actively and purposively teach for transfer, and students … thoughtfully learn for transfer.*" (Tuomi-Grohn and Engestrom, 2003 p21). But what did he mean by "teaching for transfer?" and how might the dental educator best promote student transformation from a pre-clinical being to a clinical one? This is one of the more important question for this study. Patient safety, student learning and confidence are all bound up in the ability of the student to effectively apply pre-clinical learning to early patient care.

SUMMARY OF CHAPTER TWO

In this chapter, I have explored theoretical aspects of purpose, learning, fidelity and transfer as they relate to the transfer from pre-clinical to clinical restorative dentistry. This exploration has raised a number of questions, some of which I can hope to answer within the confines of this study, others not. In the next chapter, I use this exploration and these questions to formulate research questions for the study.

CHAPTER THREE
FROM LITERATURE TO RESEARCH QUESTIONS

The primary aim of this study is to gain some understanding of the relationship between pre-clinical simulation and patient safety. This has involved an exploration of purpose, learning fidelity and transfer. Out of this have emerged a number of questions identified in this chapter.

The chapter also provides a summary of the main findings of the indicative literature review and follows the structure laid down in that chapter, of purpose, learning, fidelity and transfer. There is significant overlap between the domains, a relationship which itself gives rise to further questions. This overlap is apparent in several places during the following discussion.

THE PURPOSE OF SIMULATION

In the discussion of purpose for simulation, I noted that patient safety was its main driver but it also has other important features.

- Simulation simplifies pre-clinical activity and thereby reduces the cognitive load for the student. The corollary of this is that the student is less well prepared for the complexity of clinical activity. In view of the simplified picture that pre-clinical simulation provides, how well do students cope with beginning patient care?
- Simulation affects student confidence during the transfer to real activity. While measuring confidence levels is a very subjective activity, nevertheless, increased confidence levels are almost uniformly reported. Is that also apparent in this study?

- Simulation provides for standardised learning and assessment. This makes assessment easier, and provides the basis for viewing the pre-clinical course as a gateway to patient care. But standardisation may have negative consequences because clinical activity is not standardised. How do students view standardisation, and does it help or hinder their transfer to the clinical setting?

Does pre-clinical learning have any real effect on clinical skill? A question which has been asked elsewhere (Chambers, 1987, p238; Curtis et al., 2007, passim), and is repeated in this study is whether success in the pre-clinical course is mirrored in subsequent clinical activity? If it were, this would suggest that pre-clinical assessment has something valid to say about student ability and patient safety. If there is little correspondence between pre-clinical and clinical accomplishment, this must cast doubt on the use of pre-clinical assessment as a guarantor of patient safety.

Nevertheless, this does not fully answer the more complex question of how well the student is prepared for clinical activity. That requires an understanding of the links between skill development, fidelity, practice, confidence and transformation.

LEARNING AND ASSESSMENT

This section discussed both learning and assessment. The simulation literature on learning offers two main paradigms: the experiential one exemplified by the Kolb learning cycle, and the social/situated one usually exemplified in the literature by the "community of practice" concept. The situated paradigm appears to offer a more satisfactory explanation of pre-clinical learning, but viewing simulation through a situated learning lens requires us to confront the relationship between simulation and

reality and leads to questions about the authenticity of the simulation process. In it, questions about learning in simulation become inseparable from questions about fidelity and transfer. Discussion of implicit learning and motivation followed. Both have importance to the learning of restorative dentistry. Motivation is important to student learning, but the pre-clinical course, because it requires repetitive practice, can lack interest after a while. How engaging do students find the pre-clinical course?

As a result of this discussion, I adopted an apprenticeship stance to pre-clinical learning. Cognitive apprenticeship in particular appears to offer a combination of theoretical and practical learning. It provides a helpful explanation of how the student learns from observation and practice. It also describes a social component, and ascribes implicit learning to observation and mimicry, as much as to experiment (Chin et al., 2004, passim).

The validity of pre-clinical assessment is critical to patient safety. The limited correlation between pre-clinical and clinical performance noted by both Chambers (1987 ibid) and Curtis et al. (2007 ibid) mentioned above is concerning. But how valid a predictor of patient safety is pre-clinical assessment? Or is informal judgement by the pre-clinical teacher a more valid way of assessing the student, as Chambers later suggested (1997, p738)?

FIDELITY

During the discussion on fidelity I noted that the relationship between skill development and fidelity is ambiguous. Central to the transition between pre-clinical and clinical activity is the simplified picture presented by the “phantom head” as

partial task trainer and the degree to which this contributes to student skill development and clinical confidence. Low physical and psychological fidelity may also have advantages in reducing cognitive load. However, does the partial task trainer provide an adequate preparation for the complexity of clinical activity? What skills are not taught that could be and what problems do students see arising from the fidelity of the "phantom head"?

The discussion touched on the complexity of the fidelity construct. In the view of study participants, would increasing physical fidelity improve the transition to clinical practice and what is their understanding of how this increased fidelity could be achieved?

A situated view of learning requires us to ask questions about the relationship between fidelity and authenticity. The literature on fidelity is extensive but that on authenticity less so. Nevertheless, both are underdefined concepts, and this makes clarifying their relationship difficult. In an attempt to improve the "authenticity" of the pre-clinical course Cardiff University School of Dentistry has recently adopted a blended learning approach to the BDS programme (blended learning has for many years formed part of the dental therapy programme). Students work in the clinical setting concurrently with the pre-clinical laboratory course, allowing them to practise on "phantom heads" in dental chairs, on each other, and eventually begin limited patient care. During the course they gain experience of dental teamworking and the clinical environment. This relatively recent development is being assessed as part of this study. Do students perceive the blended learning approach as offering

"authenticity"? Does it increase their clinical confidence, and are they better prepared for more extensive clinical activity when that begins?

TRANSFER

Classical understandings of transfer, the "identical elements" theory of Thorndike and Woodworth (1901; Thorndike 1913), and the "general principles" theory of Judd (1908 ibid), still resonate in current thinking. However, neither appears compatible with a situated understanding of learning. An alternative is to understand transfer as a transition which involves the student crossing boundaries, and as part of the individual's development of clinical wisdom. As far as transfer itself is concerned, the literature seems to indicate a generally retrospective nature, implying more significance to the clinical setting than the pre-clinical. What emerges from the boundary crossing metaphor is the concept of boundary objects that can help or hinder student transition. These include identification, coordination, reflection, and transformation. I suggest that some of the learning tools of cognitive apprenticeship could equally be viewed as boundary objects, including modelling, coaching, articulation and exploration.

So how important is pre-clinical learning once the student has transferred to clinical activity? Personal observation suggests that transformation of the student into a "clinical being" is not guided, but left very much to the individual student. Do students also recognise this and would they prefer this process to be more managed? If so, do they have any suggestions on how dental educators might "teach for transfer"?

RESEARCH QUESTIONS

The indicative literature review and its summary have raised a number of questions. The following have been selected to structure a discussion of the study findings in chapter six.

- What is the effect of standardisation on student learning?
- Does the pre-clinical course have a role in reducing student anxiety about beginning patient care?
- Does the study make any useful contribution to understanding pre-clinical learning?
- How well does pre-clinical simulation prepare the student for clinical activity?
- How engaging do students find the pre-clinical course?
- How does a managed transition affect student preparedness for clinical practice? Do students perceive the blended learning approach as offering "authenticity"?
- Is pre-clinical assessment a valid judgement of student clinical ability?
- What aspects of "phantom head" fidelity gave most concern?
- In the view of study participants, would increasing physical/psychological fidelity improve the transition to clinical practice? If so what is their understanding of how this increased fidelity would be achieved?
- Does transfer take place from the pre-clinical setting to the clinical one?
- What barriers exist between pre-clinical and clinical activity?
- Does the study suggest how dental educators might "teach for transfer"?

CHAPTER 4 – RESEARCH METHODOLOGY

INTRODUCTION

This case study of student transition from pre-clinical to clinical activity uses a variety of different types of data to address the research questions. These include a comparison of pre-clinical with clinical performance, a set of focus groups with staff and students, and the administration of a questionnaire. In its five sections, this chapter:

- examines the use of case study as an appropriate tool to answer the research questions;
- comments on qualitative research methods, and case study in particular, in dental research;
- discusses the rationale for using focus groups;
- discusses ethical issues raised by the study;
- details the data collection process;
- details the analysis of the data.

SECTION ONE – CASE STUDY AS AN APPROPRIATE TOOL FOR THIS STUDY

A study design must achieve three ends; it must attempt an answer to the research questions, it must do so reliably, and the research tools used must have face validity for the intended audience. In this section, I discuss the use of case as the most appropriate way to address the research questions in this study.

In the transition from pre-clinical to clinical dentistry there are multiple, inter-related factors affecting student performance. The aim of this study is to explore these factors and bring some understanding to the transition process. The choice of case study was inevitable for this research given the small numbers of participants but in fact there were several reasons for its choice.

- Case study can examine complex issues. It can undertake *"… in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, program or system in a 'real life' context"* (Simons, 2009, p21). It can do so in circumstances where the researcher has little control over the context or over the behaviour of subjects. As Yin (2009, p18) puts it, case study is the research method of choice *"when the boundaries between phenomenon and context are not clearly evident".* The transition from pre-clinical to clinical dentistry is complex and dynamic with changes to the Cardiff School of Dentistry pre-clinical course taking place during the lifetime of this study, and partly as a result of it.
- Case study can deal with complex data. Yin (2009) suggests that case study research is appropriate for complex investigation because of its *"unique… ability to deal with a full variety of evidence"* (p 11). Much of the data in this study is conversation, collected in focus groups but there is also evidence provided by student grades and a questionnaire. Case study design is well suited for managing this variety.

- Case study can be used where there are relatively few study participants. In this study, statistical methods are largely inappropriate.
- Case study can be used as an exploratory tool in poorly understood settings, because it excels at providing *"individual idiosyncratic understanding in settings where quantitative analysis is not the primary objective"* (Yin 2009, p11). The transition from pre-clinical to clinical dentistry has been a feature of dental programmes for decades, yet for a number of reasons it is understudied and poorly understood. The object of this study is to increase that understanding.

In spite of these advantages, case study has been much criticised for its lack of rigour, and its lack of generalisation, criticisms which have some justification. The need to make general statements appears to be a core motivator for research activity (King, Keohane and Verba 1994, p7), and as Falk and Guenther (2006, p1) note, qualitative research is often used inappropriately in this context. Case study needs to acknowledge such criticisms. Study design must be rigorous and any generalisation needs to be theoretically justifiable.

RIGOUR IN CASE STUDY

It must be admitted that validity and reliability are limited where case study is concerned. True reliability in an experimental sense is not possible because of the nature of narrative data collection. An alternative way of understanding case study reliability, therefore, is to triangulate its findings with other data, multiple cases and/or multiple studies by different researchers. A mixed methods approach, combining qualitative with quantitative data is also frequently recommended (Duffy, 1987 passim;

Risjord et al., 2002 p273) and conformity of findings across a range (of methods, cases and/or studies) is considered to increase the reliability of any one method, case or study. In this study, I have used both multiple cases, and multiple methods. Unfortunately studies in the area of learning in pre-clinical dentistry and its transfer to clinical activity are rare, so comparisons with other studies are limited.

Where a study contains multiple focus groups, predefined questions promote reliability. In most of the focus groups and interviews for this study, I used sets of interview questions to control the "focus" in the group. But there is a tension inherent in this approach – that the imposition of structure by the facilitator may affect the data collected. With this in mind, I tried to make that control as minimal as possible to maintain a balance between focus, and freedom of participant expression.

A structured approach to data analysis also promotes reliability. I have imposed the same structure – purpose, learning, fidelity and transfer – on the analysis process. Separate analysis of each interview (see section three below), allowing for quasi-independent cross-case comparison has been another way of promoting reliability.

Validity is equally important. Case study research has little face validity in the dental field, as I will discuss below. There are good reasons for this. A potential difficulty with validity in case study is researcher bias (Roberts and Priest, 2006, p44). This can result in selectivity, perhaps unconscious, in the collection and interpretation of data. My use of pre-existing categories (purpose, learning, fidelity and transfer) poses this danger. Compounding it is a lack of independent verification of the coding categories that I used in my analysis of focus group data. This was inevitable since the study is part of a degree qualification, but it means I need to consider the validity of my analyses very carefully.

One way of doing this is to look hard at the data for any participant comments that do not fit into the four predefined categories. The results of this and its implication for understanding pre-clinical dentistry will be discussed in the next chapter.

GENERALISATION FROM CASE STUDY

The most common foundation for generalisation from research is a statistical one, involving inferences from representative samples collected randomly from a study population. This is the process typically used in quantitative research. But case study, with small, non-random groups of participants, can make little claim to statistical generalisation. A "common sense" approach is to focus on rigour. As I noted above, reliability and validity of the study can be promoted by using careful study design and multiple cases.

Mayring (2007, Section 3) identifies two theoretical groundings for a criticism of generalisation from qualitative research, a contextual one and a "Popperian" one. The argument in the first of these is that all knowledge is time and context specific. The "Popperian" argument is that complete inductive proof is a logical impossibility. Responding to the first of these arguments is straightforward; if the contextual nature of knowledge is absolute, there would be little point in using simulation in student learning. The second argument has some logical validity in that only inductive **dis**proof is possible, a process of searching for exceptions to a postulate. But human activity is never absolute and exceptions will always be found. These need not affect the validity of a generally applicable pattern. Mayring himself (2007 ibid) argues for a middle position which he calls "moderatum generalisation", a process of generalisation with caution, in

which *"We have to specify what sorts of arguments or inferences are aimed at with generalization and what procedures of generalization are used."*

There is extensive argument in the social sciences literature, for generalisation on analytical grounds (Hammersley et al., 2000 p104; Evers and Wu, 2006 p515; Yin, 2009 p38). With the possible exception of grounded theory methods, generalisation takes place in relation to, and is validated by the underlying theoretical framework. Findings are generalisable according to the degree of support they provide to the original propositions. However, as Evers (2006, p516) points out, this means that "generalisations may be only as warranted as the background theory". Using generalisation to support underlying theory and, at the same time, using underlying theory to support generalisation, results in a circular argument. Because this tendency is common, analytical generalisation is a weak tool, and must be used carefully. It does have one significant advantage: because there is no attempt to assert statistical representation, case numbers become less important, permitting research methods that would not otherwise be possible. Nevertheless, multiple case studies are still useful in the sense of enhancing *"analytical generalisation through replication"* (Crosthwaite et al., 1997 p204).

SECTION TWO – QUALITATIVE RESEARCH IN DENTISTRY

Qualitative research and qualitative case study in particular are not a popular among dental researchers. As this study is particularly addressed to dental educators, this section defends the methods used.

Case reports are familiar to all dentists as short clinical papers whose purpose is to share the features or management of an unusual clinical case with colleagues. The emphasis on evidence-based healthcare, however, has diminished the number of such case reports in the literature because they are deprecated for their quality of clinical evidence (GRADE Working Group, 2004; CEBM, 2013). By association, this disdain extends to qualitative research in general and narrative research in particular. Yin (2003, p15) suggests several components: a perceived lack of rigour in case study methods, a concern that they "*provide little basis for scientific generalisation*", and a tendency for case reports to consist simply of narrative, meaningful to the author, but uninteresting to readers.

This bias has had significant effect on the study of dentistry. While dental research has historically been based in a positivist paradigm, the practice of dentistry, at individual and population level, is as much social as technical. Historically there has been a tendency to study these social interactions using positivist tools, partly because these are familiar to the researchers and partly because of the disdain for qualitative research. This is nicely summed up by Mechanic (1995, p1492). Although he is referring to healthcare research in general, his comments are very applicable to dentistry: *"… while much of the challenge in healthcare is social … the emphasis of the health enterprise and the supporting research has been substantially technologic and reductionist, treating these complex sociomedical problems as technical fixes."*

Analytical generalisation, and its limitations, has already been discussed. I suggest that the application of statistical generalisation to social sciences can be equally flawed. Human health is a complex subject, dependent on the environment, the host immune

system, lifestyle, psychology, and other uncontrolled variables. As Johnson (1999, p68) notes: *"All too frequently, the methods of the physical sciences are applied to … concepts which are ill-defined and probably too complex for such statistical generalizations to hold good."* The use of "moderatum generalisation" from quantitative research may stem from recognition of this complexity. Whatever the cause, in practice healthcare decisions are commonly made on the basis of consensus derived by generalisation through replication. This process is standard irrespective of the nature of underlying research methodology.

As Schon (1983, p60) has noted, there is a need, in healthcare research (and I might add, in dentistry in particular) to develop *"an epistemology of practice which places technical problem solving within a broader context of reflective enquiry"*. This has already happened in other healthcare domains, where case study has become an accepted research tool and there are signs that such a change is slowly happening in dentistry, for example (Gift, 1996 passim; Bower and Scambler, 2007 passim; Stewart et al., 2008 passim). The present study is set within that changing context.

SECTION THREE – THE USE OF FOCUS GROUPS IN THE STUDY

The most significant data collection in this study, in terms of volume, was a series of focus groups. This section discusses the focus group as a data collection tool.

The focus group is particularly useful in healthcare studies because it can explore "*complexity, nuance and contradiction*" (Kamberelis and Dimitriadis, 2013 p51). It has been suggested that focus group methods are ideal for exploratory research and this is the principal reason for their use in this study. Data collection through focus groups is

based "… *on the premise that meanings are constructed in interaction with others, in specific social contexts.*" (Wilkinson et al., 2004, p48) Because sharing between individuals is critical to the method, focus groups must provide participants with a non-threatening environment in which they feel able to contribute (Onwuegbuzie et al., 2009, p14). Group size and cohesiveness are critical to successful focus group research. This study was designed so that each group was composed of small groups of students who already knew each other and were used to interacting in other settings. While there were dominant individuals in most of the focus group sessions, group cohesiveness was such that their presence was not a significant factor. Due to the informal nature of the groups, I was able to draw in the quieter voices without difficulty. Because of the group interactivity many of the ideas which surfaced did so with little input from myself (Kreuger and Casey, 2002 p24).

Focus groups can have disadvantages. One is the inability to access more personal information of relevance, because sharing of such information can be difficult, even in an informal group setting. Another is the nature of the group's relationship with the interviewer/facilitator. This individual must strike a balance between control and permission. He/she needs to direct the path of discussion, but allow participants the freedom to express themselves. My relationship with all groups as both researcher and teacher has advantages and disadvantages. At some point I taught every student on all focus groups and my role as their teacher probably played a large part in gaining the cooperation that I had from all participants. On the other hand, some aspects of that relationship have biased the conversation. One possible cause is the authority of the teacher inhibiting overt criticism. Another is through my use of prior knowledge. The

questions I asked controlled the direction of each focus group. These questions were influenced by prior observation and theorising as reported in chapters one and two.

As noted above, unreliability is an accusation that can be made of much qualitative research, sometimes with justification. In a certain sense unreliability is inherent in focus group research because it is impossible to hold the same interview twice. The presence of the interviewer also imposes a bias on group interaction, so that findings are not easily replicable by other researchers. In spite of these defects, focus groups offer a useful tool for gaining understanding of issues that could not be explored in any other way. They contribute to understanding of individual situations, while analytical generalisation through replication applies equally to focus group data as to any other qualitative techniques.

SECTION FOUR – ETHICAL CONSIDERATIONS

The most significant ethical issue raised by the study was the relationship between myself and study participants. All were students on the BDS and BSc programmes, or their teachers within the school. In parallel with my role of researcher, I was also a teacher to all the student participants. As a researcher, I was also asking questions of my colleagues whose comments and answers, if made public, had the potential to cause embarrassment.

ETHICS COMMITTEE APPROVALS

Ethical considerations varied for the different components of the data collection (see below), but general guidelines applied throughout: no individuals were identified, quantitative data were only used in aggregated form and qualitative discourse data

were anonymised during transcription. All participants were assured of anonymity, and students were reassured that whatever comments were made, these would not be reflected in their academic progress.

Ethical approval for the original study was sought from (and granted by) Birmingham School of Education research ethics committee (REC) and separately from Cardiff School of Dentistry REC. It was granted directly by Cardiff School of Dentistry REC. It was granted by Birmingham School of Education REC on condition that I distance myself from the recruitment process by asking the pre-clinical course director to make the initial approach to student groups concerned I was also asked to separate the recruitment briefing from the process of taking consent. I have complied with these requirements, with exceptions as noted below.

Data collection had several components. These were:

- collection of student pre-clinical and clinical performance data for comparison;
- a series of focus groups with staff and students and
- administration of a questionnaire to evaluate a blended approach to student transition from pre-clinical to clinical activity.

Specific ethical considerations relating to each component are detailed below.

PRE-CLINICAL AND CLINICAL PERFORMANCE DATA

There was no need, for the purposes of this section of the study, to collect individually identifiable information. I was provided with anonymised paired data sets by the school academic office.

Focus groups required direct and open interaction with students, most of whom I also encounter in settings where I am the teacher. This has many advantages; indeed it is the reason why this study is taking place. But it renders the participants a vulnerable group, and provides me, to some degree, with a power to coerce. I can understand potential student concerns about participation, the most obvious being that refusal to participate might affect progression. These ethical concerns were discussed frankly with each of the student groups as part of the recruitment process for focus groups. Potential participants were assured of independence and anonymity in the study and any data collected. In fact the concern appeared to be mostly on my side. Therapy students in both groups appeared quite happy to participate, volunteering unanimously even before I had completed the recruitment briefing. This happened for both academic years involved in the study, with the result that I could not comply in this case with the request to separate the student briefing from the process of taking consent. BDS groups similarly seemed unconcerned about independence and anonymity, happy to accept my assurance about both. I have a slightly greater psychological distance from BDS students because of the numbers involved, so that it was easier to separate briefing from consent. During the briefing, I asked those willing to volunteer to contact me by email. While the requirement that students contact me generated relatively few volunteers, it did ensure genuine consent.

The study also involved collecting data from teachers. This group are also potentially vulnerable if identified as individuals. But they are more accustomed to the research

process and those I approached were happy to accept my assurances of anonymity, and to give their consent.

In all cases individual written consent was obtained using a standard school REC consent form.

Questionnaire

The questionnaire was a component of programme evaluation, requested by the school. As such it did not require ethical approval. However, ethical approval was sought from the school ethics committee for the specific purpose of using the data generated as part of this study. In the same way students were made aware of and consented to this use of the data. The front page of the questionnaire included an information sheet and a standard school REC consent form, which participants were asked to sign before continuing with the questionnaire. During data entry this front sheet was removed and saved separately as a record of consent. From this point onwards the data themselves were anonymous.

The study involved a number of data sets and a mix of qualitative and semi-quantitative methods[3]:

- Pre-existing student assessment data, from the pre-clinical course and the first year of the clinical course. Assessment grades were compared to test the assertion that pre-clinical performance is a poor predictor of clinical ability. As I noted above, this comparison has been undertaken previously by Chambers (1987, passim) and by Curtis et al. (2007, passim). Both studies identify a lack of correlation. The exercise was repeated here to confirm (or otherwise) the findings, and make some preliminary comment on the reliability of pre-clinical assessment.
- A series of twelve focus groups with student volunteers from BDS and Therapy programmes, over two academic years (Cases BDS 1, BDS 2, DipDT and BSc in fig. 1 below and in table 1). Each participant took part in one focus group at the end of the pre-clinical course and two during the first clinical year. This was done in order to understand the transition process from the student perspective.
- A series of five interviews with staff involved in clinical teaching, pre-clinical teaching, or both. This was done in order to understand the transition process from the staff perspective.

[3] The term semi-quantitative has been used to indicate some degree of quantitative manipulation of ordinal data. In particular this relates to student pre-clinical and clinical grades.

- Finally, to understand the effects of a blended learning transition course, a complete cohort of 77 BDS students were asked to complete an evaluation of this course by questionnaire.

The timing of these various components is indicated in figure 1.

Figure 1. Data Collection Timeline

A COMPARISON OF PRE-CLINICAL AND CLINICAL PERFORMANCE.

Student pre-clinical and clinical performance is routinely recorded for all students of dentistry. I was given access to data, in anonymised form, for one academic year of 79 BDS students. Because pre-clinical teaching for BSc students is very different, and because group sizes are small, they were not included in this comparison.

Pre-clinical data came in the form of two grades for each student. For each of two practical assessments, the student was graded between Good / Pass / Pass (borderline) / Fail. I was also given clinical data provided by the SALUD© clinical management programme for 75 of these same students. These data come in the form of four grades: Above average / Average for the student's stage in the course / Some cause for concern / Significant cause for concern.

Comparison of pre-clinical and clinical performance has some limitations. Pre-clinical grades only assess the student's ability to conform to an ideal standardised cavity and restoration. They do not assess other aspects of clinical activity.

