Students' Perceptions of two Different Dental Simulators

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Abstract

This research used the Theory of Planned Behaviour, the Technology Acceptance Model and general motivational models as the basis for investigating first-year, undergraduate dental students' perceptions of two dental simulators: a virtual reality based simulator and a traditional plastic-based simulator. Until now an empirical measure of student perceptions of dental simulators has not existed. This research aimed to address this gap by firstly designing an instrument that could be used to measure dental student perceptions a simulator before empirically testing first-year, undergraduate dental students' perceptions of two different dental simulators. The simulators were integrated into the year 1 undergraduate dental curriculum and were used to teach basic cavity preparation skills. A questionnaire based on the Theory of Planned Behaviour, Technology Acceptance Model and motivational models was developed. The students' initial perceptions of the simulators before they had used them were assessed using this questionnaire. After using the simulators for one term the students' perceptions were assessed again using the same questionnaire. Qualitative data regarding the students' experiences of using the simulators was also collected using worksheets and the questionnaire. Statistical testing was then carried out in order to determine the students' perceptions of the two simulators and how the variables from the different models were related to each other. Structural equation modeling was then used to develop a new model for the student perceptions of the simulators.

All of the models showed acceptable levels of model fit. The variables Cognitive Absorption Heightened Enjoyment, Cognitive Absorption Focused Immersion, Subjective Norms, System Quality, and Perceived Usefulness were significant in the hapTEL simulator pre-usage questionnaire. The variables Perceived Usefulness, Perceived Ease of Use, System Quality, Emotion and Interest were significant in the mannequin-head simulator pre-usage questionnaire. The variables Perceived Usefulness, Subjective Norms, Interest, System Quality, Emotion, Self-Efficacy Technology and Perceived Behavioural Control were significant in the hapTEL simulator post-usage questionnaire. The variables

Perceived Usefulness, Perceived Ease of Use, Task Value, Cognitive Absorption Heightened Enjoyment and Cognitive Absorption Focused Immersion were significant in the mannequin-head simulator post-usage questionnaire. The variables from the Technology Acceptance Model were found to be more useful in measuring the students' perceptions of the simulators than the variables from the Theory of Planned Behaviour.

Overall, the results showed that the students were initially positive towards using both of the simulators but after having had first-hand experience using them they became more positive towards using the traditional plastic-based simulator. The negative issues regarding the virtual-reality simulator included the levels of reliability, realism and Perceived Usefulness.

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1 Context of Study

1.1 Introduction

This research used the Theory of Planned Behaviour, the Technology Acceptance Model and general motivational models as the basis for investigating first-year, undergraduate dental students' perceptions of two dental simulators. The results from the two empirical studies carried out in this research will provide both an initial understanding of the perceptions of the two dental simulators used in this study as well as the factors that contribute to a student's perception of dental simulators in general. Additionally, a measure of student perceptions of simulators will be developed that could be utilised by other researchers. The results from this research are discussed in terms of their implications for the development, selection and implementation of simulators into dental courses and in terms of the theoretical and methodological implications of using the Theory of Planned Behaviour, the Technology Acceptance Model and motivational models to measure dental students' perceptions of simulators.

Until now an empirical measure of student perceptions of dental simulators has not existed, although some related measures have been developed to measure students' opinions of other types of medical-based simulators, for example the Satisfaction with Simulation Experience Scale (Levett-Jones, McCoy et al. 2011) and the Simulation Design Scale (NationalLeagueofNursing 2011). However, these measures have tended to focus on students' overall perceptions of simulation as an educational technique rather than their perceptions of a particular simulator (for a detailed discussion of these previous measures, see

Section 1.3.3). This research aims to address this gap by firstly designing an instrument that can be used to measure dental student perceptions of a simulator before empirically testing first-year, undergraduate dental students' perceptions of two different dental simulators.

This introductory chapter provides an overview of the research aims and rationale for this study. The chapter begins by describing the research context of this study in terms of simulators used for training health-based professionals and the simulators used in this study. The conceptualisation of behavioural-Intentions and behaviour are then discussed followed by the need to specifically address dental students' perceptions of dental simulators. An overview of previous attempts to measure student perceptions of simulators is then presented. Finally, the research questions for the study are then outlined along with an overview and brief description for each of the following chapters in the thesis.