SALUD© grading for BDS students covers three separate categories for each patient appointment: knowledge, clinical skill and professionalism. This reflects the commonly held construction of professional activity as having three distinct components: knowledge, skills and attitudes (Jarvis, 1983 pp38-39). In application, a clinical skill grade represents an amalgam of cavity cutting, restoration finishing, time management, patient management and other tacit components. Nevertheless, the clinical skill grade coincides most closely in intent with the pre-clinical grade. The intent of the knowledge grade is to assess transfer of academic knowledge to clinical activity, while the professionalism grade is intended to assess the student's attitude to patient care. The difficulty in assessing each component of clinical activity is acknowledged. There are a number of reasons for this difficulty. It is partly due to variation inherent in clinical activity and the impossibility of imposing simple assessment criteria onto this variation; it is also partly due to a difficulty in separating, and separately assessing, the different components.

In spite of these difficulties, this grading system is in routine use, and is the only possible avenue for comparing pre-clinical and clinical performance. Correlation was calculated separately between the pre-clinical grade and each component of the clinical grade. The results are displayed graphically in the next chapter.

Student participants for the focus groups were drawn from both the Dental Therapy and the Dentistry programmes. The focus groups ran over two consecutive academic years. The separation of each of these participant groups into different cases facilitated data analysis, and made longitudinal and cross-case comparisons possible. These comparisons provided useful insights into the transition process. The table below details the characteristics of each case:

Table 1 – Cases

Cases		Participant numbers
Case DipDT	Students undertaking a Diploma in Dental Therapy & Hygiene (DipDT) 2010 intake. This was the final intake for this qualification	7 at first focus group 6 subsequently, as one participant left the programme
Case BDS1	Students undertaking a Bachelor in Dental Surgery (BDS) 2009 intake	6 at each focus group
Case BSc	Students undertaking a BSc(Hons) in Dental Therapy & Hygiene 2011 intake (BSc). This was the first intake for this qualification, which replaced the DipDT at this time	6 at each focus group
Case BDS2	Students undertaking a Bachelor in Dental Surgery (BDS) programme 2010 intake	4 at each focus group

Sampling was not uniform over the 4 cases. Student intakes for the dental therapy programme are small in Cardiff University School of Dentistry. In cases DipDT and BSc the whole of the student intake volunteered to take part, so sampling strategies were not

a concern. BDS student intakes are much larger. Participants in cases BDS1 and BDS2 were self-selected, not random. Self-selection was an ethical requirement, but a possible source of bias.

The four cases differed from each other in ways that potentially affect the data:

- **Prior patient care experience.** In 2011 the undergraduate Diploma in Dental Therapy and Dental Hygiene was replaced by the BSc in Dental Therapy and Hygiene. Initially I expected this to make little difference to the study but, in fact, it changed some of the characteristics of the student intake. Students in case DipDT were all (except one) from a background of dental nursing. These individuals already have extensive experience of patient care. The move from a Diploma to a BSc attracted a different sort of candidate, and students in case BSc were all from an A-level background with no prior patient care experience. Likewise, students studying on the BDS programmes come almost exclusively from an A-level back ground. No participants in cases BDS1 or BDS2 had previous experience of patient care.
- **Early exposure to clinical activity.** The dental therapy programme gives students earlier exposure to clinical activity, in the form of dental hygiene care. By the time of the transition to restorative clinical activity, students in cases DipDT and BSc have had significantly more clinical experience than students in cases BDS1 or BDS2. Overall their ability to manage patient interactions is far superior to that of BDS students at the time of first restorative contact. During the course of the study the BDS programme also adopted an early patient contact strategy. This change took place in time for BDS2 but not BDS1.

- **Timing of transfer to clinical activity.** BDS1, BDS2 and BSc students undertake a year-long pre-clinical course ending in May/June. DipDT students undertook a much more intense pre-clinical course from January to April. This affects the transfer to clinical restorative activity. Cases BDS1, BDS2 and BSc began clinical activity during the following academic year, between September and November, a delay of up to 6 months after the end of the pre-clinical course. DipDT students, on the other hand, transferred to patient care immediately following the end of the pre-clinical course.

For each case, I undertook a series of three focus group sessions. The first of these took place during the pre-clinical course, the second after approximately one term of restorative clinical activity, and the third at the end of one full year of restorative activity. Cases were interviewed separately; at no time did any two cases take part in a focus group together. This was to control group size and, thereby, encourage interactivity within the group. There is a general consensus (Kitzinger, 1995 p301) that the ideal group size for a focus group is between four and eight people. Joining two cases together would have increased the group size to the point at which participants might begin to withdraw from the process. A further reason is that joining cases together would create focus groups where not all the participants knew each other well, with effect on interactivity. As it was all participants in each focus group felt at ease with people they knew well.

Each focus group took place during a lunchtime. I provided lunch each time, partly as an incentive and partly as a reward to the students concerned for donating their time. Providing lunch also established a relaxed, non-threatening setting for the focus group.

The duration of the focus groups was typically 30–45 minutes in order to fit into the participants' lunch hour. The shortest was 28 minutes, the longest 53.

In each case, as previously noted, I used a question list to maintain focus. I did not adhere rigidly to it but allowed participants to explore relevant issues with as little intervention as possible. Focus groups were recorded, with permission for later analysis. Recording took place direct to a notebook PC using a USB microphone and a simple freeware audio recording programme called Streamosaur©. Video recording was not part of the focus group, partly because participants expressed concern about video recording, though they had no issues with audio recording. In fact, it was noticeable that relevant discussion continued, and more freely, after the end of the focus group, when the recording equipment had been switched off. Even the presence of audio recording affected participant response to some degree. Other factors in the decision to avoid video recording were that audio data are easier to anonymise through the transcription process and that it was difficult to manage video recording as well as run the focus group.

FIVE INTERVIEWS WITH SIX STAFF MEMBERS

The staff view provides a different insight into the student transition. I undertook four one-to-one interviews, and one interview which involved two staff members. This was suggested by the individuals concerned for reasons of time. Sampling was purposeful with individuals selected to capture the views of both pre-clinical and clinical teachers; of the six individuals interviewed, four teach in both settings, one in the pre-clinical setting only and one in the clinical setting only. Staff interviews were directed by the same themes of purpose, learning, fidelity and transfer. As with student focus groups, I

used a question list to maintain focus, yet allowed participants to freely discuss relevant issues. However, these were one-to-one interviews. Although I was able to have in depth discussions with all staff participants, because I have known them all for a long time, interviews were not interactive in the way that student focus groups were.

Both staff interviews and student focus groups were transcribed using F4 transcription software by an individual who has not met any of the participants, in order to preserve anonymity. During transcription all participant names were removed from the text; the only remaining link to individuals being the original audio recording.

AN EVALUATION OF A BLENDED TRANSITION

The school has long recognised the difficulties encountered by students in transition from pre-clinical to clinical activity. During the lifetime of this study the school began a new approach to managing transition. This change applied to BDS students only, because the dental therapy programme has long employed a blended learning transition between these two phases. During the course of the academic year 2012/13, I was asked by Cardiff University School of Dentistry to evaluate this new approach, referred to within the school as P4P. The request also contributed to this study by offering me the opportunity to ask whether such overt management of the student transition has contributed to skill transfer and student transformation.

The evaluation involved one cohort of 77 Year2 BDS students, from a subsequent academic year, so that no participant had taken part in any of the focus groups related to the study. In the P4P course students continue with the standard pre-clinical course, but only for half of the timetabled sessions. The remainder of the

course consists of practical sessions in a clinical setting. The intention is to make the student experience as authentic as possible. Instead of patients, the student experience begins with “phantom heads” placed onto dental chairs. This is followed by some clinical procedures carried out on colleagues, though, for obvious ethical reasons, the extent of experience is limited.

After spending 1 term in this routine, students then begin patient care, though this is limited to reversible procedures such as dental examination and charting, treatment planning, the giving of oral hygiene instruction and scaling teeth. Only towards the end of the academic year, once relevant competence assessments have been passed in the “phantom head” laboratory, were students allowed to undertake closely supervised irreversible restorative procedures.

In order to get input from the whole student cohort the evaluation was undertaken using a questionnaire. While questionnaires have limitations in a quest for understanding, they are a useful method of surveying a larger group of participants. In order to focus questioning appropriately, the questionnaire was developed partly with the help of four students from the cohort, who were asked to suggest the sort of questions that should appear in the questionnaire. This contribution did not completely define the agenda for the questionnaire, because I had already formulated questions of my own, but it nevertheless provided useful input. The questionnaire was also piloted with staff involved in the teaching of P4P, which resulted in further modification.

The final version of the questionnaire had three sections:

- A section on the student's practical experience prior to beginning patient care. This explored the extent of student experience during this time using three word summary type questions to elucidate student feelings about practice on "phantom heads" and on colleagues. For the purposes of course evaluation it also included an open question asking students how they might like to see such sessions run in the future.
- A second section evaluated student learning during clinical activity. It explored the extent of student clinical experience, for comparison with simulated experience. It asked for features of the clinical session that the student felt were important to learning, and also included an open question on the relationship between simulated practical experience and patient care.
- The purpose of the final section was to evaluate transition. It attempted to distinguish between understanding and performance of clinical procedures using a pair of attitude scales. It also asked for a student self-assessment of confidence at first patient contact, also using an attitude scale and a three word summary question. Finally it asked the student to indicate the importance of various support components to their confidence during the same period.

A copy of the final version is found in appendix 2. On receipt of ethical approval from the school REC, the questionnaire was presented to all 77 students in one academic year over a period of one week.

SECTION SIX – DATA ANALYSIS

This section details the processes undertaken to analyse the data gained from these four different collections.

A COMPARISON OF PRE-CLINICAL AND CLINICAL PERFORMANCE

There are a number of reliability and validity concerns with making this type of evaluation, which affect the data, in particular comments made by student participants in the focus groups relating to the unreliability of preclinical assessment. This is not a new finding; in both the preclinical and clinical settings issues with reliability are well documented. But as I noted in chapter two, the validity of preclinical assessment is also an issue because the "Phantom Head" is only a partial task trainer.

Obviously reliability in both preclinical and clinical assessment is critical to comparing student performance in the two settings. Because of this, analysis of the assessment data also included an evaluation of reliability. It took the form of correlation between the two preclinical gateway assessments in the relevant academic year; this was used as a measure of reliability of the preclinical assessment process. Reliability of clinical assessment was more difficult to establish within the bounds of this study, however there are known to be issues from study of the collected assessment data within Cardiff University School of Dentistry. These relate both to the reliability and validity of clinical assessment grades; clinical assessment involves a number of different assessors over a long period of time, and a simple grading system cannot adequately capture student performance in complex clinical activity.

The second step was to aggregate both preclinical gateway assessment grades into a single score, and all student clinical grades for the academic year into a separate single score. It was then possible to look for correlation between them. The correlation was taken (with some reservations) as an assessment of the predictive value of pre-clinical assessment in clinical activity.

FOCUS GROUPS

Analysis of staff and student focus groups began with transcription of audio recordings. These transcriptions were analysed thematically, using NVivo8© software. Content and thematic analyses are standard treatments for discourse data (Joffe and Yardley, 2004 p56). Content analysis refers to a wide range of different techniques for textual analysis *"ranging from impressionistic, intuitive, interpretive analyses to systematic, strict textual analyses"* (Hsieh and Shannon, 2005 p1277). The terms content and thematic are often used interchangeably, though strictly thematic analysis represents one member of this family of techniques. Gibson and Brown (2009 p128) suggest that thematic analysis has three aims: to examine commonality, difference and relationship.

The use of thematic analysis in this study needs some discussion relating to issues of fragmentation and datum size and reliability of coding. Criticisms of thematic analysis centre round fragmentation of data, suggesting that to take data out of context is to lose some of their meaning (Hollway and Jefferson, 2000 p68). The process is defensible only because it allows each datum to be seen in the context of other data in the transcript which deal with the same issue. The ability to contextualise is, of course, dependent on how the data are coded and on the analyst's interpretation. It is also dependent on the size of the individual datum. Thematic analysis will more naturally use sentences, ideas

or paragraphs as units of analysis, thus bringing meaning with it from its original context. *"… you need to include a sufficient length of passage for the coded segment to make sense*" when recontextualised (Bazeley, 2007 p89). Except where spoken sentences are incomplete, this analysis uses the sentence as its smallest datum and tries to use larger fragments where possible. It is common practice to improve coding reliability by using two or more calibrated coders. Nevertheless, in this study all coding was carried out by one coder, an inevitable limitation of doctoral research.

Coding of each interview or focus group began with an initial reading of the transcript to see it in its entirety and grasp the general structure. Each interview was then analysed independently, identifying common themes. NVivo8© software was used for this analysis. Rather than directly identify patterns across transcripts, each transcript was initially coded to a set of unique free nodes within the project database. The purpose of this was to maintain data independence between transcripts as much as possible at this initial stage. Only during a second pass analysis were each set of free nodes aggregated with a developing network of themes stored as tree nodes within NVivo8. The set of tree nodes had their roots in the literature review; I began with nodes labelled "purpose", "learning", "fidelity" and "transformation". In recognition of the number of references to motivation and frustration, a separate category of "student factors" was added. I found that analysis did not actually stop at this point. During the writing up of the results relationships between different sub-themes continued to suggest themselves. For this reason the next chapter is entitled "results and preliminary comment".

Questionnaire data were transferred to an EXCEL© spreadsheet for analysis. A number of different processes were involved in the analysis:

- Data which involved numbers of procedures, or their ranking by importance, were simply analysed by graphing.
- Section three of the questionnaire included three attitude scales. Measurements on these scales were analysed by calculating means and standard deviations.
- Parts one and three contained three word response type questions. These responses were imported into NVivo8©, in order to develop word frequency counts.
- Parts one and two had open questions, inviting free text comments. These were also imported into NVivo8© for content analysis.

SUMMARY OF CHAPTER FOUR

This chapter identifies the research methods used to address the research questions. Taken as a whole this is a case study, a strategy used because the study is trying to understand a complex transition using data gathered from a relatively small number of individuals in a setting which itself is evolving. Case study has both strengths and weaknesses, some of which I have briefly addressed above.

The study examines the pre-clinical and clinical settings and transition between them using a variety of different data types. The use of multiple data sources provides some triangulation, reinforcing the validity of the findings. Because the transition is a complex,

culturally dependent activity, generalisation to other cases of transition from pre-clinical dentistry can only be justified through replication.

The chapter details the different data collections, representing a mix of cardinal, ordinal and textual data. Its final section details how each of the data collections was analysed. The next chapter reports the results of those analyses and makes some preliminary observations.

CHAPTER 5 – RESULTS AND INITIAL COMMENTS

This chapter reports the results of the four different data sets identified in chapter four, i.e. student pre-clinical and clinical performance, student focus groups, staff interviews and questionnaire. For convenience and clarity of reporting, the results for each data set are reported separately. As I noted in chapter four, during reporting, and partly as an outcome of it, relationships between themes continued to emerge. In order to remain faithful to the dynamics of data analysis, these are noted as the text proceeds, so that this chapter contains both results and some initial interpretation.

While the framework of purpose, learning, fidelity and transition is used to report some of the results, particularly those from the focus groups, the overall structure of the chapter is defined by the four data sets.

SECTION ONE – PRE-CLINICAL AND CLINICAL PERFORMANCE

This section compares pre-clinical and clinical performance of one academic year of BDS students using existing pre-clinical and clinical assessments. Evidence of correlation would support the idea of a predictive value for pre-clinical assessment in clinical performance, knowledge and/or professionalism.

A COMPARISON OF PRE-CLINICAL AND CLINICAL PERFORMANCE

Assessing correlation between two preclinical gateway assessments

As mentioned in chapter 4 the first component of the comparison was to test for correlation between two separate preclinical gateway assessments. Preclinical assessment in Cardiff School of Dentistry has only four grades, because it is thought that

a simple grading system aids marker reliability. The grades available are good/satisfactory/borderline/fail. To carry out the correlation, these were converted to ordinal equivalents 1, 2, 3, and 4. Correlation was assessed using both Spearman's rho and Kendall tau-b. Both are appropriate tests for correlation of ordinal data. Both were used here because they give slightly differing results when tied ranks are present, as is the case in both these data series. Results for both tests are shown in table 2 below:

Table 2 Correlation between 2 preclinical gateway assessments

Statistical tests			Assessment 1	Assessment 2
Kendall's tau b	Assessment 1	Correlation Coefficient	1.000	**.133**
		Sig. (2-tailed)	.	**.174**
		N	79	79
	Assessment 2	Correlation Coefficient	.133	1.000
		Sig. (2-tailed)	.174	.
		N	79	79
Spearman's rho	Assessment 1	Correlation Coefficient	1.000	**.149**
		Sig. (2-tailed)	.	**.191**
		N	79	79
	Assessment 2	Correlation Coefficient	.149	1.000
		Sig. (2-tailed)	.191	.
		N	79	79

As is usually the case, the correlation coefficient for Spearman rho proved to be slightly higher than that for Kendall's tau-b. However, both tests indicate a low probability of relationship between the two assessments, with correlation coefficients of 0.133 (Kendall tau-b) and 0.149 (Spearman rho). For both tests the calculated p values are above 0.05. These low values may be interpreted in a number of ways; for example student improvement over time, or struggling students experiencing difficulty with the more complex assessment. A more likely cause is low assessor reliability. Inter- and intra-

assessor reliability has been noted as an issue in pre-clinical dentistry by other authors (Vann et al., 1983 passim) (Jenkins et al., 1998 p679). It does suggest though, that pre-clinical grades need to be used with caution, whether as a gateway to clinical activity, as a predictor of student performance and as a basis for mathematical comparison with clinical performance measures.

Assessing correlation between preclinical and clinical grading

The second statistical operation was a calculation of correlation between preclinical and clinical assessment marks. Because each student in this cohort had two preclinical assessment scores and multiple clinical gradings, some preparation of the data was required in order to make comparisons.

For the preclinical score the two preclinical assessments were added. This gave a range of results between 2 and 8 (with 2 being the highest in terms of student performance), with both median and mode values of 4.

Reduction of clinical grades to a single performance figure was more complex. A major difficulty was ensuring that this single figure retained an adequate representation of student performance.

Firstly, as mentioned in chapter four, clinical activity is considered (at least in Cardiff University School of Dentistry) to have three components: performance, knowledge and professionalism. These are not easily combined, so the student's aggregated pre-clinical grade was compared against each category separately.

There are a number of different options available for determining a clinical mark for the student. The first was to calculate individual student clinical activity using the formula

x=(n/A) where n= the number of assessments for the student and A= the average number of assessments for the student group as a whole. However, this only indicates the amount of work done. To inject some understanding of student performance into this correlation, grades were treated as below:

- *Grade 1 (work at a standard above that expected from the student) was multiplied by 3*
- *Grade 2 (work at the standard expected) was multiplied by 2*
- *Grade 3 (standard of work not that expected) was used without change*
- *Grade 4 (standard of work causing serious concern) was multiplied by 0, effectively removing grade 4's from the student performance mark*

Grades could then be summed to provide a final weighted performance mark **w** for each student, in each of three categories. There is still an issue with how the calculation may best reflect student performance, and two different methods were chosen for this study.

The first was to calculate the average performance for each student at each assessment using the formula x=**w/n**, where **w** = the weighted performance mark for the student and **n**= the number of assessments for the student.

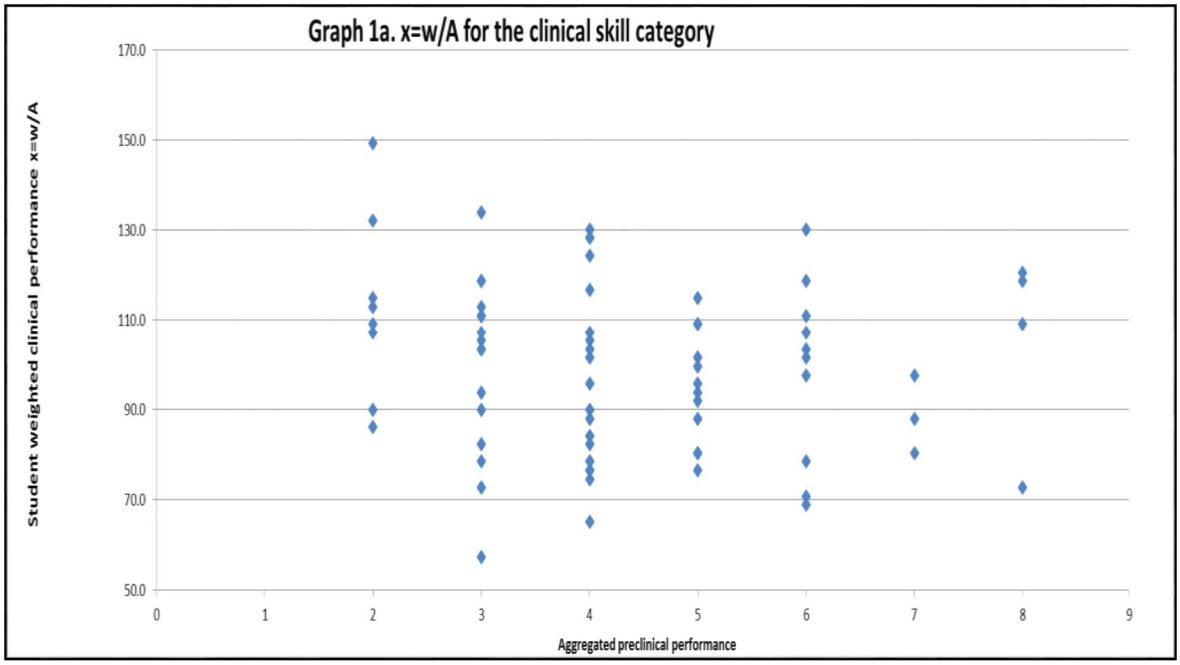
The second was to calculate the performance of each student in relation to the class average using the formula x= **w/A**. In this case **w** represented the weighted performance mark as before and **A** was the average weighted performance mark for the student group as a whole.

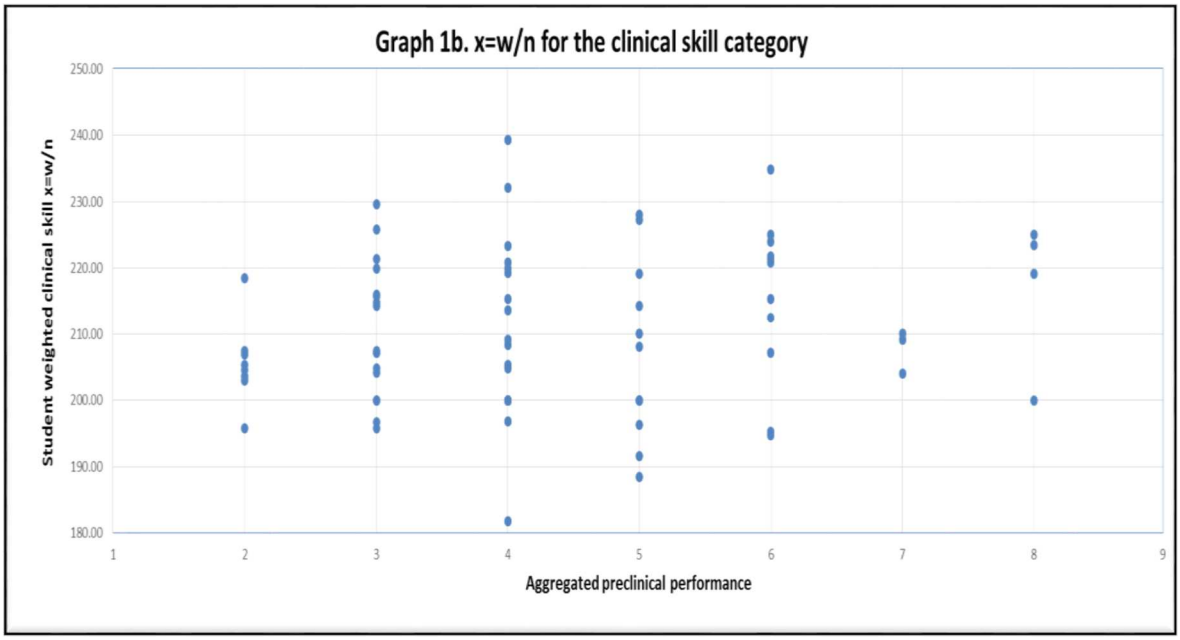
Both calculations were undertaken for each of the three clinical performance categories: clinical skill, clinical knowledge and professionalism. Correlation was assessed using both Spearman's rho and Kendall tau b as before, and the results shown in tables 3a and 3b below.

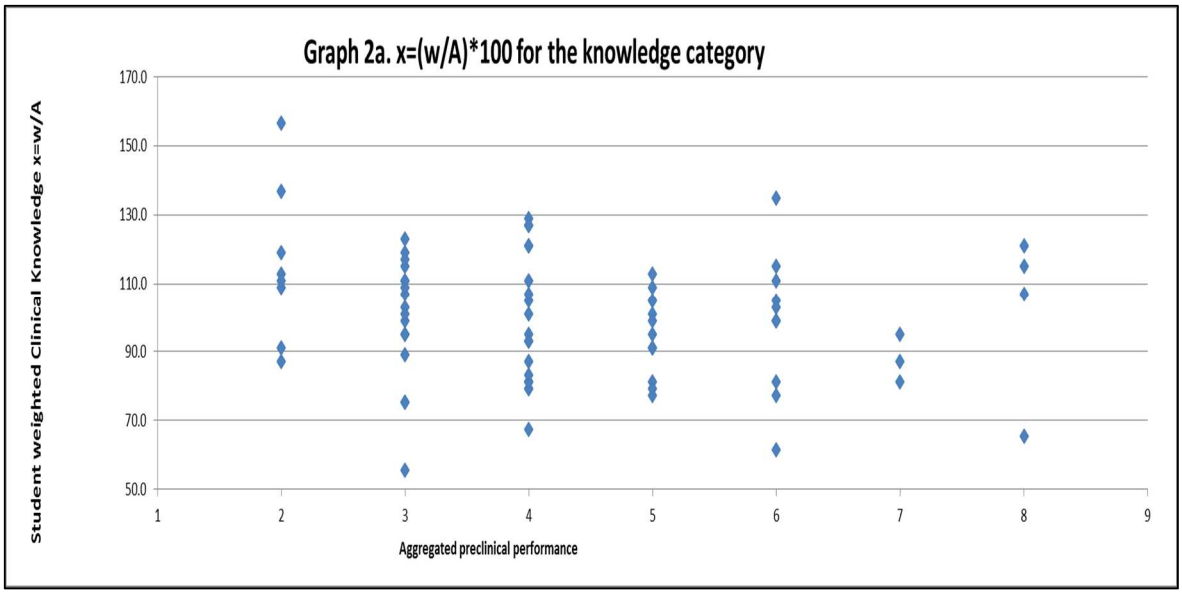
Table 3a. Correlation between aggregated preclinical scores and clinical performance (calculated as x=w/n)		
Category	**Spearman rho correlation coefficient**	**Kendall tau b correlation coefficient**
Clinical skill	-0.162 (Sig 0.165)	0.144 (Sig 0.185)
Clinical knowledge	-0.077 (Sig 0.509)	-0.66 (Sig 0.453)
Clinical professionalism	-0.035 (Sig 0.765)	-0.026 (Sig 0.761)

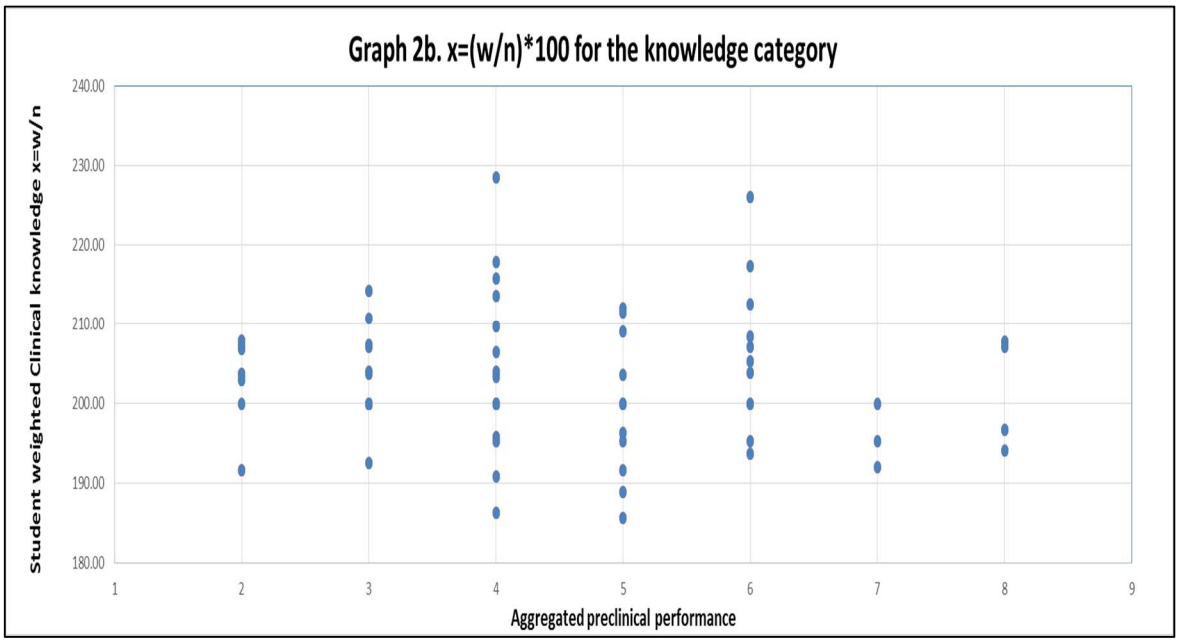
Table 3b. Correlation between aggregated preclinical scores and clinical performance (calculated as x=w/A)		
Category	**Spearman Correlation coefficient**	**Kendall tau b correlation coefficient**
Clinical skill	-0.161 (Sig 0.167)	-0.116 (Sig 0.176)
Clinical knowledge	-0.188 (Sig 0.107)	-0.136 (Sig 0.114)
Clinical professionalism	-0.165 (Sig 0.158)	-0.120 (Sig 0.162)

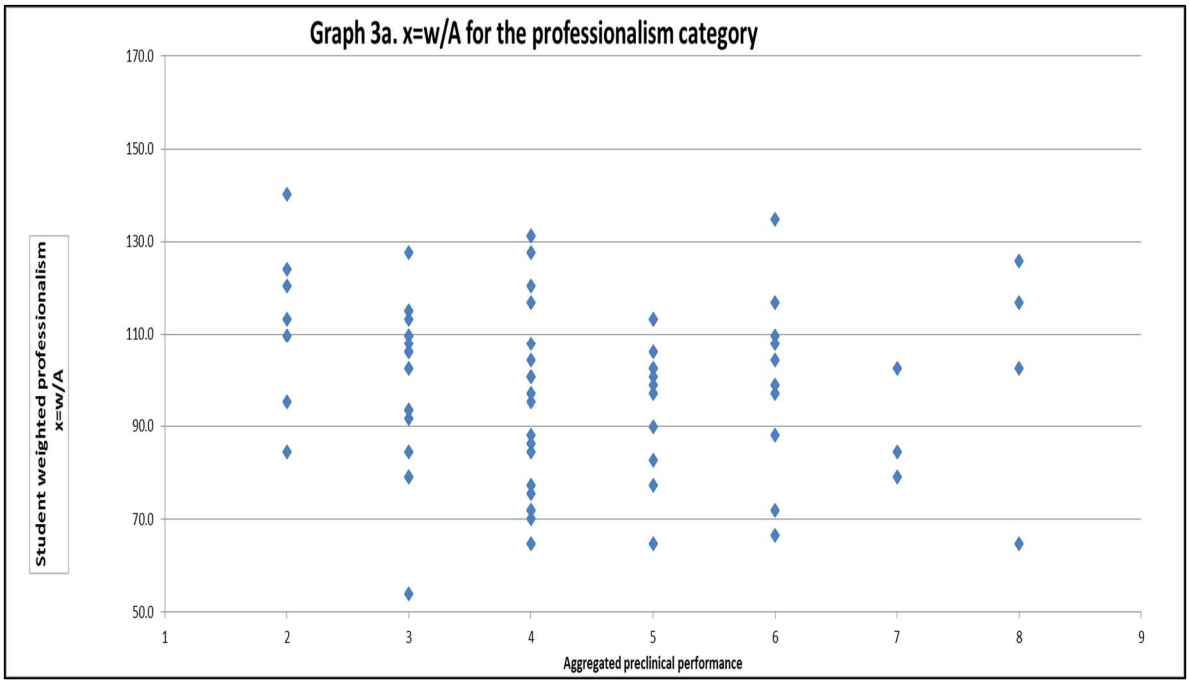
Results are also displayed graphically and those for both x=w/A and x=w/n are shown in the following series of scatter plots. For this purpose clinical scores were expressed as percentages:

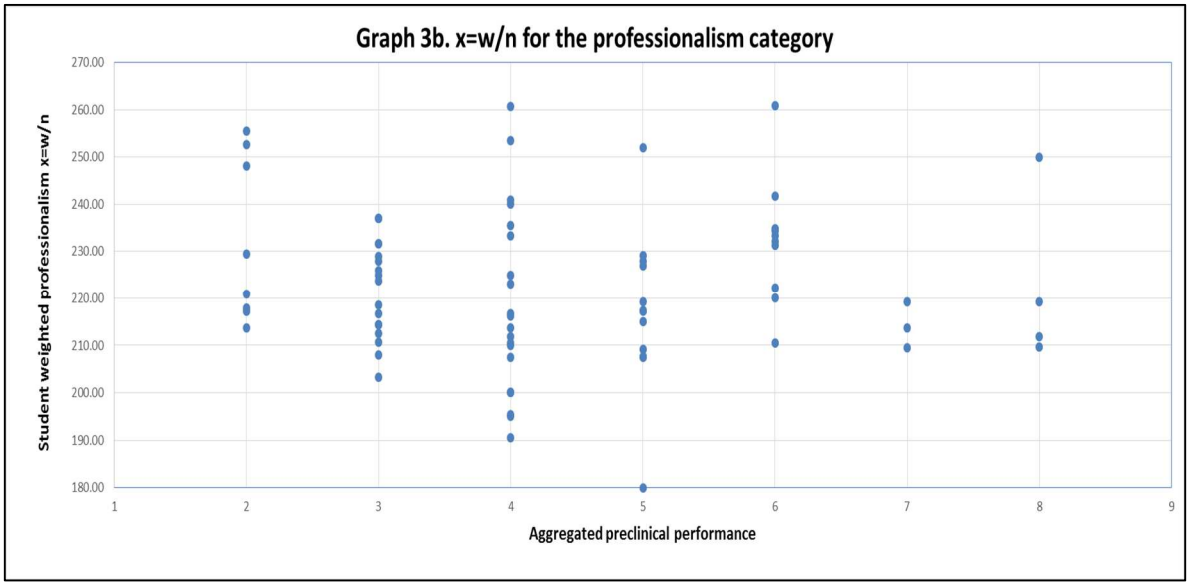





Graph 2a. x=(w/A)*100 for the knowledge category
Student weighted Clinical Knowledge x=w/A
170.0
150.0
130.0
110.0
90.0
70.0
50.0
1
2
3
4
5
6
7
8
9
Aggregated preclinical performance


Graph 2b. x=(w/n)*100 for the knowledge category
Student weighted Clinical knowledge x=w/n
240.00
230.00
220.00
210.00
200.00
190.00
180.00
1
2
3
4
5
6
7
8
9
Aggregated preclinical performance





The apparent negative correlation coefficient is, of course, because preclinical grades run inversely with 1 being the highest. Allowing for this, both Spearman rho and Kendall tau b identify very weak correlation between preclinical grades and clinical skill, knowledge and professionalism. In no case does significance approach the generally accepted 0.05 level. Examination of the scatter plots of the same data series (graphs 1a/b, 2a/b, 3a/b above) shows little visual evidence of correlation.

These conclusions must, of course, be tentative; the aggregated preclinical grades are based on only two assessments, whose reliability has been demonstrated to be poor; and aggregated clinical grading is documented as unreliable. Nevertheless, the data point to the same conclusions as those of other authors, and suggest that preclinical assessment performance should be carefully interpreted in the context of clinical activity.

SECTION TWO – STUDENT FOCUS GROUPS

This section details the findings of the series of student focus groups. There were twelve of these – three with each of the four cases. Their findings are reported under headings of purpose, learning, fidelity, transformation and student factors. Participants comments are identified in brackets by case (BDS1, BDS2, DipDT or BSc) and interview number (1,2 or 3. Each case took part in three interviews; the during the preclinical/managed transition stage, the second after a short time in clinical patient care, and the third after a full academic year of clinical patient care). The arrangement of cases is described in chapter four.

PURPOSE

Participants in the student focus groups had a great deal to say about the purpose of pre-clinical dentistry. The 85 references on the subject were further divided along lines suggested by the indicative literature review into those dealing with standardisation, safety, learning/skill development, confidence and gateway.

Participant comments on standardisation

Participant understanding of standardisation showed significant differences between BDS students (cases BDS1 and BDS2), and therapy students (cases DipDT and BSc). Discussion was related to teaching and assessment for BDS participants, and teaching and transfer for BSc participants.

The focus for BDS students was the lack of standardisation in teaching and assessment. Most comments from this group regarded standardisation as positive and non-standardised teaching as unhelpful. BDS students are taught by a range of teachers both in the pre-clinical and clinical settings, and comments reflected the confusion generated when students received different messages from different teachers, the worst case being students taught by two teachers who directly contradicted each other.

Therapy students are taught by only two pre-clinical teachers, and had no issues with regard to standardisation in teaching and assessment. All of their comments related to standardised cavity shapes and their negative transfer to clinical activity. A typical comment was *"But when you're on a patient, it's just not like that at all"* (BSc, 2). That understanding does not appear to have developed until late in the course. There were two comments attesting to the stress caused by this; for example *"I was thinking, I never want to do cons* [restorations] *on patients because how are we going to make those perfect shapes in people's mouths"* (BSc, 2).

Participant comments on safety

There were also significant differences in understanding of safety between BDS and Therapy groups. There were eleven references discussing the topic. For all participants safety meant patient safety; personal safety was not discussed. But for BDS groups, safety

was primarily linked to skill development and assessment, as shown in the comment *"They wanted to know that we were safe … that we could hold things, knew the instruments and that if we were seeing a patient, we were accountable …"* (BDS1, 2). There was only one comment recognising the concept of simulation as a safe environment in which to make mistakes: *"If you were just put straight onto a patient, you would struggle, probably hit all the teeth"* (BDS2, 2). This is in contrast to therapy groups, all of whose comments were focussed on this concept.

Participant comments on learning/skill development

Participants showed a general understanding of learning as a purpose of pre-clinical dentistry. There were 77 references on the subject. This number suggests the importance to participants. Most identified perceptual-motor skill development, using such terms as: *"basics", "mirror skills", "angulation", "manual dexterity", "tactile feel", "to get used to the tools", "hand positions", "sitting"* (referring to seating positions), *"the different burs", "practicing cavities", "to build a technique", "practise working in … a tiny environment", "position the patient"* (All cases represented). Such comments seem to indicate a role for pre-clinical simulation of manual skill development, so that *"when you're finally on clinic, you solidly concentrate on the patient and you're not thinking about the instruments and they all feel natural in your hands"* (BDS1, 2). One individual referred to a higher level of skill, commenting that the pre-clinical course allowed the operator *"to be able to use … memory to cut cavities"* (DipDT, 3). Unfortunately, I did not follow up on this comment at the time.

Some participants also recognised the academic learning they gained from the pre-clinical course. One suggested that it helped in the identification of dental caries, another

that it provided *"a plan of how to tackle restorations"* (BDS2, 3). Others talked about familiarisation with the different restorative materials in order to make decisions on how and when to use them.

Simulation literature identifies availability as a benefit of simulation, contrasting this with reality, where the availability of learning situations depends on many variables. One participant picked up on this, saying that on the *"phantom head you can get so much more experience because you can do like three teeth per day whereas in clinic you have to wait a couple of months or so"* (BDS1, 2).

Participant comments on assessment as a purpose of pre-clinical dentistry

Several participants recognised assessment as a purpose of the pre-clinical course. There were ten references in this context. Most related to the gateway role in identifying safe performance, though none attempted to do more than comment on the existence of this role. For example, one participant identified that *"…rather than just ensuring that you know how to do it, it is also a source of them knowing that we know how to do it"* (BDS1, 2). There was also recognition of the value of self-assessment in comments such as *"… for us to be aware of what our own particular areas are for practice"* (DipDT, 1).

There were a number of concerns raised regarding validity of the assessment process which are explored further in the section on learning.

Participant comments on confidence

Confidence is well-documented as an outcome of simulation. There were seven references by student participants. Most related to the performance of technical procedures in restorative dentistry, and most arose in response to the direct question

'could students have started directly on patient care, without a pre-clinical course'? The answer in all focus groups was no; the pre-clinical course was a necessary part of student preparation for clinical activity. As one individual expressed it, *"... although we're nervous now ... if we didn't have phantom head, it would be a nightmare"* (DipDT, 1). Additional details that amplify this answer were that the pre-clinical course reduced stress levels, and that positive feedback from the pre-clinical teachers is an important part of the confidence building process. An interesting counter-comment came from one individual. This person suggested that simulation can sometimes promote overconfidence: *"I think we were expecting too much of ourselves as well, I think we were expecting to have come out being able to do everything, to be an amazing operator"* (BSc, 2).

LEARNING

This theme grouped together 317 participant comments which related to learning. The comments covered a variety of topics including: teaching, coaching and demonstration, assessment, the role of practice, reflection, time pressure and motivation. Though some of the comments were primarily concerned with simulation fidelity, this was invariably in a context which linked physical fidelity with more effective learning, illustrating a degree of overlap common throughout the study.

Participant comments on pre-clinical and clinical teaching practices

Similar teaching practices happen in both pre-clinical and clinical student activity, and for all student groups. There were a large number of comments on this sub-theme, covering both pre-clinical and clinical teaching, as will be obvious from the content.

There were eight comments relating to dental nurses. Students do not work with dental nurses in the pre-clinical laboratory, so these comments related to clinical activity. Most came from students during the managed transition period, in which dental nurses appear to have a significant scaffolding role. For example *"Working with experienced nurses is helpful"* (BSc, 2), *"I had a qualified nurse just passing me everything and it was really different"* (DipDT, 1) and *"… the nurses were quite good on that one so they would just know what ones to get you"* (Case BDS2, 2). Students also valued dental nurse input on *"how to speak with the patient, how to comfort the patient"* (BDS2, 2), and *"how to explain things…"* (BDS2, 2).

Participants highlighted the extreme importance of the student/clinical teacher relationship. *"I think a lot depended on the supervisor we had because some of them expect a lot of you straight away, so the transition is very hard"* (BDS1, 2). As one commented, *"On phantom head if you didn't know or weren't too sure what to do … they would actually give you really good instructions or come over and show you exactly what you were doing wrong … but I've often gone on clinic and came out feeling terrible …* [You] *think you've done something well and … you just get shouted at … it really knocks your confidence"* (BDS1, 3).

It is the presence of the patient which sharply distinguishes the clinical setting from the pre-clinical. Because restorative dentistry means irreversible procedures on patients, an important component of the teacher role is one of reassurance and feedback (Fugill, 2005 p133). Whereas students in the pre-clinical setting have no difficulty asking for feedback, the clinical setting is different. Students need assistance and feedback in a way that does not damage their relationship with the patient. They do this by developing "*code such as 'I'm having a bit of difficulty up here' which is code word for you saying 'I have*

no idea what I am doing, this is going bad, I know it's going bad, so before it turns into drastically bad, come over and help me.'" (BDS1, 2). Whether clinical teachers understand and listen for this code is unclear, an issue considered in the discussion chapter.

Participants appeared accepting of their responsibility toward the patient. As one commented *"… if I don't understand something, I'd rather ask, especially if you've got a patient in front of you"* (BDS1, 3). But from their point of view, clinical teachers did not always respond appropriately to student requests for help. For example *"they might tell you to do something and you've never done it, and you don't want to say in front of the patient that you've never done it, so you try and explain and ask a few questions … they …walk off and see someone else and that can be incredibly frustrating"* (BDS2, 3). Contrasting this comment with *"… others who… slowly gathered the information because I'm freaking out … and gone 'you do know this, just think about it for a second and let me help you'"* (BDS1, 2) helps understand student dependence on a good rapport with their clinical teacher.

Participants also appeared to have a problem knowing how much autonomy they have in their restorative procedures. This depends to a large extent on what they are doing and how much experience they have had but a further factor is the attitude of the teacher. In the opinion of participants this varied a great deal, from teachers who were happy to discuss a variety of approaches to teachers who would not countenance any deviation from their own ideas.

Finally, a series of comments in this sub-theme identified areas in which teaching was lacking. These were: the giving of oral hygiene instruction, the identification of dental caries, tooth morphology, management of non-carious tooth tissue loss, the use of matrix

bands, tooth shade taking and the placement of rubber dam. One individual suggested that *"In one of the first weeks maybe, they should teach us temporary fillings because then if you do … knock out a filling … you can easily just put one in"* (BSc, 1). Both the BDS and the Dental Therapy programmes do, in fact, contain teaching in all of these areas, as participants agreed on further discussion. But the consensus was that this teaching had not taken place in a situated way, at an appropriate time in their learning or had not been extensive enough.

Participant comments on the role of coaching and demonstration in learning

One of the more frequent comments related to a lack of coaching. There were 35 references on this topic. Coaching, and in some cases demonstration, from clinical teachers was mostly considered helpful by participants but there was not nearly enough of it. Lack of demonstration was linked, in the opinion of participants, to a teaching philosophy based on product not process. Pre-clinical teaching appeared to consist, according to several participants, mainly of a description, either verbal or visual, of end product, which students are then expected to reproduce. In other words *"They tell you what to do but not how to."* (BDS1, 2) There was some, but not much demonstration of process, other than via some videos made by one member of staff; *"The best time was when she showed us that video of how to pack an amalgam … I knew exactly what I was meant to be doing"* (BSc, 1). Participants with more clinical experience also said that there was relatively little individual demonstration on patients, although some courses used group demonstration as a teaching method. As a result students are sometimes not sure what they were supposed to be achieving, or how to achieve it *"… a couple of times, we were asked to gather round one head and then it was shown to us but I never really had*

someone come and watch what I was doing saying 'No, you need to do more like this'" (BSc, 1). This teaching practice is at least partly related to staffing levels. Ratios of 1 to 10 are common in the pre-clinical laboratory, and 1 to 6 or 7 in the clinical setting. This makes a difference as observed by one participant: *"On phantom head … you'd get the work checked and then get your changes made and then you'd have to wait a half hour or hour for them to come back, whereas on clinic … it doesn't take that long … so I think it's easier to ask on clinic for advice or help than in phantom head"* (BSc, 2). One participant commented that in the pre-clinical laboratory being "pushy" actually meant that you got more attention from teachers.

There were mixed opinions as to the value of demonstration, particularly among participants with more clinical experience, i.e. those from interview three of each case. There was recognition that group demonstration on a patient was not easy because of size constraints. While some found group demonstrations useful, commenting that *"watching someone do it with a patient, I think you remember things more"* (BDS2, 3), others tended to *"switch off"* because they could not see properly. They also suggested that students early in their career would benefit less from demonstration because they lack the experience to understand what is going on.

While models still confine teaching to product rather than teaching process, one group of dental therapy students were positive about their use. They commented that *"sometimes, with a 2D image, you kind of get the idea, but when you get the 3D … you go 'now I see how it's meant to look from different angles' … rather than … translating a 2D image into a 3D image before you think about the actual cavity"* (DipDT, 1).

Participant comments on pre-clinical assessment

There were thirty references to assessment. The message coming from participants was a complex one, but one of general dissatisfaction with the assessment process. On the one hand they complained about a lack of absolute standards in assessment, commenting for example, that *"… say you'd done it with X, it would have got you a good … then I would do the same with Y* [who] *would say it just needs to be squarer"* (BDS1, 1). On the other hand there were a lot of critical comments about the validity of standardised cavity preparation as an assessment, typified in this comment: *"With the competencies … there was certain measurements, so we had to be a certain amount of millimetres deep and wide etc. A lot of people had to repeat the* [assessment] *because* [the cavity] *was slightly too shallow … it doesn't seem to equip you that well*" (BDS2, 3). One individual, in relation to one of the assessments, admitted that he had *"never done a satisfactory one until I did the test and don't know what I did differently* [to pass the test]*"* (BDS2, 1).

Participant comments on the role of practice in skill learning

Although there were only nine references to practice, these covered a number of different topics. Most referred to the way in which practice helps to develop skill. But practice in an authentic setting was the preferred option. Two participants expressed a desire for more practice on colleagues. One found it helpful to practise a procedure on a "phantom head" just prior to undertaking that same procedure on a patient. This is an established option for Year 3 BDS students, and has proved popular with some.

On the other hand some students find that practice is not helpful; it can be quite demoralising because *"Being told to go back and do it again makes you feel as though you are going nowhere"* (BDS1, 1).

One participant comment on reflection

Comments on reflection were limited to one short discussion between students in case BDS2, during their final focus group after a full academic year seeing patients. Therapy students have a short debrief at the end of the patient appointment. As part of this, students are required to assess their own performance. Neither the debriefing, nor the self-assessment are regular features of BDS clinical teaching. As one participant said *"We're supposed to be graded ... and some people ask you how we think we've done but it depends on the tutors"* (BDS2, 3). Although it had been a rare experience for this group, they approved of self-assessment in principle: *"I think that kind of thing would be useful because you do reflect more on what you've done in the session."* and that it "*would be quite useful actually to reflect on everything because it makes you think about why you're doing things a bit more"* (BDS2, 3).

However, it is safe to say that conscious, formal reflection and its articulation rarely have a role in learning for students of dentistry, unless required as a formal part of teaching or assessment. This does not necessarily imply a complete absence of any type of reflection, a theme I will consider in the discussion chapter.