1.2 The use of simulators in training health-based professionals

Simulators are physical objects or representations that attempt to replicate a particular task. The word simulator can cover a broad range of technologies with simulators existing in many different fields including the military, aviation, nuclear power and space program industries. The reason why areas such as these have relied on simulators as part of their training is due to the cost and potential danger associated with training for particular events in the real-world (Bradley 2006). Similar concerns exist with regards to the training of health-based professionals. The potential exposure of patients to unqualified and possibly incompetent students has seen an increase in the use of simulators for training health-based professionals such as doctors, nurses, radiographers and dentists (Gallagher, Ritter et al. 2005).

The benefits of using simulators in the training of health-based professionals is not just limited to increased patient safety but also includes: the ability to repeat a procedure as often as desired, the capacity to perform unusual or complex procedures, a reduction in cost and staff time, the option to create standardised cases and the facility to repeat a procedure as often as desired (Bradley 2006). This has seen a wide market of simulators being developed for healthcare education with, for example, an increase in the number of human-patient simulators being incorporated into nursing programs, (Kardong-Edgren and Starkweather 2008) and an increase in the number of haptic-based simulators being developed for training dental students (Rhienmora, Haddawy et al. 2008).

The wide scope of simulators available has led some researchers to call for a clearer taxonomy of simulators in order to aid research on comparisons of simulators. The taxonomy of simulators and its implications for research will now be discussed.

1.2.1 Taxonomy of simulators

As discussed in the previous section, the word simulator can cover a diverse range of technologies. Even when focusing down on simulators designed for training health-based professionals, there are still a number of different devices that can be classified as a simulator. There also needs to be a clear distinction made between simulation and simulators. A simulation exercise does not necessarily require a physical device. Role-playing for instance is a type of simulation but there is no actual 'simulator' present.

This variation in simulators has led some authors to suggest that an agreed upon taxonomy of simulators needs to be developed (Alinier 2007; Cumin and Merry 2007; Kerr and Bradley 2010). The authors propose that a clearer taxonomy of simulators would ease the comparison of simulators by enabling researchers to compare similar simulators with each other. A number of taxonomies have been developed in order to aid classification and comparisons of simulators. These taxonomies typically group simulators together by factors such as: the type of simulated procedure, hardware, software, interaction, realism, fidelity, use of haptic technology etc.

When investigating student perceptions of simulators it is important to distinguish exactly what type of simulator is being considered. This is due to a principle within behavioural-prediction research which states that behaviours are better predicted when the behaviour to be examined is precisely defined (see Chapter 3, Section 3.2 for an explanation). Therefore, a clear taxonomy of simulators is helpful in order to facilitate the comparison of student perceptions of different types of simulators.

Generally, most taxonomies consider that health-based simulators fall into two main categories; task trainer simulators and full-scale simulators. Task trainer simulators are designed to provide students with the opportunity to gain, develop and practise a particular skill or set of skills needed for a specific procedure, for example, inserting an intravenous line correctly, e.g. the CathSim simulator (PennStateHershey 2010). Full-scale simulators on the other hand are designed to reproduce the entire experience of a procedure or several procedures and are usually geared towards team-based, complex scenarios (Gordon, Wilkerson et al. 2001) These include simulators such as SimMan®3G which is a mannequin 'patient' that can simulate multiple scenarios at once such as bleeding and convulsions (Laerdal 2011). Even within these two categories of task-trainer simulators and full-scale simulators, further sub-divisions exist. Seropian et al. (2004) breaks down task-trainer simulators into four separate groups: plastic-based nondynamic simulators; plastic-based dynamic simulators; virtual reality simulators with low-fidelity haptics; and virtual reality simulators with high-fidelity haptics.

This research focused on dental students' perceptions of task-trainer dental simulators. Although it is theoretically possible to measure student perceptions of full-scale simulators, it is likely that the variables that contribute to their perceptions of the simulator and the associated relationships between these variables will differ significantly for full-scale simulators compared to task-trainer simulators. This is due to the fact that full-scale medical simulators are less likely to involve the teaching of one particular task, meaning the student may find it difficult to isolate their level of perceptions of each specific task they have been taught. It is also less likely to be a repetitive training process where students are regularly engaged with the learning of a specific set of skills.

Full-scale simulation may also involve the presence of other individuals who are also undertaking the learning activity, again creating difficulties for the student in separating the activities they themselves have undertaken and attributing the learning to the physical simulator. Additionally, full-scale simulators often focus less on the teaching of clinical skills themselves and more on the team-working and decision making skills of the students (Levett-Jones, McCoy et al. 2011). This removes the more direct link between the 'physical' object of the simulator and the tasks being undertaken by the student. Finally, it can be difficult to define exactly what constitutes the 'simulator' in full-scale simulations owing to the more clinical environment in which they are often established and the supplementary features that are often found in full-scale simulations such as video replay and feedback sessions.

Owing to these issues regarding full-scale simulators, along with the fact that the majority of dental simulators are task-trainer style simulators, this research has focused on measuring dental students' perceptions of task trainer simulators. However, as mentioned previously, task-trainer simulators can be further broken down into distinct types (plastic-based nondynamic simulators, plastic-based dynamic simulators, virtual reality simulators with low-fidelity haptics, and virtual reality simulators with high-fidelity haptics.) When investigating student perceptions of a task-trainer simulator it is important to consider exactly what type of task-trainer simulator it is, as the factors that affect student perceptions of a specific type of task-trainer simulator may vary. An overview of simulators used in dental education will now be presented followed by a description of the dental simulators used in this research.

1.2.2 The use of simulators in dental education

Dental students use simulators in order to develop manual dexterity skills by practising certain dental procedures, for example, drilling a cavity in a tooth or preparing a tooth for a crown (Dougherty 2002). Simulators designed for training dental students have historically consisted of plastic mannequin heads mounted on metal rods (Jasinevicius, Landers et al. 2004). These mannequin heads can then be manipulated in a similar way to a real patient. The teeth located in the mannequin-head upon which the students practise are typically either extracted human teeth or synthetic plastic teeth. The mannequin-head simulator is usually located within a larger dental workstation that attempts to replicate, or in some cases actually takes the form of the workstation that dentists would use in their professional practice for example the Frasaco Dental Simulator (Frasaco 2010).

A more recent development within dental education is the use of virtual-reality simulators (Gal, Weiss et al. 2011). These simulators often, but not always, incorporate haptic technology. Haptic devices allow the user to feel and interact with simulated objects that are not physically present; for example objects that are generated by a computer or remote objects that are in a different location. The advantages of haptic simulators for dentistry are the same as for all simulators but include the added benefits of being able to create virtual teeth that are capable of providing force feedback to the user. This force feedback has the potential to be developed in such a way that it mimics that which is provided by real human teeth. The synthetic teeth available to dental schools often do not have the material properties required to accurately replicate the tactile sensations of real human teeth (Kim and Park 2006). Additionally, the option of using extracted human teeth in mannequin simulators is diminishing due to both the decline in the number of teeth being extracted from patients and ethical concerns regarding the use of human tissues (University of Birmingham 2011), therefore increasing the need for a viable alternative. Virtual teeth could provide this alternative if they are found to have adequate content validity.

Even though virtual-reality based simulators offer some additional advantages, mannequin-head simulators are still the most popular simulators used by dental schools. In the UK for example, all but one of the sixteen dental schools have mannequin-head facilities (the exception uses DentSim, a hybrid mannequin and virtual reality simulator). That being said, virtual-reality dental simulators are increasingly being incorporated into dental programmes (Duta, Amariei et al. 2011). This study investigated student perceptions of both a plastic-based, mannequin-head simulator and a virtual-reality, haptic-based simulator. The two simulators used in this study are now presented along with the reasons for considering student perceptions of the two different types of dental simulator.

1.2.3 The dental simulators used in this research

Two task-trainer dental simulators were used in this research. The first was a plastic-based, nondynamic simulator. This will be referred to as the mannequin-head simulator. The second was a virtual-reality simulator with low fidelity haptics. This will be referred to as the hapTEL simulator. Further information regarding the specification and use of the simulators by the students can be found in Chapter 3, Section 3.2.

The purpose of both the mannequin-head simulator and the hapTEL simulator in this study was for students to develop and practise the basic manual dexterity skills required to successfully drill a cavity in a tooth. The fact that both simulators were used for the same purpose is beneficial as it allowed for comparisons between the perceptions the students have of the simulators. This is because the behaviour students will be engaging with will be the same (developing and practising manual dexterity skills) and the main variable changing will be the simulator that they use to carry out this behaviour.