Participant references to the concept of tacit knowledge

Though the concept was not overtly referred to, there were seven references that indicated some understanding of the tacit nature of clinical knowledge. For example, one participant commented that *"a lot of the basic things weren't actually explained, they sort of assumed we knew"* (BDS2, 1). An example of this was shade taking, an activity that was not be taught in the pre-clinical setting, and that was mentioned a number of times by all student groups. Participants understood that there were some

aspects of clinical activity that have to be learned through direct experience. One comment identified that *"You have to get a feel for materials … You can't* [learn] *just watching someone else do it"* (BDS2, 3). Another individual noted that his student group had been taught how dental caries feel by examining real carious teeth, and encouraged to *"… stick a probe in and it feels sticky…"* (BDS2, 1). Another illustrated the effect of low fidelity simulation on transfer: *"… you haven't had that on phantom head. If you actually do that to a patient … you go 'ahhhhhhh…'"* (DipDT, 2).

In focus group number three in the series from case BDS2, there was some discussion about how much theoretical knowledge was needed for clinical activity. Participants in this case had at the time of interview spent one full academic year in clinical activity. Even so there was some discussion about the relevance of academic knowledge to patient care. However, as the discussion continued members began to recognise the theoretical knowledge that they did possess and make use of. This suggests that tacit learning, and the tacit application of academic knowledge is important to clinical patient care.

Participant comments on the duration and frequency of clinical and pre-clinical sessions

There were 70 references related to time pressure, suggesting a significant degree of concern over this topic. In the clinical setting these concerns related to both duration and frequency of patient appointments; in the pre-clinical setting students were concerned about duration and frequency of practical sessions.

Participants working in the clinical setting felt that they had insufficient clinical time, both in the length and frequency of appointments. Several participants commented on the time pressure during a clinical session. Most were accepting of this, recognising that *"The rest of*

our lives is going to be timed" (DipDT, 1). However, there were limits to this acceptance. Some suggested that clinical teachers were expecting them to achieve more than they could manage during the early stages of their clinical career, and that this expectation was affecting their learning. One participant, for example, commented on a move to two patients in a clinical session: *"I had only an hour and a quarter or so for a history and an exam … it's just more daunting than having … a single patient"* (BDS1, 2). One individual suggested that student transition to restorative patient care might be easier if students operating in pairs had one patient each, so that each in turn acted as operator and assistant, *"… and then build it up to two like we did when we did scaling"* (DipDT, 1). Spending a portion of their precious clinical time queuing to get clinical work checked also appeared to increase the sense of pressure. The tentative nature of student working meant that this pressure appeared more significant to participants during the early months of their clinical activity. One commented that *"because I'm really not confident, I have it checked a lot so that takes even longer, so you end up not having time to do everything that needs doing"* (DipDT, 2). Almost all participants also felt that the frequency of patient appointments was insufficient.

Those at the transition stage felt particularly disadvantaged by this, as they felt that it affected their learning. Comparing the clinical setting with the pre-clinical, one commented that *"The advantage of phantom head is you are doing your skills every week, whereas on clinic, you may be 3 or 4 weeks* [between repeating the same thing] *… I don't feel I've got enough continuity of that to feel that … the clinic side of thing has helped me"* (DipDT, 3). Another commented that this intensity of pre-clinical sessions was important because *"If you'd had a bad session on a Tuesday morning, you knew you had a*

Tuesday afternoon to get it right and a Wednesday morning to get it right, and a Thursday morning to get it right" (DipDT, 3). This feeling only appeared during the very early stages of clinical activity, during interview two of each case, after only one academic term of clinical activity. Participants in interview three of each series, who had more clinical experience, were instead concerned about the effect of infrequent appointments on their patients rather than on themselves, because this prolonged the duration of treatment.

In spite of such comparisons, participants who were still at the pre-clinical stage had similar concerns over duration and frequency in the pre-clinical course. One suggested that it *"… would be a good thing in phantom head if they timed you to do a filling because you've got no concept of how long it takes"* (DipDT, 1). In fact timing had been part of some pre-clinical exercises. Those involved commented that the awareness of being timed made them work faster, and made them realise that they could work faster. They also recognised the effects of tentative working. As one put it, *"I spend a lot of time 'do a little bit, reassess it, do a little bit, reassess it'. That's a huge time consumption when it doesn't necessarily need to be"* (DipDT, 1). Although lack of time in the sessions could sometimes be ascribed to the student, this was not always the case. Students in the pre-clinical laboratory also have to wait to get work checked. As with the clinical setting *"There's not enough tutors, you used to have to wait for ages for somebody to check our work, it does mean that we're wasting loads of time"* (BSc, 1). Time constraints affected student learning to some degree. For example, one individual commented that they did not practice polishing and finishing restorations very much because *"… by the time I'd actually placed whatever it was, there wasn't much time at the end of the session to do much finishing"*(BSc, 2). Inter-case comparisons proved interesting. Because of the constraints

of their programme, case DipDT undertook a relatively intense pre-clinical course lasting only three months, from January to March, with several sessions each week. After this they moved directly onto restorative patient care. Participants from this case commented on how short their pre-clinical course was, but how much they had learned in that short time. They also said that a course of this intensity was extremely tiring. All other student cases experienced a longer, but less intense pre-clinical course extending over an academic year. In practice, this meant that students on the longer course had only one practical session each week for most of the time. This low frequency appears to have had an effect on student learning. Case BSc noticed this most, because they could directly compare their long pre-clinical course with the shortened one of their immediate predecessors in case DipDT. They commented on the once weekly frequency of laboratory sessions commenting that *"you forget after a week … you have to go back to the beginning … they did like 6 weeks of every morning … at least they don't forget, they just keep going and they keep building on skills whereas* [we] *have to do that confidence build-up every single session all over again"* (BSc, 2). They also commented on the long duration of the pre-clinical course, suggesting that it had *"dragged out so long that I can't remember what we did in October"*, and that *"it feels like we've been doing it forever and it's just non-ending"* (BSc, 2).

Participant comments on teamworking

Participants made a limited number of references (6 in total) to teamworking. This was limited to operating and assisting in the patient care context. Participants liked working in pairs because this allowed the operator to focus on the patient. With the assistant managing the dental unit, the operator is not faced with a *"mega embarrassment …sitting*

there going 'I don't even know what's in that cubicle'" (BDS1, 1). Participants preferred working with dental nurses rather than student colleagues, because dental nurses know how to manage the working environment. They are also much more experienced at "4 handed dentistry". Four handed dentistry is not something students experience in the pre-clinical setting, and appreciate this aspect of the dental nurse role. The downside of teamworking was that it increased the pressure on the student because they were now being watched as they worked. Noticeably absent from the discussion was any concept of the larger dental team, and the participants' role within this. Nor did students talk about learning through teamworking.

Participant comments on preparedness

All focus groups were asked to comment on how well their pre-clinical learning had prepared them for patient care. Most participants felt generally unprepared, even therapy students (cases BSc and DipDT) who had a transition built into their programmes. One individual commented that *"… just putting the drill to someone's teeth, I'm already so frightened"* (BDS2, 1). Participants in all groups, from both pre- and post-transition, stated that *"nothing can prepare you for it"* (BDS2, 1). This reaction is not unexpected as almost all students of dentistry experience "stage fright" as they approach their first interaction with patients, their first local anaesthetic or restoration; in fact most firsts give rise to some degree of anxiety.

However, participants raised some specific areas of concern in the context of transition:

- Pretransition participants worried that they will face criticism from teachers in the clinical setting because of unpreparedness.

- Linked to this was a concern that students do not know enough to adequately treat a patient because they are partway through their programme and do not have a full range of clinical skills at their disposal.
- Pretransition participants who had just "scraped through" the "phantom head" assessments, felt that they had not adequately mastered restorative procedures. Some passed only after several tries. One individual in particular seemed unaware as to how he had managed to pass.
- Several post-transition participants voiced concern over the validity of "phantom head" assessment, suggesting that it did not prepare them for restorative patient care.

Participant comments on motivation

Participants commented on a number of personal emotional states as affecting their pre-clinical learning an, their clinical learning or the transition between them. These emotions were mainly those of frustration and anxiety, though others were mentioned occasionally. This was a minor surprise because affect did not surface in the discussion around purpose, fidelity and transfer which formed part of the introduction to this report. However, its importance to student learning is not surprising. This sub-section reports participant comments on frustration, fatigue, anxiety and accomplishment and their effect on motivation.

Learning in pre-clinical dentistry and transition to clinical dentistry has an emotional component. Participants made 62 references to a variety of emotions, so that this is obviously a topic of importance. The most frequent comment related to frustration. This came mainly from participants in focus group 1 of each series, because focus group 1

took place at the end of the pre-clinical course, whereas focus groups two and three took place after some clinical experience. Perhaps because of the imminent transition to clinical activity, some individuals indicated a desire for more pre-clinical practice. However, the majority considered they were ready to move onto patient care. Perhaps if participants had been interviewed at another time, frustration with the pre-clinical course would not have been so evident.

Some expressions of frustration related to achievement or its lack, because several individuals commented on how pre-clinical activity had become easier with practice; yet at the same time more boring. These frustrations were portrayed by some as a series of "*good days and bad*" days, with three different participants suggesting that sometimes they get into a "*vicious cycle*" (DipDT, 1), feeling demotivated because things keep going wrong. Perhaps linked with this were some comments on how tiring many of the participants found working all day, presumably because of the concentration required. They also referred to the low frequency of pre-clinical sessions; for BDS students the typical frequency was once weekly. This frequency frustrated participants because *"… if … something is not going well for whatever reason, that's that whole session that's affected then and … you've got to wait a week to correct any mistakes"* (BSc, 1).

Skill development takes practice, but engaging in repetitive practice takes motivation, which was not always present. *"It was a bit demoralising just because it was frustrating and you didn't really look forward to going because you know it was just going to be as annoying and frustrating as last week"*(DipDT, 1). As one individual admitted *"sometimes you just get up on Tuesday morning and think 'I just can't face it this afternoon' … if you're not in the mood for it, it drags and then you're waiting around for*

people to check and then it's always two steps forward and one step back and you never really learn anything and then you have a bad day" (BSc, 1). Another thought that *"… what made it more frustrating and unenjoyable is that you knew you could do it and it was … doing it and being told to go back and do it again, and then you feel like you're going nowhere ... being told to go back and do it again was demoralising. After you've done 5 in a session, you're just like 'I don't want to do this anymore'"* (BDS1, 1).

Frustration was also linked to lack of understanding. For example, one individual, struggling with a particular technical point of cavity preparation, said that he was frustrated by this until it was explained to him *" … the whole clearing the contact point thing, we've always thought that was a really big deal until recently when they said 'Oh, that's just how you get the matrix band on'"* (BSc, 1). Frustration was linked to motivation by one student participant who admitted that for him frustration was demotivating *"…if you've had a bad afternoon where things have been difficult and you have become frustrated with it … the next day you … go in already demotivated so you have to challenge yourself before you even start … you almost can get yourself into a vicious cycle …. As soon you cut a cavity right, it's OK and you're back on track, but it is getting out of that cycle"* (DipDT, 1).

Low fidelity also appeared to contribute to lack of motivation. The *"phantom head is not a real person"*(BSc, 2) and *"… you don't … worry that potentially you're going to cause the patient any discomfort and you potentially give yourself a little bit more room than what you would on a patient"* (DipDT, 3). By comparison *"When you go into the clinical environment, as you say, there's a patient there that you need to manage at the same time as concentrating*

on what you're actually doing on the tooth. It was more emotional … because you've got to consider that patient … but with phantom head cheeks who cares?" (DipDT, 3)

Other frustrations related to low staffing levels and difficulties with equipment. Participants found staffing levels frustrating because this meant that they were queuing for significant amounts of time for feedback. The main equipment related issue was the annoyance of having to dismantle the head regularly. It is easier for the pre-clinical teacher to comment on student work if it is removed from the "phantom head", but in order to do this *"You have to unscrew everything, you have to take off the heads, pull out the tubes, unscrew everything …and that takes quite a lot of time, even if it's just the tiniest bit of filling done"* (BDS1, 1). There were also comments about the "phantom heads" that can be taken into a patient clinic and mounted on the patient chair. Some of these were not really designed for current makes of dental chair and *"… after 2 or 3 weeks you knew, I'm going get there early so I don't sit on those three because the head falls all the time"* (BDS1, 1).

Some participants also expressed anxiety. This is perhaps not unexpected in most learning settings, but for at least one participant, anxiety was made worse by clinical teachers saying *"If you're terrible at this we're going to kick you out*" (BDS1, 1). Such comments appeared to affect the self-esteem of this individual, as indicated by the continuation of the preceding comment: *"Why do they give you this fear? People want to find confidence in themselves don't they, really quite early on so they can justify they can do this rather than sitting there feeling I can't do any of this"* (BDS1, 1). Lack of time to assimilate learning was another cause for anxiety, as another individual explained: *"Every time you think you've got something, you quickly move on to the next thing, you still*

haven't finished the last thing you're doing, you then forget that, you're then on to the next one and it's constantly changing" (DipDT, 1).

The final comment on motivation is that it appears critically dependent on the student's relationship with the pre-clinical, and perhaps more importantly the clinical, teacher. Criticism appeared particularly demotivating. One individual commented that *"… on phantom head they don't come round really and check your work, but on clinic they do, so they pull you up if you're not sitting properly or even if your finger rest is slightly wrong … today it was all finger rest for me and I was a bit down hearted"* (BDS1, 1). There were several comments on the power that the teacher has to motivate and demotivate the student in both the pre-clinical and clinical settings. The following example relates to the clinical setting, and exemplifies the issue; *"…it's not so much being better than someone else, it's just how much you enjoy it, how much help you feel you've got and how much at the end of the day, you feel like 'OK, I didn't know everything there but I still felt like I was doing quite a bit and I was working really well with the clinician' and at other times you feel absolutely miserable coming away from clinic thinking 'I didn't learn much, I felt I just got shouted at and I really didn't feel like I helped the patient, I just felt belittled'"* (BDS2, 1).

Participant comments on autonomy

There were three comments related to autonomy. Two came from interview one and were related to pre-clinical activity. The other came from three and so was probably a reflection of clinical experience. Each described a different aspect of autonomy. One described how he/she disliked being watched by pre-clinical teachers, and preferred to make mistakes in private. Another felt restricted and frustrated by the standardisation of the pre-clinical course and expressed a desire to be allowed some independence of

thought. The final comment was from an individual with some clinical experience, but who nevertheless felt increased anxiety when *"… someone is watching you and you're thinking 'Oh, I don't know if I'm doing it right, I don't know if I'm doing it right'"* (BDS2, 3).

FIDELITY

Participants also commented on the fidelity of the "phantom head" simulation. They were able to identify a range of fidelity related issues which they considered to be affecting their learning. Most of these related to differences between the simulated and real settings, which I have categorised as physical, psychological or environmental. Participants also identified complexity as distinguishing the clinical environment from the pre-clinical simulation, and this forms a fourth category. Where participants had experience of both pre-clinical and clinical activity (during interview 2 in each case), they were comments on the importance, or otherwise, of early familiarisation with the clinical setting. The results provide a fascinating insight into both the transition process and the role of fidelity in learning, and generated a huge amount of discussion spread across 105 references.

Physical differences

The anatomy of the "phantom head" was a significant issue. Almost all participants said that "phantom heads" are not a very good simulation of a patient. Their reasons included *"…moisture control, you've still got your patient management, your mirror will be in different positions, you know people differ, a pair of cheeks might be hard to retract or something. Whereas in phantom head … positioning and everything is so different"* (DipDT, 3). One individual noted *"… definitely the biggest difference going from phantom head to patients is*

the tongue …" (BDS1, 2). Another said that *"Angulation and access is compromised a lot more* [in patient care]*"* (DipDT, 2).

The "phantom head" allows students to "cheat", making changes to simplify access or cover up mistakes. *"In phantom head, you can move the cheek out of the way … and do what you need to do to get the perfect restoration"* (DipDT, 2). For example cutting cavities in upper teeth is much easier if the student adjusts the position of the "phantom head" *"so you can see the upper teeth … facing the ceiling"* (BDS1, 2). Some participants admitted to taking the jaw and teeth out of the head and carrying out cavity preparation on the bench. Yet other participants confessed to changing a tooth for a new one when they had made a mess of the cavity preparation; *"I just change them. In fact, someone even checked it and then I changed it, she was like 'I swear you damaged that tooth' and I was 'No'"* (BSc, 1). Several admitted that such cheating ultimately made patient care much harder. One said that "*If it's an exam … you would force yourself not to"* (BDS1, 3) cheat in this way. Another suggested that cheating is acceptable because *"I think 'well, I'm not actually doing it on a patient…'"* (BDS2,1).

All participant groups commented on the plastic teeth used in the "phantom head", with 35 references on the topic. There was a general wish for *"More practice with real teeth. Real teeth have real caries"* (DipDT, 2) However, participants acknowledged the difficulties in acquiring suitable ones. Generally the only real teeth that are available are those extracted because that are very carious, and are *"… pretty broken down, and it's difficult to get a good specimen"* (BDS2, 2). The most common complaint about plastic teeth was related to sensory learning, because *"… real teeth don't behave anything like the*

plastic teeth" (BDS2, 1). For some participants plastic teeth were *"more forgiving"* (BDS2, 2); others regretted the lack of tactile fidelity provided by the plastic material, saying *"It's actually a lot easier to cut a real tooth and into decay and know what we should be feeling"* (DipDT, 1). One participant commented that *"The thing I like about drilling on extracted teeth is the difference between enamel and dentine, you can actually feel that on the extracted teeth"* (BSc, 1); another wished that *"… you got told how hard you could use the excavator on dentine"* (BDS1, 2). One participant acknowledged that they had actually *"… been told the difference between carious and non-carious dentine …"* (BDS2, 1), but that this was not sufficient. Such comments illustrate the importance of the tactile (and tacit) element of learning in restorative dentistry. Although participants accepted the need for plastic teeth, and agreed that *"It's good to start on plastic teeth as opposed to just starting on a patient"* (BDS2, 1), several individuals identified the lack of tactile knowledge as a transfer barrier. One commented on *"…the fear, the first time you cut into a decayed tooth, the feeling of it is completely different from anything you get with a plastic tooth"* (DipDT, 1). The low fidelity of plastic teeth affects the restorative process in other ways. It *"takes away the whole realistic element to getting the* [matrix] *band around the tooth"* (DipDT, 1). It also makes checking occlusion impossible, so that students had little preparation in this aspect of restoration prior to treating patients: *"… nothing that we were taught showed us how to adjust occlusion after restoration …"* (BDS2, 3). This turned out to be a barrier to treating patients. As one commented when first exposed to amalgam restoration in the clinical setting, *"I was trying to shape it not realising it was in contact with the opposing teeth and then it would just end up fracturing"* (BDS1, 3).

A lack of realistic dental caries also had a significant effect on pre-clinical learning. In plastic teeth with no simulated dental caries, teachers rely on standardised cavity preparations to assess student ability. But standardisation imposes limits *"… because that's not what you do on a patient to remove the caries. It's been good … to use the fast handpieces … learning how to hold them and controlling them properly"* (BSc, 1). And "*… no-one has ever said to us 'OK when you go onto clinic, you're not going to be making a 2x2 box with a fast handpiece'"* (BSc, 1). Teeth do exist that have simulated dental caries, but using them does not appear to require the same clinical criteria used to judge real caries removal because *"On a real tooth, you know as soon as you're in dentine when to stop, how wide it's got to be and everything. It's just easier"* (DipDT, 1). The lack of appropriate criteria appeared to create a significant transfer barrier for some individuals *"… when we get onto clinic … we're going to be asked to follow the caries and I've only done that twice and to be doing that in somebody's head is quite daunting"* (DipDT, 1). Those participants who were fortunate enough to experience dental caries removal on real teeth (extracted) commented favourably; *"I think that's why it's got better lately through doing it on the teeth. When they say 'remove the caries' … that's what we'll actually be doing and we just haven't had enough of those sessions"* (BSc, 1). Participants with clinical experience said that *"One of the main differences* [in dealing with real dental caries] *is you don't go in with a definite end result in mind"* (BDS2, 2) and *"On clinic, you … make sure all the caries is gone but on phantom head, we'd have a set shape … you might find quite difficult to get that transition between the two"* (BDS2, 2).

When asked what physical similarities there were between simulation and reality, participants identified *"placing a filling and things like that, the feeling of packing an*

amalgam or curing a composite" (DipDT, 3). Because of this similarity, participants generally *"... felt quite confident, quite comfortable placing a filling ... So yeah, phantom head is really useful for that"* (DipDT, 3).

Psychological differences

The psychological space between simulation and reality was recognised in a number of ways. One participant admitted *"... sometimes, I used to lean on my little phantom head, or like your hand would be on his nose"* (DipDT, 2). Another noted that *"The pressure is off in phantom head because you know it's not real"* (BDS2, 2).

The pressure associated with a real patient appears to be partly related to the fear of causing harm; *"You know there's no repercussion from phantom head ... so you kind of just relax, whereas if you make a mistake on a patient..."* (BDS2, 1). Working on the "phantom head" reduces that anxiety, but some participants confessed to relaxing to the extent that *"You've got absolutely no precision or anything ..."* (BDS2, 1) and *"I'm just cutting a box, it doesn't matter, just change the tooth over ... the amount of times I changed a tooth..."* (BSc, 2). This relaxation may affect learning. When asked, one individual commented that *"I probably learn less ... because you don't focus as much ... if the clinician says 'you have to do this for this reason', then I remember much better than I would in phantom head with the pressure off, I'd ... just discard that information... I just tend to remember things more in that clinical moment"* (BDS2, 2).

Participants also recognised in themselves a fear of causing pain to a patient, and that this did not apply to the "phantom head". As one commented *"you don't have that worry ... you potentially give yourself a little bit more room than what you would on a*

patient and you apply that extra pressure than you would with a patient because it's not a real person who's going to be uncomfortable" (DipDT, 3).

Complexity

Working on a "phantom head" is a relatively straightforward activity. It does not initiate students into the complexity that is clinical activity. As one individual explained, complexity can lead to cognitive overload; *"… your patient always will come in with a multiple of twelve different things and your mind is racing at all twelve different factors trying to solve them all at once … because of that it takes time to … just have a simple guide plan through your head of each stage and what's happening and where to go, how to prioritise things and so on"* (BDS1, 3).

A significant component of this complexity is the need to make clinical decisions. There were a total of 26 comments on clinical decision making, 23 of which came from case BSc. There is no reason why this issue should affect case BSc more than others except that as their clinical teacher I had, prior to the relevant focus group, been discussing their clinical decision making with them. The reason they gave for a reluctance to make clinical decisions was that they were not encouraged to do so as part of their pre-clinical work. Instead they expect to follow instructions. As one commented *"I think I would know what to do but I don't think like making the decisions myself…"* (BSc, 1). Another admitted that he/she *"… wouldn't know if I'd gone too far, if I'd made the cavity too big … I'd still be relying on my tutors on clinic… you think you've done it and then* [the clinical teacher] *says you've got to clear the ADJ. In my mind it is* [clear] *… when you're using plastic teeth and there's no caries, you don't see the ADJ, you don't see what you're clearing"* (BSc, 1). This uncertainty is partly because students

have not had extensive experience with dental caries and *"... don't know what caries looks like or how much of it we should take away. We don't know at what point to say 'that's enough'"* (BSc, 2).

Another layer of complexity is added by the need to communicate with the patient. This too is difficult to simulate. Given its importance to patient care, communication gave rise to surprisingly few comments, even from participants with clinical experience. Some recognised the need to *"... keep communicating with a person as well"* (BDS2, 1) and the tendency to focus on the procedure *"when you're concentrating, you sometimes can disconnect from that person"* (BDS2, 1).

Environmental differences

In an ideal simulation, the student would use the same equipment, materials and procedures as in the clinical setting. Participants said that this did not happen, for three reasons:

The first of these was the lack of choice in filling materials available in the laboratory. There was usually only one of each type, and even these were occasionally out of date, which changed their setting behaviour. But most importantly, participants said that this lack of choice meant that they did not learn how to choose. As one commented *"I don't have a clue about the different types of composite ... so if I had different composites in front of me, I'd choose 'eeny meeny miny mo'"* (BDS1, 3). This is unfortunate because there are different variants of most materials for different purposes. It is also important when working with a dental nurse to be able to ask for different variants by name.

The second was the small differences in the equipment used in the pre-clinical laboratory compared with that available in the clinics. Such differences may not seem significant to qualified dentists, nor to students with some clinical experience. But they are different enough to create a barrier for students in transition from one environment to the other. Changes such as a different shape of cutting bur, different instruments for manipulating filling materials or the non-availability of FenderWedges© in the clinics were enough to create anxiety. Several participants commented on the non-availability of the cutting burs they used in the pre-clinical laboratory. One didn't like that *"... some of the instruments, some of the burs aren't transferred onto clinic"* (DipDT, 2). Another commented on how such tiny changes make the transfer process more difficult, saying *"Initially you panic because ... you're so used to having that set of burs and that set of instruments ... and then all of a sudden to go on clinic and try and get the same set up and you can't then that sets me into panic before the patient even gets into the chair. It's kind of another obstacle to get over before you've even looked at the tooth"* (DipDT, 2).

The third important factor was the clinical working environment. This differs quite considerably from the simulation. One example of this is the presence of moisture during cavity preparation. Moisture affects the properties of most restorative materials and reduces vision during cavity preparation. It is present in the patient from both cooling water and patient saliva. Although cooling water is used during cavity cutting on the "phantom head", *"... it's more important in the patient's mouth because we didn't have to deal with that very much with phantom head"* (DipDT, 2). The dental nurse uses suction to control moisture, which means suction equipment in the

patient's mouth, restricting access for the operator. The dental nurse is also responsible for managing the ergonomics of the dental procedure and looking after the welfare of the patient. It means that someone else is observing the patient, so that the operator *"can get on with his own side of things"* (BDS1, 3). But suction takes up space in the patients' mouth that has previously been available to the student. As one individual noted *"We've got used to having the space and being able to see … on phantom head, we haven't got any soft tissue or any suction"* (DipDT, 1). Another confessed to working without suction in the "phantom head" in order to do better work, commenting that *"… now having someone there with the suction is making a big difference … I didn't potentially use phantom head as well as I could have"* (DipDT, 2). Finally participants in a first interview speculated that the presence of a dental nurse would mean *"… somebody else there watching you do it and you haven't had that before"* (BSc, 1).

The effect of familiarisation with the clinical working environment

Because the clinical environment is so different from the pre-clinical laboratory, it is reasonable to ask about the effects of familiarisation activity on student learning. Participants in cases DipDT, BSc and BDS2, experienced a gradual introduction to patient care, carrying out a limited range of dental procedures on "phantom heads" placed in dental chairs, and on each other. Simply to know *"where everything is on the clinics"* (BDS1, 2), *"how to use the chair"* (BDS1, 2) and *"what to do with the kits after we use them"* (BDS1, 1) appeared to generate confidence. This is a not unexpected aspect to learning in a situated setting.

But some individuals said that it also made the simulation *"… a lot more realistic… it's not such a jump then when you move on"* (BDS1, 2). Working on "phantom heads" in the clinical setting was popular with most; *"It definitely got more realistic when we took the heads into clinic and did it that way"* (BDS1, 3). There were a number of facets to this realism. One was the psychological one of simply being in the clinical setting. As one individual noted *"I took it a lot more serious*[ly] *when it's on clinic even though it's still phantom head"* (BDS1, 3). Participants also had to learn *"patient positioning", "being able to move around the chair"* and how to work around suction equipment in the mouth. All of these are new to the student making their experience *"… just that step closer to actually being a dentist, you're actually on clinic, you could hear everybody sounding just as panicked you were."* (BDS1, 3)

Being in the dental environment appears quite helpful to students. However, there were several comments to the effect that, in spite of working with "phantom heads" in a clinical environment *"… you still won't be comfortable until you do a patient"* (BSc, 3). One participant added the suggestion that *"… it would be useful near the end of phantom head to have something added to make them* [the "phantom heads"] *more realistic because at that point, you grasp the idea of hand-instruments and making the shapes correct and stuff, but you need the challenges of a tongue"* (BDS1, 3).

IMPROVING "PHANTOM HEAD" FIDELITY AND OTHER CHANGES.

Participants in all cases were asked for their suggestions on how the pre-clinical course and/or the transition to clinical activity might be improved. One of the questions asked was on the importance of simulation fidelity was to learning. The

common view was that simulation should be as realistic as possible, but no participants were able to explain the advantages of increased realism. When asked directly, there were almost no suggestions for improving fidelity. One comment typified the participant response; *"… it's really hard to make it more realistic. I think the only way you're actually ever going to make it more realistic is to have a patient … On phantom head, you know it's a phantom head…"* (BSc, 1). However, one individual suggested that realism might be a personal choice, saying *"It's up to you at the end of the day to make phantom head as realistic as you want to make it…"* (BDS1, 2).

In a separate question, participants were invited to suggest changes to the pre-clinical course. In spite of the apparent poor understanding shown in the above discussion, most of these suggestions were related to fidelity, including:

- improving the anatomy of the "phantom head". *"… if we could add cheeks?"*, *"A tongue would be good, because the tongue is a massive problem, especially after you've given LA"*, *"… and maybe giving it saliva". " … because things like that can affect how you position your hands"* (All quotes from BDS2, 3):
- using real teeth with real dental caries;
- using models with deliberately imposed orthodontic problems such as imbrication in order to make restorative access more challenging;
- imposing moisture control procedures to the same standard as that required for patient restorations;
- imposing cross-infection procedures to the same standard as that required for patient care;

- using the same burs and materials that they would use in a clinical setting;
- spending more time using "phantom heads" in the clinical setting, and using this to explore teamworking;
- setting time limits to pre-clinical work, just as there would be during a patient appointment;
- extending the range of procedures that students practise on each other, in order to practise clinical procedures impossible to undertake on the "phantom head";
- providing clinical overlay scenarios to pre-clinical activity, for example *"the inclusion of some history taking"* (BDS2, 3) or seeing pictorial examples of dental caries, and asking students to make treatment decisions. A further suggestion was the incorporation of *"… an actual case study, like the radiographs … and stuff like that …"* (BSc, 1);
- greater autonomy in "phantom head" work; allowing students, for example to make *"… decisions for instruments and burs ourselves like them saying 'what are you going to use now and why'"* (BSc, 1).

Overall, participants seemed reasonably content with the pre-clinical course as it stands. One summed up this general feeling, saying *"I don't feel like we're really been let down by it at all and I feel like I'm quite confident on clinic as well. So I don't feel like the phantom head course has really caused a major problem … or that something drastic needs to change … It is a certain transition and you know while you're going through this course, you do transitions through things and it is a learning curve throughout … given a two million pound robot*

[a reference to the Hanako robot] *that can blink and vomit and gurgle and things like that, I'd rather just slowly step my way into things"* (BDS1, 3).

There were a very few suggestions for improvement that were not fidelity related. They are included here for the sake of completeness. Participants suggested more teachers and more practice. They asked for sessions in which they could practise a restorative procedure immediately prior to undertaking that restoration on a patient. In view of the importance of communication in the dental clinical setting, I was surprised to see only three suggestions for improving communication skills. One individual suggested simulation with *"human pretend patients*" (BDS1, 3), another requested a dedicated communication course. The third was a request for quite specific instruction on *"… how you address the patient and how you treat them … Because when we were treating our first proper patients, we were kind of like 'what do I do now' and then asking the clinician constantly for help"* (BDS2, 2).

TRANSITION

In spite of satisfaction with the pre-clinical course, student transition to clinical activity was still a significant step. *"I don't know if complicated is the right word to use, but it was a bit of a challenging experience to go from phantom head to clinic with actual patients"* (DipDT, 2).

The transition to clinical activity is a complex process. As indicated in the literature it would appear to involve transfer, transformation and also contextual factors. It involves the unlearning of previously learned skill which is now inappropriate. In the metaphor of boundary crossing, it also involves recognising boundaries and overcoming barriers.

This section discusses these components under the headings of unlearning, transfer, barriers and boundaries. It also relates participant comments on the managed transition.

Unlearning

One component of transition that is often overlooked is that of unlearning. There were seven student comments on the phenomenon of unlearning. All came from student dental therapists (cases BSc and DipDT), possibly because these groups tend to have clinically relevant life experience, as many come from a background in dental nursing. This has traditionally been looked on as helpful, but it also creates preconceptions. The way in which dental caries is managed has changed rapidly in the past two decades, but the habits learned from watching someone else can be difficult to change. As one individual commented *"… if you have nursing experience and you've been there a long time it's very hard to take a skill away because … it's automatic … We have to change our thinking"* (DipDT, 1).

Preconceptions are also created in the pre-clinical laboratory itself. One source is the standardised approach to cavity preparation. As one participant commented *"I think initially, I was looking to … cut these cavities that we've been taught and then you realise you can't"* (DipDT, 3). Implicit in the notion of unlearning is that of adapting and new learning. The following comment illustrates the adaptive process *"… you see a patient and you think 'OK this is what I want to do' and discuss it with somebody and they're like 'No, that's not what you want to do…' and suddenly, you've got to learn to change that mindset"* (DipDT, 3). All participant comments on unlearning contained the idea of adaptation.

Transfer

Focus groups two and three of each series (participants had begun some clinical activity) were asked about their transfer to clinical activity. Some individuals looked back to their pre-clinical experience for guidance, but this was only for the most basic skills. When asked what skills had transferred from the pre-clinical setting, participants mainly referred to perceptual-motor skills, as described in the section on purpose, and the manipulation of materials, for example *"… placing a filling and things like that, the feeling of packing an amalgam or curing a composite …"* (DipDT, 3). But as one said *"… it's purely knowledge of conventional preparations in teeth and materials and I don't think it stretches further than that…"* (BDS1, 3).

When asked about the relationship between fidelity and transfer, participants from cases BDS1 (during interview 1 prior to any patient contact) said that simulation fidelity helped because *"… you can apply it then to a patient easily, like you can easily transfer those skills …"* (BDS2, 1) and *"You feel natural on the patient then"* (BDS2, 1).

Classical understandings of transfer, such as those espoused by Thorndike (1913), and that of Judd (1908), consider it primarily as a prospective activity. Comments such as these appear to support this view, at least in the case of the perceptual-motor skills of restorative dentistry. As one participant commented, *"I just had a simple Class II the other day … and it was literally directly from what we were taught in the phantom head."* (DipDT, 3). However, as students transition from pre-clinical to clinical activity, most appear to have little idea of what this will entail. Participants said that they "*try and play along with it as best as possible"* (BDS1, 2). This does not accord with a prospective view of transfer, and an alternative one, of transfer as retrospective, is easier to justify. In this view,

students can be seen as looking back to the pre-clinical setting for direction on how to solve problems in the clinical one. For example one individual commented that *"… when you do it in the mouth … it was quite nice because it was like 'Ah, OK, now I see where I was going on phantom head to this point'"* (DipDT, 3). But retrospection implies learning and adapting in a way that prospection does not. One participant summed up the general feeling by saying that *"… phantom head was like learning to drive, but then since you passed, that's when you actually really learn to drive… That's how I feel they like teach you skills to pass the test but then once you pass the test, you actually need to learn how to actually do it"* (BSc, 2). One of the more contentious issues in relation to transfer was the variation in pre-clinical experience, and the concern that this was *"not broad enough* [to ensure] *that everything we encounter on clinic, we have encountered on phantom head"* (BDS1, 3). This also implies the need for new learning in the clinical setting.

For some participants, clinical activity was so different that pre-clinical learning *"… totally went out of my mind … you get presented with your caries and you've got to kind of problem solve and think what's going to be best for me to use, you don't think 'Oh, 2mm deep'"* (BDS2, 3). Others suggested that the intersection between clinical experience and academic knowledge is more important than that between pre-clinical and clinical activity, because learning *"… happens more when you read something, and then you understand… the science behind it and then it makes more sense clinically. I don't think it does with phantom head"* (BDS2, 3). Others went further, implying more significance to learning in the patient care setting, as suggested by the following: *"… positioning for me, like when I was doing my first scale and polish, I had to work it out in my head first of all before I managed to get good positioning and everything"* (BDS1, 2). Another commented

that *"As much as I think they're both as important as each other, phantom head and clinic, I think I've learnt more on clinic than I did on phantom head"* (BSc, 2). Yet another, that *"We're kind of learning as we go now, aren't we… you've taken from phantom head how to use instruments and sort of how to use burs, but you still have a learning process"* (BSc, 2). This argument was also framed in terms of situated learning, for example in relation to lectures on facial growth *"… there was so much stuff, without knowing the clinical context and when you would use them and why"* (BDS2, 3). The same individual also suggested that because students were learning a practical discipline *"… you'd rather do it the other way round* [i.e. learn practice before theory]*… once you've done it clinically even once or twice, it all makes sense"* (BDS2, 3).

Barriers and Boundaries

All focus groups identified with the concept of boundaries, and agreed that boundaries were important factors in transition. One individual, for example, was quite categorical that pre-clinical and clinical activity were *"… separate things, I didn't quite make the link, I went to OPDENT* [the pre-clinical course]*, I learnt how to use the handpiece … and then when I did start cons, I kind of took it from my perio, like I had to treat my patient, had to adapt to it and then I just had another task to do. I didn't really go from one to the other. In my head … OPDENT is completely different to clinic"* (BSc, 2). Another commented that *"You've learnt how to actually cut a prep.* [cavity preparation] *but you don't learnt how to cut a prep. in a patient. It's two separate things, completely"* (BSc, 1). Most were less radical, but still recognised the idea of a discontinuity between simulation and reality, recognising *"… that there's differences and people accept the fact that they're going to have to step up to move through different changes … even though people complain a bit … they kind*

of think yeah, actually, there's the positive about seeing my patient and actually, I have done this before, I can relate to this" (BDS1, 2).

Regardless of any theoretical interpretation of transfer as boundary crossing, the idea of barriers was understandable to participants. Many of those that came up in discussion were related in some way to the fidelity of the simulation, which may indicate a relationship between fidelity and transfer.

Some barriers were physical. The effects on learning of anatomy, plastic teeth and poorly represented dental caries have been discussed above. Low physical fidelity appeared to have an effect on confidence levels because students had initial difficulty with even small differences between the two environments, as demonstrated by the discussions around cavity cutting burs. A completely unexpected barrier was the simple matter of identifying burs. In the pre-clinical laboratory these tend to be referred to by a name, whereas in the clinic dental nurses are used to identifying them by number. Patient positioning was also unexpectedly significant, *"… because I can only get about 10% of my patients to actually go fully flat …That was a big one, because you can just lie a phantom head straight back and get into a nice position whereas that's quite a struggle with patients"* (BSc, 2).

Other barriers were psychological. In particular the presence of the patient made a huge difference to the student. This is not necessarily negative because *"… you've got to make sure the patient is OK, you've got to explain everything to them and that sort of calms you down and you explaining to your patient, kind of makes it clear in your head what you're about to do"* (BSc, 2). Nevertheless, participants were faced for the first time, with carrying out

irreversible treatment on a real individual. As one commented *" you do need that constant reassurance of 'keep going, cut a little bit more, keep going, cut a little bit more' and it's probably taken until now, that I would be really comfortable that 'well I think that's carious and I'm going to take all that out, rather than checking at every stage'"* (DipDT, 3).

There were also cognitive barriers. One participant suggested a link between physical fidelity and learning, suggesting that *"… the instruments that you're using are actually changing the way you learn, the way you practise your technique"* (BDS1, 2). Several comments indicated a lack of connection between pre-clinical practice and patient care *"… this week is the first time we've mentioned … even the idea that we have got to do this out of the phantom head room. So it's never really been in my mind*" (BSc, 1). Participants also mentioned the boundary between academic and clinically applied knowledge, recognising that they *"… go in, like knowing everything in a book … but it's totally different when applying it to patients … you get clinicians asking you questions applying to the patient and you're a bit like 'I don't know what you mean' but … if they had asked in a different way probably that was a bit less clinical or whatever…"* (BDS1, 3).

Participants also recognised cognitive load as a barrier. The complexity of clinical activity results in significant cognitive load for the student. As foreshadowed theoretically in chapter two, increased cognitive load appears to have a significant effect on student performance. One description of a first restoration included the phrase *"… right now I'm seeing my first ever patient and doing my first ever filling, my mind is in complete chaos"* (BDS1, 2). Another participant confessed to managing by *"just focus*[sing] *on the mouth regardless of what's around it"* (BDS2, 3). Here too, the student's relationship with the teacher was seen as important *"… a lot depended on the supervisor …*

some of them understood you knew what you were doing and you just didn't know how to organise yourself, orchestrate yourself for those first couple of times, and others didn't so they really hammered you for it" (BDS1, 2). Cognitive overload may play some role in poor communication with the patient, something that many students struggle with during their transition to clinical activity. One individual commented that it was caused by concentration on cavity preparation; *"… in the zone … with the phantom head that all you're going to see is the tooth and nothing else around you, your patient could have like passed out and anything you would just carry on drilling"* (BSc, 1).

Not all barriers were related to fidelity. The literature review suggested that chronological distance might also pose a barrier, and results confirm this. A major theme of focus group discussion was time, much of which related to the time separation between pre-clinical and clinical activity. This seems to have been a significant concern for all student groups. As one individual commented *"… we had a really big gap over summer from when we finished phantom head and then we were supposed to be starting cons, then as soon as we got back, so it was like a month and a half from when we stopped phantom head to when we were supposed to be doing it on patients and by that time, I'd forgotten everything from phantom head"* (BSc, 2). Participants also expressed concern over the pattern of pre-clinical practice, in which they had laboratory sessions only once a week. All would have preferred a shorter, more intense, exposure to the "phantom head" because *"…think it would have been easier if we'd had it in a block because then it would have been a smooth transition … rather than you know phantom head and then clinic being two separate things"* (BSc, 2). Overall it seems that there is some work to be done by the school to promote *"… a smooth transition. I wasn't comfortable leaving phantom*

head actually I don't think, like I wanted more of it, and then all of a sudden, it was like a big job. If that transition had been smoother, I don't think I would have had as many nasty things to say about phantom head" (BSc, 2).

Student views on a managed transition

Student reaction to the managed transition was assessed through a questionnaire, and results from this are described in section 4 below. But managed transition also formed part of the discussion during several of the student focus groups. As previously explained, transition has always been managed for Cases DipDT and BSc. The BDS programme has recently put into place a managed transition, and case BDS2 benefitted from it.

The managed transition blends pre-clinical simulation with clinical activity, a process approved by participants rather than *"… finish*[ing] *on phantom head and then you go onto clinic and you never go back on phantom head again"* (BDS1, 3).

One intention of the school in establishing a managed transition was to reduce the size of the jump to clinical activity. With one exception, participants agreed that *"they* [students with experience of a managed transition] *have a better idea in the third year, rather than going in blind'"* (BDS2, 3). Most who took part in the managed transition commented positively on the experience, suggesting for example that they *"… have a better idea of how to calm people down when they come in" and "the only thing that's alien to us is actually doing the cons, not a patient coming in and talking to you"* (BSc, 1). Another benefit was on the usefulness of assisting during the P4P transition. Participants commented that it helped their familiarisation with the dental clinic, in terms of

knowing where to find equipment and materials. Moving the phantom head in to the patient treatment clinic was viewed positively because it gave participants experience of the clinical setting and *"... changes your thinking because then you're more aware that you will actually be doing it on a patient"* (BSc, 1). It may also simplify the transfer experience *"so it's not such a jump then when you move on"* (BDS1, 2). For another individual it was comforting to think *"I'm going in there now and I'll have a look around and I'll have a feel for it and I'll do things in it so when I get on, the only difference is there is a patient in and there's a clinician looking at me"* (BDS1, 2).

In this context focus groups were asked to discuss the value of early patient contact. This question resulted in 26 references, but 24 of them came from one group of students. This group was BDS1, a group who had no experience of the managed transition, as it was started the year after their pre-clinical course. This group were not uniform in their opinions regarding early patient contact, in spite of generally positive comments about the idea of managed transition. Some participants thought it far too early in the programme. While some approved, for example the individual who was *"... shocked when I first saw a cavity. I don't know that I really knew what it looked like before and to be in 3rd year and not really know ..."* (BDS1, 2) many were surprisingly negative. The bulk of this negativity centred around the relationship between theoretical knowledge and practical learning, as the following, contrasting, assertions show: *"I don't think the second year know perio* [periodontology] *enough to understand the relevance of scaling and polishing"* and *"... doing that earlier probably would have helped with our understanding of the science because you can relate it practically"* (Both quotes from BDS1, 2). This latter viewpoint was echoed by the only comment on this subject from case BDS2, in their final focus

group with a full year of clinical experience behind them: *"… you're learning about something practical and … you would remember it. I mean once you've done it clinically even once or twice, it all makes sense then"* (BDS2, 3).

It is surprising that case BDS2 did not explore this topic further, and unfortunately the lack of discussion across both BDS cases biases the findings in this area.

In a further step to bridge the gap between simulation and reality, several participants from cases BDS1 and BDS2 wondered if it would be possible *"… perhaps a week before you knew you were going to do a particular type of … restoration on a patient for real …* [to] *simulate it … cut the plastic tooth with a shape of preparation that we'd anticipate to actually do on a patient and fill it"* (BDS1, 2).

SECTION THREE – STAFF INTERVIEWS

A series of interviews were held with members of staff to understand student transition from their point of view. The same process of thematic analysis was used for staff interviews as for student focus groups (see the previous section). This section details the findings of that analysis around the same framework of purpose, learning, fidelity and transformation.

PURPOSE

There were 55 references to the purposes of pre-clinical dentistry. There was general agreement from all staff interviewed that the purposes of pre-clinical dentistry included its importance to safety, and its contribution to the learning of perceptual-motor skills. For one individual simulation helped "to develop awareness of health and safety issues

that surround the practical aspect of their work". There were also a number of comments on the importance of practice; one individual suggested that this helped the student develop *"small controlled muscle movements",* another that practice to automaticity is important in order to reduce student cognitive overload as the student begins to treat patients. There was also a measure of agreement that students also learn the manipulation of dental materials by using them in the pre-clinical setting.

One individual noted that pre-clinical simulation has *"an element of professionalism thrown into it"*, but was unable to identify this element nor suggest how it might be cultivated.

Teachers were more cautious concerning other purposes, including doubts concerning the appropriateness of intra-coronal cavity preparation as a means of developing perceptual-motor skills. For example, one individual suggested that, because extra-coronal preparations require a much greater precision in the clinical setting, they might be more appropriate for perceptual-motor skill development.

There was also discussion relating to the purpose of standardisation. One person suggested that it is a requirement to protect the school against litigation. However, there was criticism that it does not fit with modern concepts of the management of dental caries, and that it creates problems in the student transfer to clinical activity. Another pointed out that standardisation in teaching does not mean standardisation in learning, and suggested that pre-clinical simulation was failing to achieve its purpose because many students were coming to patient care having failed to learn the necessary skills.

There was little discussion regarding a need for standardisation of learning except for one individual, who pointed out that the pre-clinical course is not actually standard because *"… the good ones* [don't require] *the same amount of repetition, but they still spend the same amount of time in phantom head and you tend to set them greater challenges … You aim to develop them in more ways".*

A final unexpected comment related to the relationship between teacher and student. One individual suggested that a purpose of the pre-clinical context was to give students time to develop trust in their teachers. It was suggested that this trust can then carry over into the more complex clinical setting.

LEARNING

Teachers made 81 references to learning. Most were of the opinion that the pre-clinical course did not adequately prepare students for patient care. One commented that *"Students are visibly, palpably unprepared for what they're asked to do on clinic and they get very frightened"*. Another, a clinical teacher, said that *"They need a certain period when they are going to be watched closely doing restorative procedures to avoid catastrophe"* because *"they have no idea about anatomy, morphology and how … understand how the caries goes"*. The need for more, and more concentrated, practice was also generally recognised. One teacher suggested the need for a change in pattern to *"… a condensed block of phantom head … as opposed to having a long drawn out thing when you're only doing one session a week …* [and] *forget what you did the week before so you're not developing quite as rapidly"*.

There was general recognition that students do not learn complex clinical skills in the "phantom head" setting, and as a result are not ready for clinical activity. As one

individual commented *"They're not used to assuming responsibility for something really important. It's almost as if, in some cases, it's an extended computer game."* Although the staff interviews did not contain any discussion on how these skills might be taught, the P4P blended transition course is a result of such observations in the past.

Standardisation has already been mentioned in connection with purpose, but also received comments in relation to assessment. One individual in particular identifying standardisation of cavity shape as an important part of assessment reliability pointing out that the *"GDC say they want to have … evidence that … students are competent. Cutting some kind of standardised shape facilitates a more objective assessment … than cutting something quite random"*. A related strand was the interplay between the validity of personal judgement, compared with the reliability of standardisation. There were differing opinions here, some asserting that personal judgement is a more valid assessment process, others that personal knowledge of a student can warp that personal judgement. The issue was summed up by one individual who commented that *"… you certainly seem to be able to pick up people … where you think, 'good grief, how are we ever going to teach Fred Bloggs how to cut a prep' … but you're in dangerous ground if you weigh your opinions too heavily without fact to back it up".* When asked directly to comment on pre-clinical assessment as a guarantor of patient safety, this same individual replied *"If you're asking me 'have we ever excluded a student on the basis of those tests', the answer would be yes".*

There was, however, significant disagreement concerning the validity of standardised assessment. Several teachers suggested that standardised cavity features are not the most appropriate method of assessing learning because the process is *"too limited and*

they don't carry out any procedures that's anything like those standardised tests…". One person suggested that standardisation actually makes assessment *"less of a barrier to getting through, so even our weakest students this time, they're all getting through.*" Another commented on the way students are allowed multiple repetitions of standardised assessments suggesting that students who succeed at their first attempt are going to be safer, *"I think if you were to ask the public … 'do you want somebody who just scraped through or would you prefer the person who did extremely well?'…*"

Among other topics raised was that of situated learning. The concept of simulation as situated came out in comments from several teachers, suggesting that it is understood, though not fully articulated. For example, one individual suggested that the pre-clinical lab allowed the student to understand tooth anatomy clinically, rather than just theoretically. Another suggested the "phantom head" allows the student to *"explore what it is like to work in someone's mouth"*. Yet another suggested that pre-clinical simulation allowed the student to *"set all these skills in the wider clinical context".* But in this context too, it was suggested that standardisation has a negative effect: *"our current phantom head course really is extremely limited… the procedures they carry out in phantom head are very small, minimal procedures …* [and students use a] *very limited range of materials used to restore* [them]."

Fidelity

Staff comments on fidelity were mostly related to the physical and psychological fidelity of the "phantom head" and particularly of the plastic teeth used nowadays. There were a total of 55 references to "phantom head" fidelity.

These included the absence of human interaction, and the physical characteristics of working in the mouth. One teacher summed this up in the following phrase: *"The phantom head never wriggles about, it never complains, it's not got any saliva slopping around its mouth, there's no local anaesthetic to think about, our patient is never anxious."* Another commented that manufacturers seem in no hurry to replicate the presence of a tongue. Managing the patient's tongue can be difficult when working on lower teeth, and its absence from the "phantom head" means that students are unprepared for its presence.

There was uniform recognition from teachers that this lack of fidelity affects subsequent patient management. An example is the following discussion on moisture control: *"They'll say to the patient 'Would you like to sit up and have a rinse?' … and this whole concept of moisture control goes totally out of the window."* Another example was the suggestion that "phantom heads" should be constructed with tongues, as managing the patient's tongue is a significant issue in clinical dentistry.

Teaching students how to manage a patient was the subject of some discussion. One individual suggested improving fidelity through clinical scenarios, such as presenting students with radiographs *"… to improve the kind of clinical overlay, I don't think there's enough of a clinical overlay in phantom head."* The idea of using the SALUD patient management system (used by students for patient care) in the pre-clinical laboratory was also suggested in this context. Others, however, were less optimistic, suggesting that the lack of an emotional context meant that learning and assessing patient management in the "phantom head" setting was probably not possible.

Of the 55 references on this topic, 30 were related to the deficiencies of plastic teeth. This is obviously a subject of importance to pre-clinical teachers as well as to students. One individual suggested that plastic teeth help develop perceptual motor skills, but are inappropriate tools to develop the student's understanding of tooth structure. However, there was general disagreement from other interviewees. The most common opinion was that plastic teeth are not good tools even for the development of perceptual-motor skills, because they are made of softer materials than natural teeth, and do not provide the same tactile feedback. Artificial teeth are also a problem when teaching students how to manage dental cries, because they do not accurately simulate its presence, or its extension through the tooth. This is significant because students do not understand how to manage dental caries in patients, a fact that has implications for patient safety.

TRANSITION

There were relatively few direct references to transition that have not already been discussed in relation to fidelity. It indicates, I suggest, that teachers give relatively little thought to this component.

Issues of transfer and transformation did surface, but mostly in the form of barriers. One teacher commented on the *"… huge gap between … phantom head and clinical activity"*. Another suggested that *"phantom head exercises aren't contextualised"*, a comment that shows some recognition of the role of fidelity and authenticity in transfer. Another commented on the effect of cognitive load saying that *"there seems to be some sort of complete brainstorm that happens to them the minute they pick up the handpiece and are working on a real live patient for the first time."*

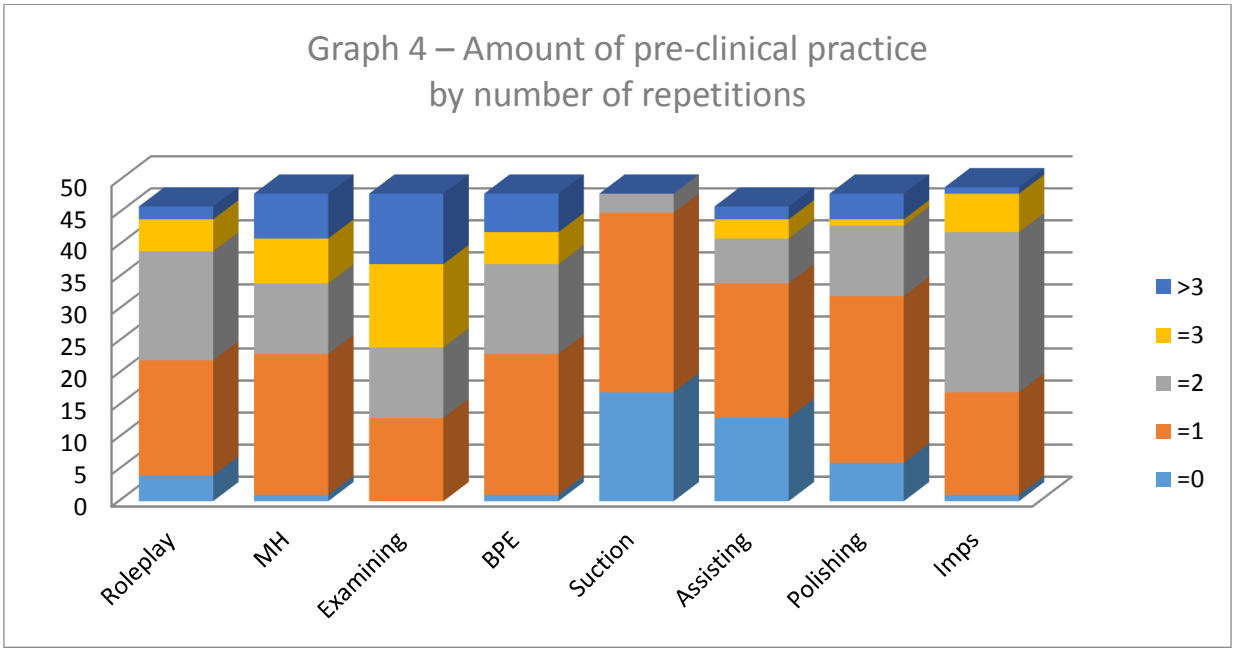
Teachers explained lack of transfer, not to a lack of physical fidelity, though there was some element of that, but to the nature of the pre-clinical environment. The first comment suggested *"… a safe environment and quite relaxed … I can't know that for certain but I perceive the students to be fairly relaxed, they're not dealing with a person on the end of their drill so they can be a little bit more gung-ho."* The second comment was that, because the pre-clinical environment is relaxed, students treat it as a *"form of a game … I don't think they're thinking patients, not very obviously anyway."*

While most interviewees were happy to remedy this by moving students onto patient care as quickly as possible, there was some disagreement over this policy. One individual suggested that the school was in too much hurry to confront students with patients, though the reasoning behind this was not explained. Most, however, were happy with the concept of an intermediate stage between the "phantom head" and the patient. For example, one commented that *"we put mannequins in the clinic … so they have more of a sense of … clinical environment. That helps a little bit, getting more used to working with a totally reclined patient which they can't really get the same sense of in phantom head."*

SECTION FOUR – QUESTIONNAIRE ANALYSIS

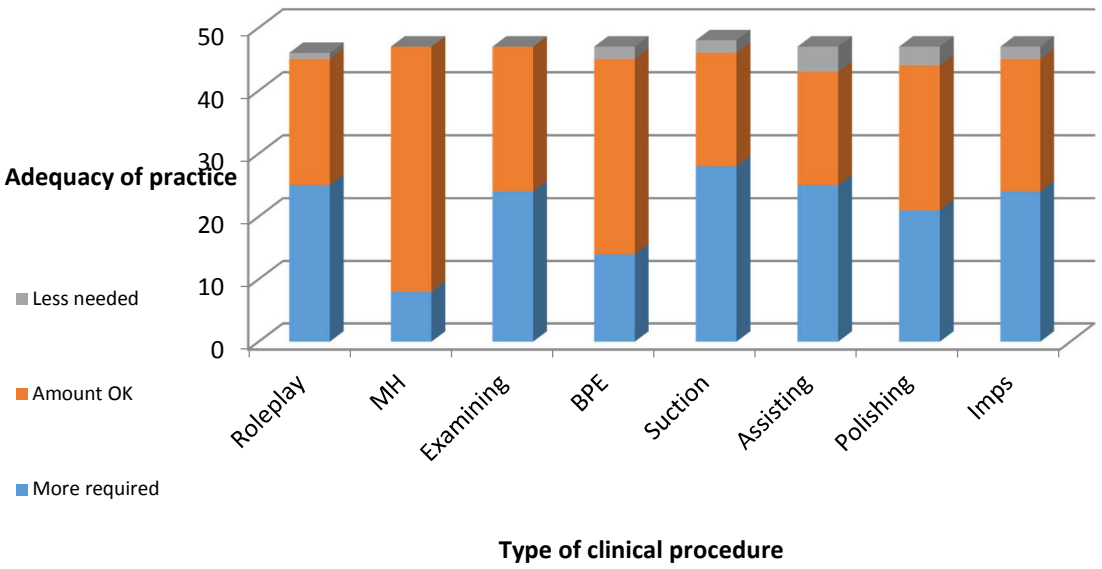
This section details the results of the questionnaire evaluation. Seventy-seven questionnaires were issued, one to each member of the 2nd Year of the BDS programme. Forty-nine were returned, a return rate of 64%. The questionnaire was divided into three parts – each of which had a slightly different purpose. The following three sub-sections contain the results obtained from each part.

The purpose of the first section was to understand the breadth of pre-clinical practical experience the student is experiencing and its usefulness. The first task was to establish extent and adequacy. Graph four below indicates the number of exposures to some key clinical procedures.



It shows that most students had one or two exposures to most of the key procedures. Very few had more than three, except as regards the intraoral examination. A significant number of students in each case had no practice. The paired question was that of perceived adequacy. As graph five shows, opinion was split on a roughly equal basis for most procedures, between adequate and more required. Very few students requested less practice.

Graph 5 – Student opinion on adequacy of practice



Part one of the questionnaire also contained a pair of three word summary questions whose aim was to identify student reaction to practicing on colleagues and on "phantom heads" in the clinical setting. Responses were analysed by word frequency, using NVivo8©. Words with a count of more than one are displayed in table 4. The word "useful" tops both lists by a significant margin, and the majority of the words used are positive in tone, indicating student appreciation of their experience. However, comments such as "unrealistic", "not like patients", "limited" suggest that some students recognise the limits of this simulated practice.

Table 4 – Student opinion of practice in the clinical setting

	Count	Describing the use of "phantom heads" on clinic	Count
Useful	21	Useful	24
Fun	9	Helpful	10
Not enough	7	Practice	7
Interesting	7	Fun	6
Practice	7	Challenging	5
Helpful	5	Good	5
More needed	4	Confidence	4
Realistic	4	Enjoyable	3
Clinical	3	Important	3
Enjoyable	3	Informative	3
Good	3	Boring	2
Informative	3	Educational	2
Limited	3	Experience	2
Not like patients	3	Frustrating	2
Daunting	2	Interesting	2
Experience	2	Long	2
Important	2	More	2
Reassuring	2	Different to patients	2
Relevant	2	Practical	2
		Preparation	2
		Realistic	2
		Unrealistic	2
		Valuable	2

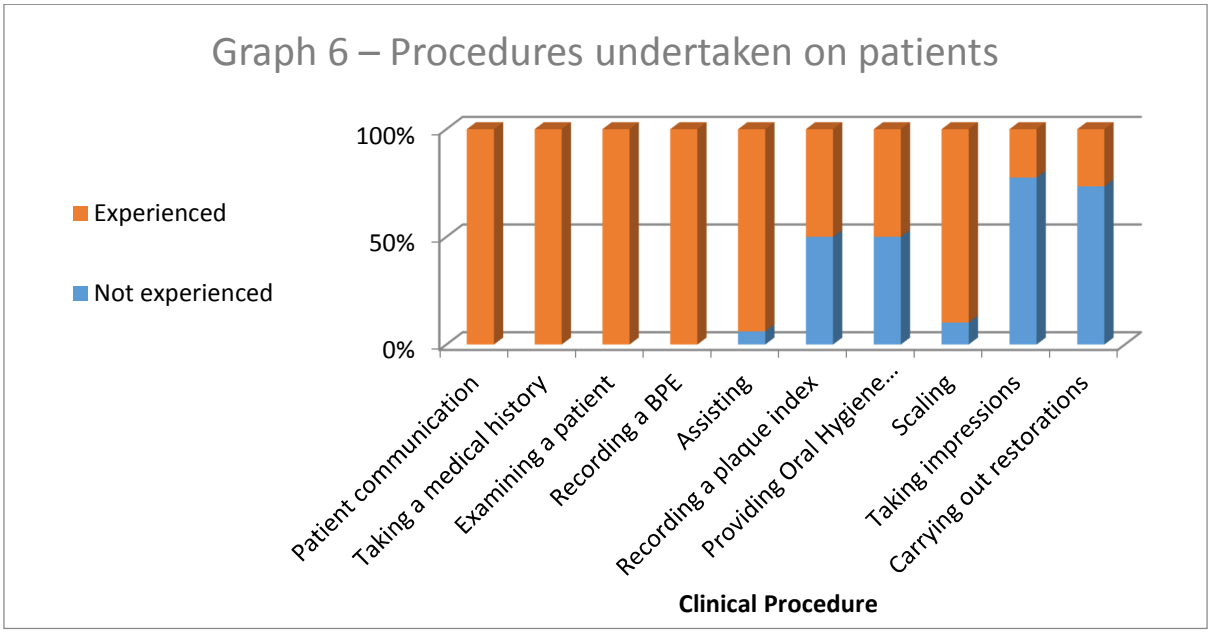
Students were also asked, in an open question, for suggestions on how the practical sessions might be managed better. The resulting comments underwent thematic analysis using NVivo8.

The four most common themes were: more practice/practical sessions (10 refs), no change (7 refs), higher staffing ratios (5 refs) and more practice on colleagues (5 refs). Also mentioned, with lower frequency were increased authenticity (2 refs), use of demonstration (2 refs), flexibility (2 refs), pre- and post-session debriefing (2 refs each).

Many of these suggestions were appropriate ones, for example *"make them* [practice sessions on "phantom heads"] *more scenario oriented", "ensure a clear target for each session with a summary sheet"* or *"more flexible in what students want and feel they need to work on".*

Questionnaire – Part two

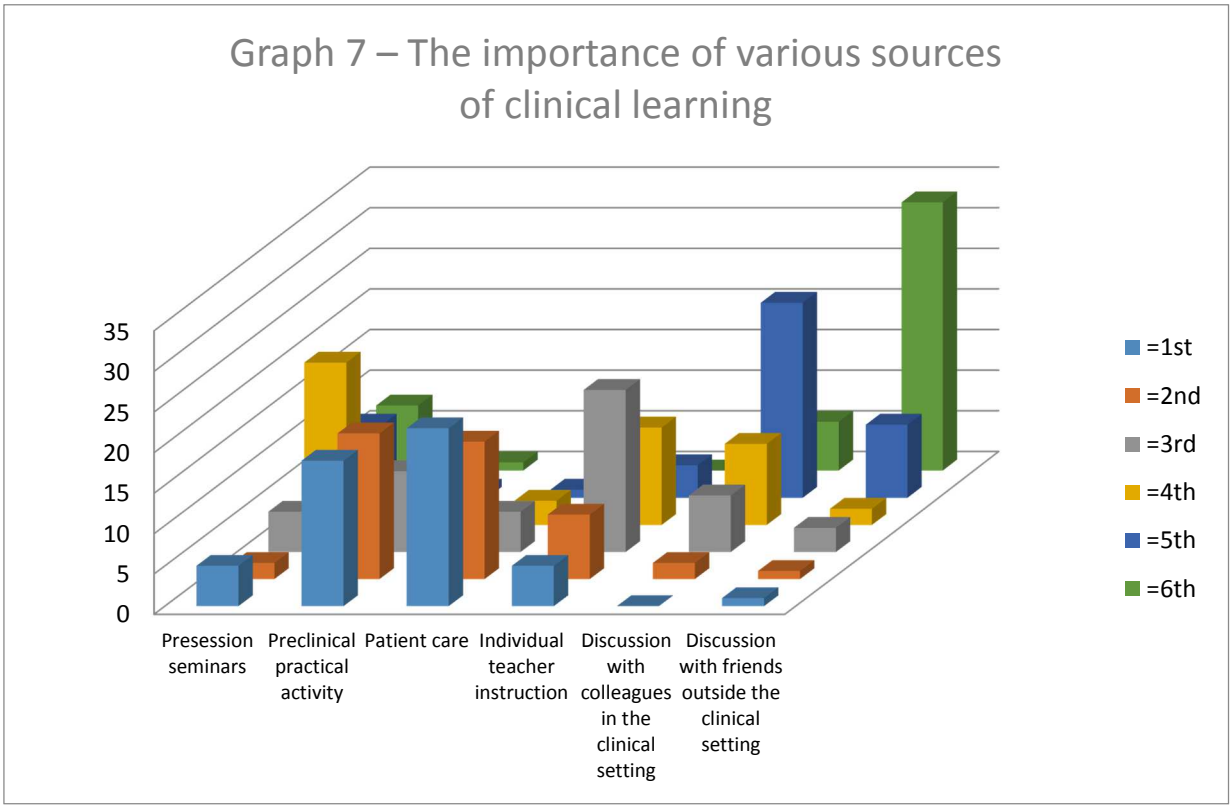
The second section was designed to evaluate early clinical practice. One of the questions was designed to understand the sorts of procedures students were undertaking during early clinical practice. This has limitations related to student memory, but the range of procedures permitted to students was limited, so the answers to the question are thought reasonably accurate. As graph six demonstrates all students who responded to the questionnaire had experience of patient communication, medical history taking, patient examination and recording a BPE.



Most also had experience of assisting and scaling teeth. For other procedures the level of experience is significantly less. A comparison of pre-clinical practice with

clinical experience shows that, while some students have had significant experience during the transition course, others may be going forward to the next clinical year with little experience in some of the fundamental skills of clinical practice.

Students were also asked to indicate the importance to their learning of a variety of components of the P4P transition course. Graph seven identifies the overwhelming importance of hands on practical/clinical activity in the view of students.



In a further open question, students were also asked to comment on ways in which the pre-clinical practical sessions had influenced their treatment of patients. Not many participants answered this question, so the results have no statistical significance. The answers that were given were analysed thematically and grouped into the following themes: skill development (2 refs), confidence (2 refs), familiarisation with the clinical environment (1 ref), learning (2 refs), practice (7 refs) and patient safety (1 ref).

The purpose of section three was to evaluate the opinion of students on their skill transfer from pre-clinical practice to patient care. All questions were intended to relate to the point of transition, though subsequent clinical activity will certainly have influenced the results. The section contained three 10 cm attitude scales relating respectively, to academic understanding of clinical procedures, ability to undertake clinical procedures and confidence levels. Results are displayed in table five below:

Table 5 – Student self-assessed understanding, clinical ability and confidence levels

	Academic Understanding	Clinical Ability	Difference (Understanding – Ability)	Confidence levels
Mean	5.15	4.78	0.37 (Range +9.0 to – 0.36)	4.11
Sample standard deviation	2.16	1.95		2.01

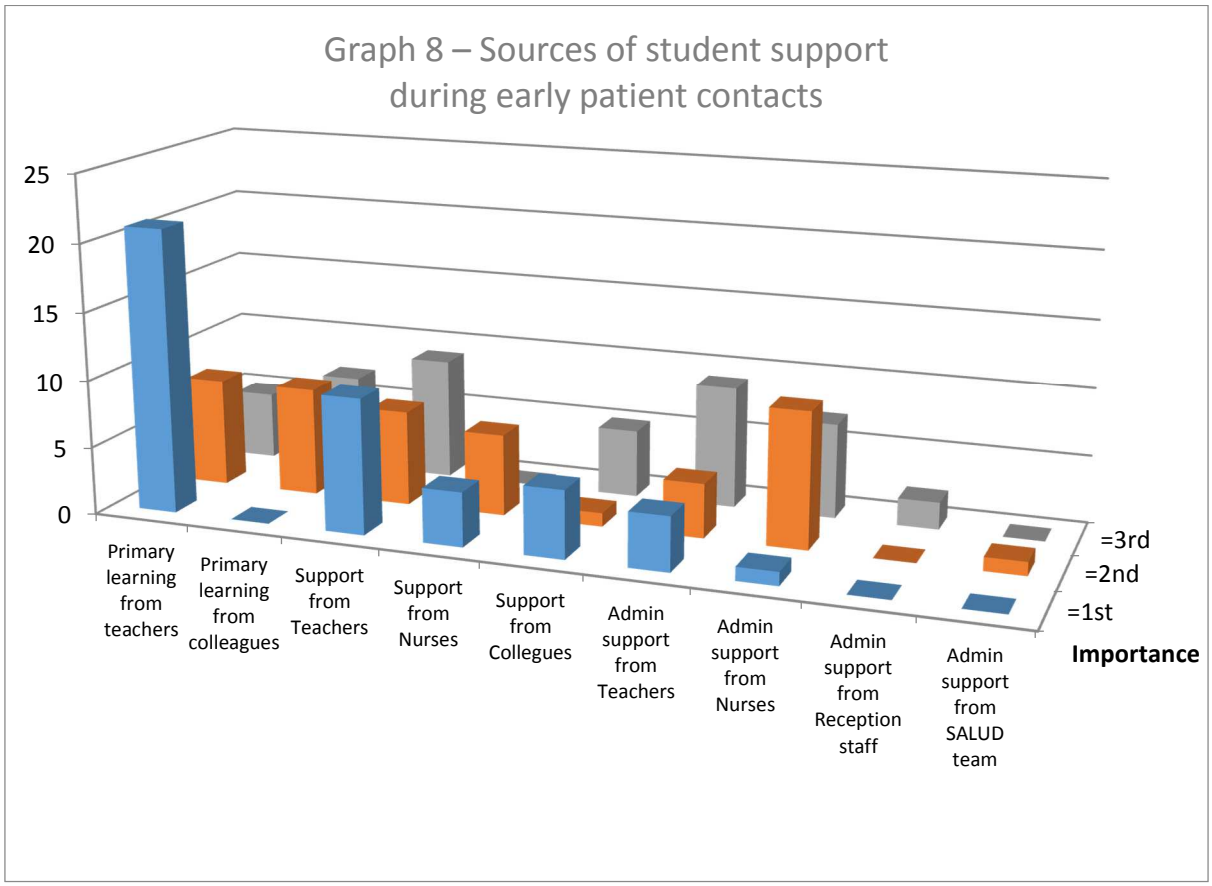
These figures, in particular the large range in their differences, seem to indicate that student understanding and clinical ability were only partially related. They also indicate the large variation in perceived confidence levels felt by students as they begin patient care.

This section also included a 3 word summary question asking for student impressions of their first patient contacts. As with previous 3 word summary questions, this question was analysed by word count. The questionnaire took place in July 2013, after several months of patient contact, so must be treated with some caution. Nevertheless the range of words used provides a fascinating insight into the student reaction to early patient care. All of them have been included in table 4 below, even those which occurred only once. To represent participant impressions in a more rounded way, individual words are aggregated into groups with similar meanings.

Table 5 –Three word summary of first patient contacts

Negative Words	Count	Positive Words	Count
nervous	23	improving	1
scary	6	gaining	1
nerve racking	4	useful	1
stressful	3	helpful	3
Anxiety	1	experience / experiences	2
Awkward	1	getting better with experience	1
Frantic	3	referrals	1
Mess	1	good experience	1
Lost	1	history	1
Pressure	1	practice	1
Pressured	1	confidence	1
Terrifying	1	learning curve	2
Daunting	1		
Confused	1	interesting	3
Shambles	1	new	1
slow	1	great	1
unprepared	2	fine	1
underprepared	1	different	2
dull	1	better	1
hard	2	easy	1
		important	1
more	2		
more patient contact would be useful	1	educating	1
slightly pointless	1	encouraging	1
		enlightening	1
being judged	2	eye-opening	1
supervisors should be more understanding	1	fun	1
		exciting	8
		relief	1
		satisfying	1
		rewarding	2
		fulfilling	1
		rapidly	1
		managed well	1

Student anxiety is a well-recognised factor during initial patient contacts. It is evidenced in the table above, and well documented elsewhere (Kieser and Herbison, 2000) (Piazza-Waggoner et al., 2003, Stewart et al., 2006). Students were asked to indicate the three most important support components (from a proposed list) during those early patient contacts. Graph eight below indicates the importance of clinical teachers as a source of learning but their role in supporting the student is more equivocal. In this context, it is worth noting the contribution of both peer and dental nurse support.



This chapter documents the results of the study in four sections, and it also provides some initial comments on them.

The first section finds little correlation between pre-clinical and clinical assessment results, suggesting that performance in the pre-clinical setting is not a good predictor of performance in the clinical one.

The second section related the findings of student focus groups in the areas of purpose, learning, fidelity and transition. Participants expressed the usefulness of the pre-clinical course in the development of perceptual-motor skills and confidence, allowing them when finally on clinic *"to concentrate on the patient"*. While there was some recognition of the role that simulation played in patient safety, this did not figure prominently. Unsurprisingly, participants had a great deal to say about learning, covering a variety of topics including coaching and demonstration, assessment, duration and frequency of practical sessions, and motivation. They particularly highlighted the importance of relationships with their teachers. However, the topic of reflection was almost completely absent from the student discussion.

Fidelity was seen as important, particularly their lack of experience on real teeth, but participants also recognised the psychological impact of treating real patients, an impact that is not present in the "phantom head". They also commented on the level of complexity presented by patient care and by the clinical environment, which is also not a feature of the pre-clinical setting. The importance of fidelity is illustrated by noting that almost all of the improvements suggested by student participants were fidelity related. Students recognised the concept of barriers at various stages of their

development, and transition to clinical activity appears to involve surmounting, several including physical, psychological and cognitive fidelity and also cognitive load. One significant effect of the managed transition appeared to be a reduction in the size of each of these barriers, and it was commented on positively.

The third section related the findings of staff interview, again using the structure of purpose, learning, fidelity and transition. Staff were in agreement with student participants regarding the role of pre-clinical dentistry in the learning of perceptual-motor skills. Standardisation generated a degree of discussion of its importance in assessment. Most teachers considered the pre-clinical course an inadequate preparation for patient care. They also agreed, for the most part, with students about the negative effects of low "phantom head" fidelity on learning, and they also described some of the same solutions; for example that of imposing clinical scenarios on pre-clinical procedures. Staff appeared to give little thought to student transition, although they did recognise the presence of barriers, and there was some discussion over the correct timing of the student graduation to patient care.

The final section describes the findings of a questionnaire on the managed transition. This was administered to an intake of Year 2 BDS students, but with only a 64% return rate. The first part of this assessed the amount of preparation in the form of practice on the "phantom head" and on colleagues. This was limited, but judged useful by respondents. The second part was designed to evaluate early clinical practice. Respondents identified clinical and pre-clinical practice as the most important components of their learning, far ahead of any socially mediated learning such as seminars and discussion with colleagues. The final part of the questionnaire

was designed to evaluate skill transfer. The results should be treated cautiously, as they rely on self-assessment. However, students rated their ability to understand academically higher than their ability to perform clinically. Students were also asked to evaluate their first patient contacts, albeit from a distance of several months, and their responses clearly show the fascinating range of emotions associated with beginning patient care.

The next chapter comments on these results, relating them to relevant literature. It returns to the study's primary framework, of purpose, learning, fidelity and transition to these.

CHAPTER SIX – DISCUSSION

The purpose of this chapter is to combine study results with findings from the literature in a discussion mainly centred on the research questions identified in chapter three. It begins with individual discussions of the study findings relating to purpose, learning, fidelity and transition. However, it has been evident throughout this study that purpose, learning, fidelity and transition cannot be treated as independent phenomena. Their integration into a coherent account begins with the summary to this chapter, and is expanded further in chapter seven.

SECTION ONE – THE PURPOSE OF PRE-CLINICAL DENTISTRY

This section discusses the findings of the study as they relate to standardisation and student confidence.

What is the effect of standardisation on student learning?

Standardisation is integral to pre-clinical dentistry in its present form. It is also built into some of the third generation simulation technology that is just beginning to appear in dental schools. There are several aspects of this trend that need recognition. There is, for example, the political one of concern over healthcare standards in the UK. In this context standardisation of assessment has a role in protecting the school from the increasing threat of litigation. There is also an evidence-based agenda to healthcare education which promotes a standardised approach to patient care. There is also an ethical component to standardisation. The patient care model of learning creates a significant ethical dilemma for the educator and the professional regulator. In this context

standardisation of knowledge and a focus on assessment reliability, is seen as a guarantor of patient safety, when being treated by students. For example, a common justification for standardised cavity shape is that it enhances handpiece control. Finally there is the strand of thought that identifies standardisation with reliable assessment. Of the many reasons for standardisation, it can be argued that this is the primary one at the level of the individual pre-clinical course, because reliable assessment allows the school to assert that the student meets required standards. Indeed, this was suggested by one of the pre-clinical teachers in the study.

According to student focus group participants, standardisation is important in identifying the poor performer and the areas in which he/she needs remediation. Other than for these reasons standardisation was viewed negatively by all students, and some staff, participants. Clinical performance is highly dependent on the development of individual and personal skills, gained through personal experience. Such dependence on personal experience appears at odds with the formalised, standardised learning experience offered by pre-clinical dentistry. Participants linked their dislike of standardisation to a lack of clinical fidelity, suggesting that this limited their exposure to clinical reality and restricted the skills that they were able to develop. Their most significant issue occurred with standardised cavity preparation. Many of them completed the pre-clinical course unable to manage dental caries in patients. In part this was because they had not encountered in the plastic teeth used in the "phantom head", but it was also caused by their standardised approach to cavity cutting which rendered them unable to adapt to clinical variation.

The focus on reliability appears comes at the expense of validity of assessment, and a lack of clinical reality in caries management, both of which are affecting student

learning. It seems that dental educators are offered a choice between student learning and reliable standards, and need to ask whether standardisation is justified. An obvious question to ask is whether the pre-clinical course function could without standardisation. Apprenticeship based education flourished for centuries without it, so learning and assessment is possible in a non-standardised setting, but standardisation and reliability are so entwined in modern educational practice that this is unlikely ever to happen. Are there alternatives? The study suggests that assessment of student performance may actually be dependent on two different sets of criteria: one rational and standardised, the other intuitive and personal. This second set of criteria are perhaps behind the assertion of Chambers et al. (1997, p739) that informal judgement is more predictive of subsequent clinical accomplishment.

Does the pre-clinical course have a role in reducing student anxiety about beginning patient care?

Simulation literature from other clinical domains appears to show a relationship with increased confidence, but the nature of that relationship is not understood, and its measurement is fraught with methodological difficulties. In restorative dentistry measurement is equally difficult, and drawing any definitive conclusions from the data is problematic. Experience suggests that, for many students, anxiety levels are very high as they begin patient care. This is not unexpected; restorative dentistry places a large burden of responsibility on the operator, and students are required to assume that burden at a very early stage in their clinical careers. What did the data say about the relationship between the "phantom head" simulation and clinical confidence? Firstly that at the point of beginning patient care, confidence levels did not appear to be

uniform. Most participants confessed to remaining underconfident, while a few appeared to develop confidence to dangerous levels.

The most significant, and most consistent, finding was that, without the "phantom head", early patient care would have been a "nightmare". While conclusions must be tentative due to the nature of confidence measurement, it seems that the "phantom head" confers a degree of confidence because it allows the student to develop appropriate perceptual-motor skills. However, there is potential for confusion. All student cases except one undertook a managed transition. By intention, this may also have had an effect on student confidence. Separating the effects of the "phantom head" component and the clinical practice component, as contributors to student confidence is not possible within the limits of the data collected by this study.

SECTION TWO – LEARNING AND ASSESSMENT

The study adopts cognitive apprenticeship as a learning framework, and it will be helpful at this point to reflect on the merit of that choice. Issues that surfaced in student focus groups included the role of practice, particularly practice in context, and the concept that clinical teachers held tacit knowledge. There were also a number of comments on the need to apply academic knowledge to clinical activity. Cognitive apprenticeship offers a useful framework to understanding each of these concepts. It is claimed by some to promote *"the integration of knowledge, the conditions under which that knowledge applies, and the culture in which the knowledge is used"* (Taylor and Care, 1999 p32), offering a set of useful teaching tools to help the student through the period of transition.

Does the study make any useful contribution to understanding pre-clinical learning?

The study revealed several facets of pre-clinical and clinical learning. Two concepts stand out in particular and are discussed here.

The first of these relates to the apprenticeship model of learning. During the 19th Century dental education made a conscious move away from the apprenticeship learning paradigm, to a more academic (and standardised) education model. In the UK one of the cause of this move was public unease at the informality of traditional apprenticeship learning; unease which precipitated a move towards more centralised "educational" control of many professions. It is an academic model which remains a mainstay of dental education to the present, as evidenced in this study by the desire of staff to develop students' theoretical knowledge prior to any practical activity. But it is a model which prioritises academic knowledge over skill learning, and it is a model which is not supported by student comments in this study, which hint rather at a desire for practice led learning. This does not imply a lack of need for propositional knowledge, but an implication of the situated learning paradigm is that *"… learners cannot do much with lots of overt information… outside the context of immersion in actual practice. At the same time, learners cannot learn without some overt information; they cannot discover everything for themselves"* (Gee, 2007 p120). The supposition is that teacher input is practice led, but, although there was some evidence from the study of coaching and demonstration, this appeared to be limited in extent. The apprenticeship model has a great deal to offer in terms of clinical teaching and learning, and perhaps it is time to revisit it and invest in dental curricula that are more practice led.

The second concept is that of reflection. An accepted component of learning in most models, the concept only surfaced once during the whole series of student focus groups. Does this mean that students of dentistry do not reflect? This assertion is not unusual, and undergraduate reluctance to reflect has been commented on elsewhere. However, we should not confuse reflection with articulation. Articulation is a process of expressing personal reflection, and its absence has been taken as an indicator that reflection is also absent. Is this justified? It seems as likely that it simply indicates an unwillingness or inability to articulate. It is common practice for articulation to be used as a means of assessment, but if the relationship between reflection and articulation is not clear, the use of articulation as an indicator of reflection would appear to lack foundation.

How well does pre-clinical simulation prepare the student for clinical activity?

From the student viewpoint, pre-clinical simulation was absolutely vital as a precursor to clinical activity. Its main outcome was to develop the specific perceptual-motor skills required for the manipulation and control of dental instruments and the preparation of tooth cavities. This helped them cope with the transition because the use of dental instruments felt "natural", and were one less concern during early patient care.

All participants recognised the otherwise limited nature of pre-clinical learning, highlighting obvious omissions to the clinical skill repertoire such as patient communication and patient management. Student participants also identified less obvious ones such as dealing with time pressure, working as a member of a team and dealing with the complexity of clinical activity. Pre-clinical simulation is, by intention, a partial task trainer. It is also limited because it is a simulation, and simulation is by

definition only a partial representation of reality. As a result the student gains only a partial picture of patient care. This has advantages in reducing the cognitive load for the student during pre-clinical activity, but means that the student is less well prepared for the complexity of clinical activity

The pre-clinical course offers increasing complexity over time as students progress from simple cavity preparations to more complex ones, but it does not, by itself, offer the student opportunities to gain personal knowledge of the complexities of patient care. In particular clinical decision making appears quasi-inexistent. The traditional answer to this need is that students learn most of their clinical skills during, and as a result of, patient care. This limited view of pre-clinical dentistry ignores issues of student transition and patient safety. In medicine and nursing there are a variety of simulations which reproduce the patient interface to varying extents. Perhaps some of these would be useful additions to the dental pre-clinical course, offering increased challenge and exposing the student to the clinical interactions missing from the traditional curriculum. As an example, student focus group participants expressed a wish to be enrolled on a patient communication exercise after seeing their medical student colleagues take part in one of these.

The focus on teaching product rather than process also received criticism. As one student participant put it, *"They tell you what to do but not how to."* A number of factors outside the control of pre-clinical teachers contributed to this. Low staff – student ratios are significant, as is the nature of the working space – the "phantom head" simulation of the mouth restricts easy access so that it can be difficult for an observer to see what the student is doing. But low staff-student ratios are not compatible with apprenticeship

teaching, and teaching for product rather than process has potential to affect the teacher's ability to surface tacit knowledge, with potential effects on student learning.

How does a managed transition affect student preparedness for clinical practice? Do students perceive the blended learning approach as offering "authenticity"?

The managed transition provides a partial answer to these limitations. It is possible because not all clinical procedures pose equal risks to patient safety. Many dental educators allow students to practise less risky procedures, either on phantom heads set in dental chairs, or on each other as simulated patients, before practicing them on real patients. It allows both practice of clinical skills, and development of a personal knowledge that is different to that provided by the "phantom head" alone, though the range of clinical practice is inevitably limited by time and ethical considerations.

It exposes the student to a greater range of clinical skills because it takes place in a dental clinic. Students work together in operator/assistant pairs, so that they gain experience of dental teamworking. They also role-play many of the administrative tasks that are required in actual patient care. Student response to this was generally positive. Because students carry out clinical tasks on each other, the managed transition manages to provide some authenticity while still breaking clinical practice down into simpler components. According to participants, it increased familiarity with the clinical environment, bringing clinical practice closer and more personally relevant. It allowed the student to practise teamworking and clinical administrative skills. It also had a self-reported effect on confidence. It provided students with a scaffolded introduction to patient care, though unsurprisingly the words scaffolding and coaching were expressed as support and teaching. Also unsurprisingly, clinical teachers were considered to be the

most important source of scaffolding and coaching, though dental nurses and student colleagues were also significant. Even students who had not undergone a managed transition (case BDS1) considered the concept favourably, but interestingly were not all in favour of early patient contact. The reasoning behind this was the perceived need to accumulate sufficient theoretical knowledge prior to beginning patient care.

An additional benefit was the reduction of the step size between pre-clinical and clinical activity. Several participants made reference to transition as a jump; the metaphor seemed to be one that they were comfortable with. The size of the jump, or step size, appeared to be important to them, in that transition appeared easier if the step size was small, and, importantly, if they made it for themselves. While most students felt underconfident about their first patient contacts, the managed transition appeared to reduce the feeling of discontinuity and improve confidence.

Authenticity may be related to step size. Is the managed transition authentic in part because it reduces the step size in the transition to clinical activity, increasing student confidence? Nevertheless, in spite of step size reduction, a step always exists. Student participants clearly recognised that simulation, however realistic, can never replace reality, and that *"nothing can prepare you for seeing that first patient."*

Is pre-clinical assessment a valid judgement of student clinical ability?

It is supposed, by stakeholders in the education of students of dentistry, that pre-clinical assessment is, to some degree, an indicator of student clinical ability and hence of patient safety. There is no other possible interpretation of the GDC requirement that the student be *"… assessed as competent in the relevant skills … prior to treating patients"* (The General Dental Council, 2012 Standard 1.1).

However, this study and others found little correlation between pre-clinical and clinical performance across all component areas of clinical activity. While this study only involved one group of BDS students, and the reliability of the data is questionable, it appears to reinforce the findings of the previously mentioned studies by Chambers (1987) and by Curtis et al. (2007), questioning the link between pre-clinical and clinical performance. In addition, suggestions of the low validity of pre-clinical assessment come from focus group participants in this study. A possible explanation for the discrepancy between pre-clinical and clinical performance is that pre-clinical and clinical assessment use different criteria. While in the pre-clinical laboratory, the student is asked to learn and work to rigid outcomes, clinical aims are more fluid, and satisfactory outcomes can vary widely. Pre-clinical assessment, in its current state, does not require the student to reproduce the fluid nature of clinical thinking, rendering it doubtful as a predictor of clinical performance. In defence of this statement, I cite the assertion by all staff (except one) that they could predict, very early in the pre-clinical course, students who would be high performers clinically. This agrees with the findings of Chambers et al. (1997 p739) who suggest that staff use personal criteria based on their clinical experience, and that this subjective judgement has better predictive validity than criterion based judgement. The one pre-clinical teacher objecting to this concept, did so on grounds of assessment reliability, not on those of validity.

Standardisation appears largely a result of concerns over reliability. But the desire for reliable assessment is often in tension with its validity. In this case I suggest it is because reliability is best promoted by rigid, pre-clinical assessment criteria, while validity requires fluid assessment outcomes more in keeping with clinical reality. Until better pre-clinical assessment is developed, this tension will continue to exist.

As expected from the anecdotal evidence (see chapter one), fidelity appears of significant concern to students.

What aspects of "phantom head" fidelity gave participants most concern?

Participants readily identified physical, psychological and environmental fidelity concerns. They also identified complexity as a distinguishing clinical characteristic of the clinical setting, and that it was not reproduced in the simulation.

It was the low physical fidelity of plastic teeth that created most discussion during student focus groups, particularly with regard to their poor simulation of tooth tissue characteristics and of dental caries. There appeared to be two distinct aspects to this; the lack of tactile feedback offered by plastic teeth, and the inadequate reproduction of dental caries within them. Participants identified the lack of tactile feedback as affecting their perceptual-motor learning and ability to use dental cutting tools accurately on real teeth. The lack of experience with dental caries meant that participants were unable to recognise it, and manage it effectively in the patient.

One insightful student participant commented that the instruments they used influenced their learning. Certainly most groups remarked on the lack of continuity of some of the instruments across the transition, i.e. in the clinical setting they were expected to use different hand instruments and burs to those used in the "phantom head" laboratory. The differences were minor in nature, but still sufficient to cause initial uncertainty. It is noteworthy though, that this uncertainty was only transitory. It is probable that adaptation to the new instruments represents new learning, though the relationship

between that learning and transfer of skill from the pre-clinical laboratory is unclear. This is not unexpected because the transfer concept itself lacks clarity.

As well as physical fidelity, the "phantom head" lacks psychological reality. Many student participants commented, for example, that mistakes did not matter to them, because they could easily change the plastic teeth. Others identified a lack of emotional impact in the "phantom head", in contrast to caring for people, where the emotional component is significant. Yet others pointed out that the pre-clinical setting lacked teamworking between operator and assistant, yet teamworking is also a significant component of dental care provision. Perhaps most importantly, the pre-clinical course does not require students to make clinical decisions.

How engaging do students find the pre-clinical course?

Student participants expressed a number of negative comments about their motivation and engagement with the pre-clinical course, possibly because they were availing themselves of an opportunity to express negative feelings in a safe environment. They attributed these negative feelings largely to repetitive practice, criticism and low fidelity. They also identified their relationship with the clinical teacher as important to engagement as well as learning. Leaving aside this relationship, which is discussed elsewhere, the fidelity and relevance of the learning setting may have some bearing on this lack of motivation. An example is the admission of boredom associated with the repetitive nature of their practice, whose relevance students did not yet fully understand.

They also commented on the nature of the "phantom head", suggesting that pre-clinical simulation is so divergent from clinical reality that students are unable to suspend

disbelief, and treat it as real. The lack of realism does have advantages. It allows the student working on the "phantom head" to concentrate on the technical aspects of restorative dentistry to the exclusion of all other issues and it protects him/her from the psychological consequences of mistakes. Teachers have, of course, a range of techniques to stimulate and motivate students, but can the simulation itself be constructed to enhance motivation? It is possible, as evidenced by the popular pastime of computer gaming. But is it possible in the case of the "phantom head" simulation? Teacher approaches involve techniques such as stimulation, entertainment and interaction, approaches which are difficult to provide in current "phantom head" simulations. Keller's approach to motivation (1987, p2) of attention, relevance, confidence and satisfaction may provide some clues. But further research is needed on appropriate directions for this development.

In the view of study participants, would increasing physical/psychological fidelity improve the transition to clinical practice? If so what is their understanding of how this increased fidelity would be achieved?

The ideal pre-clinical simulation should provide the student with an "authentic" learning environment, one that is not only a faithful reproduction of clinical activity, but one that also has value to real life, is of personal relevance, and requires reflection, integration and collaboration. Unfortunately, participants in this study did not view the "phantom head" experience as "authentic". The managed transition was seen as offering more authenticity, yet even this was not perceived by participants to be the same as actual patient care.

We are still no nearer to understanding the relationship between authenticity, simulation and situated learning. Hung and Chen (2007 p2ff.) identify simulation as one of several "traditional" approaches to authenticity, but one which simply models current **explicit** knowledge. This suggests an alternative possibility, that an "authentic" learning environment is one which incorporates **implicit** learning opportunities in the form of tactile feedback, valid assessment criteria and discovery learning. A useful measure of the "authenticity" of pre-clinical dentistry might then be in its ability to promote implicit learning.

Student participants linked simulation fidelity to confidence through the managed transition, suggesting a role for fidelity and/or authenticity in developing student confidence. This is a tentative conclusion. However, most of the changes to the pre-clinical course suggested by student participants were directed at increased physical fidelity, indicating a desire for a higher fidelity simulation experience. In spite of the drive toward higher fidelity simulation in medicine and other domains, there is relatively little evidence that increasing fidelity results in better learning, though there may be a link between authenticity and learning, including some of the clinical learning issues discussed above.

SECTION FOUR – TRANSITION

Central to the transition to clinical activity is the nature of skill transfer. Chambers (1987, p238) attributes the lack of correlation between pre-clinical and clinical performance to "*failure to teach for transfer of skills to new settings".* But what is the role of transfer in the student transition and how might pre-clinical and clinical teachers teach for it? While there is some literature on the subject, this literature appears at times

inconclusive and contradictory (Foxon, 1994 passim; Liu et al., 2009 passim; Maginnis and Croxon, 2010 passim; Oskarsson et al., 2010 passim; Liaw et al., 2011 passim).

Does transfer take place from the pre-clinical setting to the clinical one?

Most focus group participants regarded their "phantom head" experience as essential preparation for clinical activity. This would seem to argue a degree of skill transfer. Yet the same participants suggest that the pre-clinical course teaches them perceptual-motor skills only, and does not contribute to their learning of any of the other components of patient care. This suggests that skill transfer, if it exists as an independent phenomenon, relates only to perceptual-motor skills. Several focus group participants commented on the "naturalness" they acquired in using dental instruments through working on the "phantom head", and that not having to consciously think about using their instruments helped their transition. There is some evidence from MRI imaging studies that skill learning places high initial demands on the cerebral cortex, but that "*activation in all frontal areas and in the inferior parietal lobule decreased significantly with practice"* (Kübler et al., 2006, p1331). Perhaps skill transfer takes place more readily where demands on the cerebral cortex are less, perhaps in relation to small cognitive step size?

Having said that, the study offers little evidence for the existence of skill transfer from the "phantom head" simulation, except as regards perceptual-motor skills. There is, in the data, some suggestion of learning being applied to the clinical context through retrospection. But retrospection requires adaptation and application, so is not, I suggest, a simple example of transfer. Lack of evidence for transfer supposes that transition to clinical activity involves the learning of new skills, and possibly the unlearning of

inappropriate phantom head skills. This is also supported by the data. Focus group participants emphasised the importance of the clinical setting over the pre-clinical one. A few separated the two settings completely, suggesting that almost none of their pre-clinical learning was appropriate to clinical activity. Most though simply pointed out that the beginning of clinical activity is the student's first opportunity to apply pre-clinical learning. This preference for learning in the early clinical setting argues a need for learning through clinical experience in a way that simulation cannot provide.

What barriers exist between pre-clinical and clinical activity?

The study adopts an approach based on transition rather than transfer, recognising that, far from the image of transfer as a straightforward application of previously acquired knowledge that most clinical teachers expect, transition and transformation are complex and multifactorial. The study also adopts boundary crossing as a metaphor for transition. But does the study provide any support for this approach?

The concept of transition as a series of boundaries was identified independently by more than one student focus group. They identified poor fidelity, lack of transfer, complexity, chronological distance, a lack of experiential knowledge, relationships with clinical teachers and cognitive overload as significant barriers. These require some comment, the most important of which is their temporary nature, suggesting the importance of learning during the early clinical period. For example, although students complained about differences between the instruments they used in the pre-clinical setting and those in the clinical one, they soon adapted. In this particular instance the barrier caused by physical fidelity appeared to be only of short duration. Increases in complexity proved a slightly more durable barrier. Some participants commented on the

stress caused by high cognitive processing demands. This is a common finding in the initial stages of learning a complex skill set, but the coping strategy adopted by some student participants, of ignoring the patient and focussing on their cavity preparation, has obvious dangers.

The importance of the student/teacher relationship to learning is well documented. In apprenticeship learning, and especially in the clinical setting, which is a very difficult learning environment for the student, the role of the teacher is a complex one. He/she must expose tacit knowledge from which the student can learn, and to guide the student through its complexities, while providing emotional support in what, for the student who is just making the transition to patient care, can be a very difficult learning environment. Part of that support involves listening for that which the student cannot say in front of the patient. For example, student participants talked about using code words to alert the teacher to their difficulties without alarming the patient. It also involves providing instruction or correction in a way that does not damage the student's relationship with the patient. It is unfortunate, then, that the clinical teacher was also mentioned as a barrier to learning. Some student participants described how they expected teachers to understand the limits imposed by their current lack of clinical experience, an expectation that was not met. They also described how, in some cases, teachers appeared to take skill transfer for granted, expecting the student to apply pre-clinical learned skills to patient care without difficulty, and ignoring the significant unlearning and relearning that the student is undergoing. Students also noted that some teachers, through teaching for product instead of process, surfaced relatively little of their personal knowledge.

The supposition of uncomplicated transfer also appeared to apply to academic knowledge. In the clinical setting it is usual for clinical teachers to ask students questions. This is seen as a way for the clinical teacher to help the student integrate academic knowledge into clinical activity, but the study suggests that questioning at the wrong time simply added to student cognitive load. Not only that, but according to student participants, those who could not answer such questions felt criticised. Some teachers are, of course, more understanding than others, and different students will have different needs and different coping mechanisms. But a willingness to engage with students and respond to their learning needs would seem a pre-requisite for a clinical teacher.

A discussion on barriers to transition would not be complete without mention of chronological distance. Students on both the BDS and the BSc programmes complete their pre-clinical course toward the end of the academic year; in the case of the BDS programme this is Year 2, in the case of the BSc programme it is Year 1. Some students are lucky to immediately encounter a patient in need of restorative care. Others face waiting several months, to the beginning of the next academic year, with inevitable consequences to confidence and perceptual-motor abilities.

Engeström's (2001, passim) expansive learning theory contains, in addition to the concept of barriers, a concept of boundary objects, including identification, coordination, reflection and articulation. Perhaps the student/teacher dyad can justifiably be interpreted as a boundary object. If so, the tools of apprenticeship teaching (modelling, coaching, scaffolding/fading, reflection/articulation and exploration) can also be considered as extensions of the dyad with potential to affect barriers. In other words,

they may have a potential role in "teaching for transfer". But what is teaching for transfer?

Does the study suggest how dental educators might "teach for transfer"?

Beach (1999, p110) comments that *"Transfer is difficult to intentionally facilitate. Learning transfer seems to occur on a daily basis throughout our lives, yet attempts at intentional facilitation are highly effortful and are often unsuccessful."*

Student participants suggested a number of changes to the course, in particular to the fidelity of the phantom head. But do these changes prepare the student any better than low fidelity, and do they enhance skill transfer? Participants also identified the more authentic managed transition as important. But was it important to skill transfer, or was its importance more related to student confidence.

However, if we switch paradigms and ask instead how we might teach for transition, questions of fidelity and authenticity become easier to understand. While it is arguable that the initial stages of skill learning are aided by standardisation, transition requires the student to encounter and manage complexity. By gradually introducing complexity over an extended period, the managed transition reduces step size for the student. In this paradigm fidelity becomes a means of introducing complexity, and authenticity a means of aiding the student to "suspend disbelief". The managed transition is part of this gradual introduction of complexity, and has a logical extension. Can that introduction be extended back in time into pre-clinical laboratory sessions?

A further issue in teaching for transition is the focus on product not on process. While this may work for students of dentistry with more clinical experience, because it

encourages the process of exploration, the study suggests its unsuitability for students in transition from pre-clinical activity, who require modelling, scaffolding and coaching. They also need to develop their own personal knowledge of restorative dentistry. For this, there needs to be a focus on sensory understanding of the restorative process, and teaching of process. Teaching by product is easier because it simply requires the teacher to provide feedback on what the student has produced. It takes less time than teaching for process, which involves demonstration and coaching. Describing product is easier than describing process, and as a result, teaching becomes verbal rather than tacit.

So how could pre-clinical teachers teach for transition? The study suggests six changes that might be of benefit:

- developing a more multidimensional approach to pre-clinical learning, by progressively introducing complexity;
- redesigning the simulation to improve engagement;
- including clinically relevant skills other than the perceptual motor;
- recognising that transition is process, one that is as much the responsibility of the clinical teacher as the pre-clinical one;
- teaching for process not product, and
- addressing the issue of tacit learning, and the surfacing of the teachers tacit knowledge.

The above discussion suggests a number of changes to pre-clinical courses that might improve the student transition to clinical activity, and identifies several areas which need further study.

Firstly, pre-clinical simulation needs to be recognised as a partial task trainer, providing a limited representation of clinical activity, implying a need to enhance or supplement the preparation it offers. It needs to offer a level of complexity adapted to student needs; beginning with simple cavity preparation, but increasing in complexity to include clinical activity such as decision making. A related issue is that of pre-clinical assessment. Based on standardisation, it offers reliability but not validity. One reason for a dependence on standardisation is that little attention has been paid to clinical decision making in dentistry. There is an urgent need to understand it better, because assessment and clinical decision have significant effects on both student learning and patient safety.

Secondly the teaching of clinical (or pre-clinical) activity is not primarily an academic activity, but a practical one. It involves teaching for process as well as product, and the surfacing of personal knowledge and bias for the student's inspection. In this context apprenticeship would appear an appropriate model of learning, but its development into a rounded curriculum needs work.

Thirdly, student transition appears to be helped by a managed transition. It reduces the size of the transition and may help reduce student anxiety. The pre-clinical teacher has a role in "teaching for transfer", but the more important aspects of transition appear to take place early during the student's clinical experience, so that clinical teaching

assumes greater importance. Teachers also need to better understand the nature of barriers that exist to transition, and teach accordingly.

Finally, the simulation used in pre-clinical dentistry could, with some redesign, offer better engagement. There is some evidence that engagement promotes learning, so research into improving engagement is an important avenue for further research

CHAPTER SEVEN – CONCLUSION

> "Students must provide patient care only when they have demonstrated adequate knowledge and skills. For clinical procedures, the student should be assessed as competent in the relevant skills at the levels required in the pre-clinical environments prior to treating patients."
>
> *Standards for Education (Standard 1, requirement 1), The General Dental Council, 2012*

INTRODUCTION

Given its importance to dental education, the relationship between pre-clinical simulation, student learning and patient safety appears remarkably unexplored. This study is an attempt to redress that deficit. It began with a simple question; does success in the preclinical course guarantee good clinical skills and patient safety, as the GDC document "Standards for Education" appears to require? The study has used a framework of purpose, learning, fidelity and transition in order to answer this question. One finding of the study is that these four constructs are closely interlinked and that the relationships between them are important to student learning. In this concluding chapter I discuss these interrelationships. I also comment on the limitations of the study. Some of the study findings have potentially significant implications for undergraduate restorative dentistry and these are discussed. The chapter concludes by identifying some areas for further study.

Purpose, learning, fidelity and transfer are constructs found in the wider literature on simulation. They were chosen to provide a framework for this study, partly because they surfaced frequently during comments by students of dentistry on the "Phantom Head" simulation, but also because a review of the simulation literature suggests that each of these different constructs is an important component of the simulation environment.

This study identifies interdependence between them. Examples of this include an implied relationship between standardisation in the preclinical laboratory and inappropriate rule learning; links between poor physical fidelity and inadequate learning seen in the use of plastic teeth, and participant requests for more realistic soft tissues on "Phantom Heads"; or the suggestion that clinical overlays to "Phantom Head" exercises would help make them more clinically relevant.

Authenticity as a unifying construct linking purpose, learning, fidelity and transition

The purpose of this section of the chapter is to explore the relationships between purpose, learning, fidelity and transition. The study appears to show a unifying theme of authenticity. Although authenticity itself is a poorly defined concept, it does contribute to our understanding of these relationships. For example, some student participants observed that it was difficult to think of their "Phantom Heads" as though they were real patients, but that when the same phantom heads were taken into the clinical setting, working on them felt more authentic. But why should this be the case?

One relationship between authenticity and learning is documented by Herrington et al. (2003), who comment on the significance of *"[t]he capacity of authentic learning settings to*

promote students' willing suspension of disbelief", suggesting that they can enhance *"the effectiveness of a range of learning settings"*. In the previous chapter I suggested another possibility; a mark of authenticity is the degree to which a learning setting promotes implicit learning. These possibilities are not exclusive, but the question of how they might link learning, purpose, fidelity and transition needs exploration.

It is easy to understand why the concept of "willing suspension of disbelief" could promote psychological fidelity. Medical simulation continually strives for more realism, for example in the complexity of physiological modelling available on medical mannequins, or the use of moulage to simulate patient injuries. The psychological impact of a simulation appears to be important in preparing the student to deal with reality; for example a high level of physical fidelity may have the effect of teaching the student to minimise their psychological reaction to injury. This may be important in helping the student subsequently in providing patient care with less danger of cognitive overload.

It is also easy to visualise under certain circumstances, a relationship between transition and authenticity. Using the metaphor of transition as boundary crossing, we can see that a managed transition allows the student to encounter barriers sequentially rather than simultaneously, reducing step size and its associated cognitive load. Without a doubt some of these barriers are procedural, and the managed transition is instrumental in teaching students the relevant procedures. But as important is the psychological transition required to treat a real patient.

In both settings mentioned above, authenticity doubtless enables the student to willingly suspend disbelief. But I suggest that it also provides the student with implicit learning

opportunities that may otherwise not have occurred, so that both have a place in cultivating the authenticity of the learning setting.

While the purpose of simulation is to provide an authentic learning setting for the student, there exists a degree of tension between authenticity and simulation. For example, student participants in this study all recognised the "Phantom Head" itself as a simulation. There appeared to be very little "willing suspension of disbelief" relating to work on the "Phantom Head" itself and, while there were many opportunities for implicit learning, these were limited to one aspect of clinical activity which was itself distorted by standardisation. As one participant commented *"Nothing can prepare you for it* [treating a patient]*. Not properly"*. From the point of view of both psychological fidelity and implicit learning, it would seem that the nature of simulation imposes limits on authenticity.

Nevertheless within those limits dental educators have a responsibility to prepare the student as well as possible for restorative clinical activity, so how could we improve the authenticity of preclinical teaching? Students in the study made some suggestions, such as using clinical overlays, but these are unlikely to be sufficient in themselves. Perhaps an answer can be found in computer gaming because, in most cases, these succeed by virtue of their immersive nature. As Gee (2007, p1) points out *"designers face and largely solve an intriguing educational dilemma… : how to get people, often young people, to learn and master something that is long and challenging--and enjoy it, to boot".* This is the challenge for those involved in preclinical dental education: to involve our students, to motivate them to learn, and to simulate preclinical restorative dentistry in a way that makes the transition to patient care safer for the patient and easier for the student. We

have been using the “Phantom Head” for 100 years, but we are still not providing as effective a simulated environment as that which PC game designers have managed in far less time.

SECTION 2 - A DISCUSSION OF THE LIMITATIONS OF THE STUDY

Limits to this study have been identified in several places in the narrative, the methods and the scope of the study. This section summarises the most important of these limits.

As regards the data, they have a number of limitations identified in the text. For example primary sources were narrative in form and some of the assessment results used appear to suffer from low reliability.

As regards the data collection methods, the study made extensive use of focus group narrative, the limitations of which were explored in chapter four.

As regards the scope of the study, I suggested in chapter four that multiple cases were a necessary feature of analytical generalisation through replication. A single case is insufficient grounds for generalisation and this study represents a single case, relating to one school and one teaching programme; results must be interpreted in this context. Further limits to the study include the international dimension. Different cultures have different approaches to pre-clinical simulation. Some dental schools use it more extensively in training programmes, while others use it less; yet others use different simulations such as the Moog© system and its virtual representations of tooth cavities with haptic feedback to the user. Comparative studies are necessary in the search for appropriate simulation and the appropriate mix of simulation and patient care.

Based on the results of this study alone, there are a number of questions that need to be addressed by dental educators. Four of these will be discussed here: the adequacy of the present preclinical course as a preparation for clinical practice; possible avenues for changes to preclinical teaching and assessment; the importance of the early clinical period in student transition and how clinical teachers might "teach for transition"; and finally, implications for dental education of the trend in healthcare education toward replacing clinical experience with simulation.

The adequacy of the present course

How adequate is the present preclinical course as a gateway to patient care and as a guarantor of patient safety? Results indicate that preclinical simulation is a necessary part of student preparation for patient care, but that this is primarily related to perceptual motor skill development and student confidence. This study casts doubt on the ability of preclinical assessment adequately to predict student performance in the clinical setting with consequences for its capacity as a guarantor of patient safety. There appear to be a number of reasons for this including standardisation cavity preparation and assessment, the fidelity of the simulation in terms of the skill range that it offers, the authenticity of the preclinical experience, and the complexity of the student transition to clinical activity. As a result, the preclinical course cannot, alone, be considered an entirely adequate preparation for clinical activity.

The study also considered the role of a managed transition in preparing the student for patient care. Within limits, this allows students to habituate to the clinical environment prior to beginning patient care and, according to students, provides a degree of

authenticity lacking in the "Phantom Head" laboratory. Whether because of greater authenticity or for other reasons, the managed transition appears to facilitate student transition and the findings suggest its value for routine use. But the managed transition also has another role. However authentic the simulation, the student still has to cross the barrier into clinical activity, a barrier significant for any student, no matter how well prepared by pre-clinical learning. A closer look at this barrier reveals not one barrier but several. These include lack of skill transfer, a dependence on rules in the absence of clinical wisdom and significant changes in the student's assessment criteria for clinical activity. On top of all these difficulties, many students experience cognitive overload until parts of the clinical process can be relegated to automaticity. The re-conception of transfer as boundary crossing may provide a theoretical framework within which to understand the transition from preclinical to clinical activity; the managed transition may have a role in reducing barriers in the transition to (mostly) manageable size by presenting them to the student sequentially rather than simultaneously.

Possible avenues for change

Does the preclinical course need to change from its present form? This study and other literature suggest that authenticity and a "willing suspension of disbelief" might be key to student learning. The study also supports managed transition as a means of generating that authenticity; however, some research needs to be directed toward ways in which authenticity of the "Phantom Head" itself might be augmented. What would this involve? Addressing physical fidelity, for example by using teeth with more realistic dental caries, may help the student in learning how to deal with dental caries, but is otherwise limited in scope. Should dental

educators follow their medical colleagues, where simulation training on high fidelity, computer controlled mannequins is now routine? Another possibility is to make more use of simulated patients in teaching communication, a point specifically identified by student participants? Or should educators invest in Hanako mannequins which provide a simulated response to dental treatment, even though student participants did not see any advantages to these? It is true that most of the improvements proposed by study participants relate to fidelity, but this was not the fidelity of virtual reality or the Hanako robot. In fact the push for increased physical fidelity through virtual reality is disturbing. It supposes that learning quality is related to physical fidelity. Yet there is little evidence of this in the literature except perhaps as it relates to increasing authenticity. Student suggestions for change were simpler; more "evolution" than "revolution", aimed at improving the psychology and complexity of the "phantom head" experience as much as its physical aspects.

Another possibility is to redesign pre-clinical programmes to reduce the dependence on standardisation. But this brings with it the need for more valid assessment. The study also suggests that the "phantom head" does not appear particularly engaging and that redesigning the simulation to increase engagement may promote student learning.

The importance of the early clinical setting

How important is the early clinical setting? The commonly held view of student transfer as a continuum from preclinical to clinical activity is problematic, and based on a simplistic view of transfer. The study offers a more complex understanding which I have

named transition, of which transfer, especially skill transfer, may be a component. But transition also requires a concentrated period of adaptation and new learning. As a result, the early clinical period is an important one for the student. In chapter six, I suggested ways in which clinical teachers might "teach for transition", but this is an area that needs more development and more practical answers.

Can restorative dentistry replace patient care with simulation?

Dental education has been characterised by a mix of preclinical and clinical practice since the development of the Fergus "Dental Phantom". But it also makes extensive use of practice on patients. There are increasing ethical concerns over the use of patients in healthcare education, to which one response has been the increasing use of simulation. Dental education faces the same cultural change as other healthcare domains and we can expect increasing pressure to replace, as much as possible, the patient care model of education with simulation. In this context dental educators should be asking themselves how this pressure will change future dental education.

The study identifies limits to the learning potential of simulation, suggesting that it cannot completely replace actual patient care. The patient care model has a vital role in dental education and it appears desirable for this to be maintained. The ethical responsibility of dental educators and their regulators is therefore to ensure patient safety as much as is possible.

Finally, I consider possible directions for developing our understanding of the relationships between pre-clinical simulation, student learning and patient safety. A number of such directions have been identified in the text of the report and key highlights are summarised here.

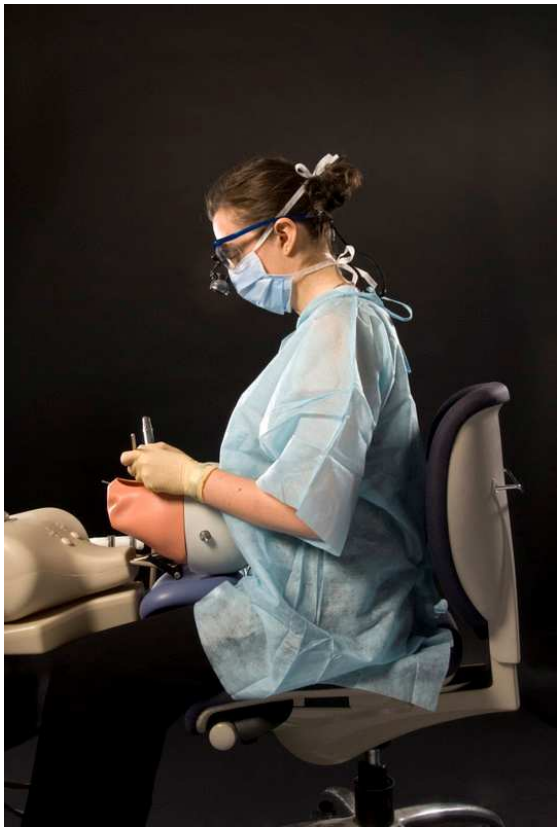
The first priority for further research must, of course, be confirmatory. The conclusions discussed here are based on only one study.

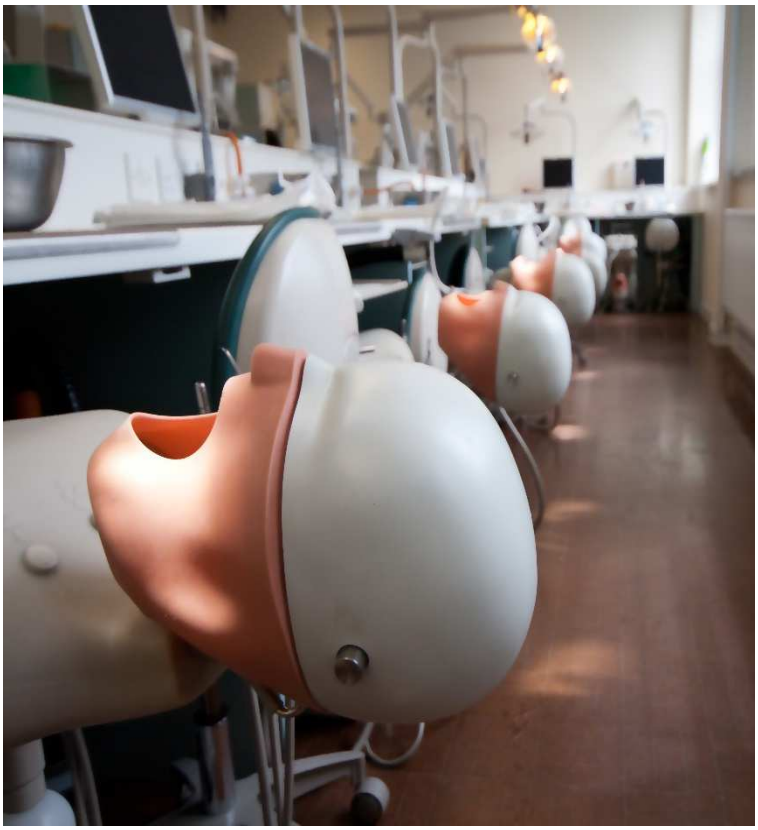
Then there are a number of underlying theoretical considerations that need further exploration, in particular the relationships between authenticity and fidelity, authenticity and learning, authenticity and transition.

On a more practical level, there is an urgent need to develop better preclinical assessment and to redesign the preclinical programme to improve complexity and engagement. These changes might involve radical changes to the phantom head simulation or perhaps extensions to the programme in order to incorporate other types of simulation.

A further area of study is the managed transition. A similar programme is already in use in a number of dental education programmes, but in those known to me that use is pragmatic with little theoretical underpinning. It requires both theoretical analysis and study of its effectiveness. Indeed, when compared with other fields of healthcare education, the dental education literature is generally poor in its discussion of theoretical underpinnings. Underlying this study is the intention to stimulate such discussion in the important area of preclinical simulation and patient safety.

APPENDIX ONE – THE PHANTOM HEAD





APPENDIX 2 – QUESTIONNAIRE

P4P is the name the school has given to the mix of phantom head, practical experience on clinic, and early clinical experience on patients, that you have taken part in during this past academic year. Phantom head has continued throughout the year, but the practical/clinical experience has divided roughly into two sections; prior to Christmas you undertook clinical practice on phantom heads and on each other, while learning how to use SALUD. From Christmas to the present you have undertaken limited patient care. The intended purpose of the P4P course is to improve your transition between phantom head and clinical dentistry.

This P4P course is a relatively recent development, and we need input from students to assess its impact. This questionnaire is designed to evaluate the structure of the practical and clinical components (not of the phantom head component). It also has a subsidiary purpose, in that the data will form part of a research project on transitions between phantom head and clinic. Ethical approval has been granted for this secondary purpose.

No personal information is required, so your responses remain anonymous. Any use of the data, either for course evaluation or for research, will only be in aggregated form. No member of the staff of this school will be able to trace comments to individuals.

Completion of this questionnaire is voluntary and you are under no pressure to take part.

If you choose to take part we want to thank you for your assistance.

Mr Martin Fugill

Version 2. 19/07/2013

Dental School Research Ethics Committee

CONSENT FORM

Title of Project:

Evaluation of the structure of the P4P course, including the research project titled:

Simulation and student transition in restorative dentistry

Name of Researcher: Martin Fugill

Please initial the box below to confirm your understanding and consent

I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions. ☐

I understand that my participation is voluntary and that I am free to withdraw without giving any reason. ☐

I agree to take part in the above study. ☐

_____	_____	_____
Name of Participant	Date	Signature
_____	_____	_____
Name of Person taking consent (if different from researcher)	Date	Signature
_____	_____	_____
Researcher	Date	Signature

Section 1: The purpose of this section is to evaluate your exposure to practical activity prior to treating patients.

During the practical sessions you experienced the following simulated dental procedures, either on phantom heads or on each other.

For each one, please indicate (in the column headed "Number of repetitions") approximately how many times you carried out the procedure during the practice sessions (as well as you can remember).

Was this amount of practice appropriate or would you have liked less or more practice? (Please write less, OK or more beside each one in the column headed "Amount of practice".)

	Number of repetitions	Amount of practice
Communicating with the patient (in a role-play scenario)		
Taking a medical history		
SALUD training		
Examining a mouth, charting your findings and entering data into SALUD		
Taking a BPE		
Learning how to provide suction from a dental nurse		
Working with an assistant including the provision of suction		
Polishing teeth		
Taking alginate impressions		

Please write down three words which summarise your experience of practising using phantom heads on clinic.

Please write down three words which summarise your experience of practising on colleagues

If you were in charge of these practical sessions, suggest how you might run them.

Section 2: The purpose of this section is to evaluate the importance of the various components of the clinical patient sessions

Since you began patient care in January, please mark all the clinical procedures that you have undertaken.

	I have done this
Communicating with the patient	
Taking a medical history	
Examining a patient, charting findings and entering data into SALUD	
Taking a BPE	
Taking a plaque score (O'Leary)	
Giving oral hygiene instruction	
Working with an assistant including the provision of suction	
Scaling and/or polishing teeth	
Taking alginate impressions	
Fillings	

Please indicate the order (1-6) in which the following were important to your learning of these clinical procedures:

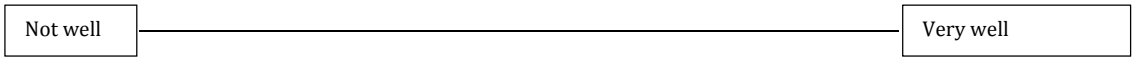
	Importance
Pre-session seminars (during the pre-Christmas practical sessions)	
Hands-on practical activity (not involving patients)	
Hands-on clinical activity (on your patients)	
Discussion with one of the clinical teachers	
Discussion with your colleagues during the clinical session	
Post-session discussion with friends	

Please comment on any ways in which the practical sessions prior to Christmas influenced the way you have treated your patients since:

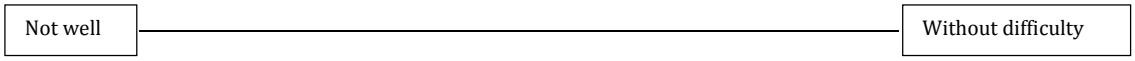
Section 3: This section is designed to evaluate your transfer to clinical activity in January this year

This pair of questions is designed to separate your understanding from your skill development **during your early patient contacts.**

On the scale below please indicate how well you understood the various clinical procedures at the point where you began to treat patients.

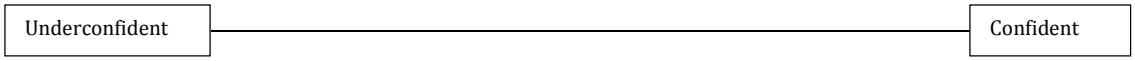


On the scale below, please indicate how well you could carry out the various clinical procedures at the point where you began to treat patients.



The remaining questions are designed to understand the role of your practical sessions in developing your **confidence** when dealing with patients.

On the scale below please rate your **confidence** levels at the point where you began to treat patients.



Please write down three words that described your first few patient contacts.

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