Considering student perceptions of both a plastic-based and a virtual reality based simulator is beneficial for two key reasons. Firstly, the factors that affect student perceptions of plastic-based simulators and virtual-reality based simulators may differ. This information can help inform the design of the different types of simulators for the purpose of training dental students. Secondly, the perceptions students have of plastic-based and virtual reality based simulators also have the potential to aid in the selection of dental simulators. Recent advancements in technology and medical knowledge have contributed to the development of more sophisticated simulators capable of replicating more complex scenarios and procedures (Rosen 2008). These more advanced simulators however can be more costly, both in developmental terms and in purchase costs, especially for virtual reality simulators that tend to be more costly, (at least initially) than their plastic-based counterparts. For example, the virtual-reality simulator Laerdal Virtual I.V.™, designed for teaching cannulation, costs approximately £6000 (Laerdal 2011) whereas the plastic-based Central Venous Cannulation Simulator, also designed to teach cannulation, costs approximately £800 (MedClick 2011). If it is found that student learning and student perceptions are high for both types of simulators then, as Levett-Jones et al (2011) claim, it may be more prudent to invest in the less costly device if it means a greater number of students can have access to a simulator.

1.3 Student perceptions of dental simulators

This research aimed to investigate student perceptions of dental simulators and the impact these perceptions have on their level of Satisfaction with the simulator and their Intention to use the simulators. This section presents the theoretical framework used for defining Satisfaction and behavioural Intention before discussing the importance of measuring student Satisfaction with dental simulators and Intention to use dental simulators. This is followed by a review of previous attempts to measure student perceptions of medical-based simulators.

1.3.1 Behavioural-Intentions to use a dental simulator and Satisfaction with a dental simulator

As is discussed in Chapter 2, Section 2.1, the goal of behavioural-prediction models, including the Theory of Planned Behaviour and the Technology Acceptance Model, is to both predict and explain behaviour. These two concepts are distinct yet still related to each other. Whist a model can predict a behaviour without offering an explanation, it is not possible for the explanation to occur without a prediction being first established. This is due to the fact that if the model shows no or very poor predictive power, then its explanation cannot be said to accurately reflect the behaviour in question (Rawstorne, Jayasuriya et al. 2000).

A study that seeks only to predict behaviour can simply measure levels of behavioural-Intention and use these as a basis for predicting future behaviour (owing to the relationship that exists between behavioural-Intention and actual behaviour, Chapter 2, Section 2.2). However, it is expected that behavioural-prediction models do more than just predict behaviour. They should also have the ability to **explain** behaviour (Rawstorne, Jayasuriya et al. 2000). In order to do this, the antecedent variables that predict behaviour (and therefore behavioural-Intention) also need to be measured. Antecedents are variables that impact upon or influence another variable. Therefore, in order to explain the levels of behavioural-Intention to use simulators, the potential antecedents of behavioural Intention were also measured. In terms of this study, one of these variables was the students' perceived level of Satisfaction with the simulator. Satisfaction is hypothesized to have a direct impact on behavioural-Intention but is also hypothesized to be affected by other variables that act directly on Satisfaction only (Roca, Chiu et al. 2006). This means that there are some variables that will act directly on Intention but also indirectly on Intention via Satisfaction (and some variables may potentially act both directly on Intention and indirectly on Intention through Satisfaction). This study sought to address which variables act directly on Intention and which variables act on Intention through Satisfaction. See Figure 1.1.

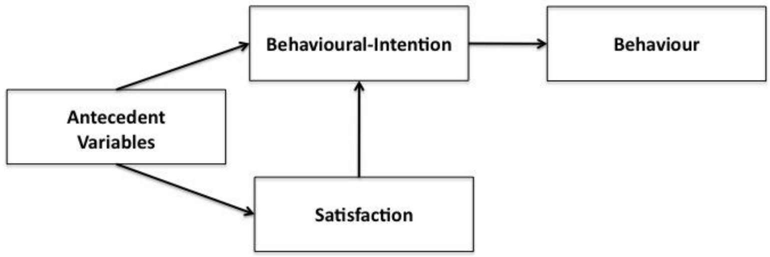


FIGURE 1.1 CONCEPTUAL FRAMEWORK FOR THE STUDY

The relationship between the antecedent variables with Satisfaction and Intention form the explanatory side of the model that was also developed in this research. The relationship between the variables and the levels of student Satisfaction with the simulator and their behavioural-Intention to use the simulator form the prediction side of the model. A model is generally judged to have accurately predicted behaviour when the variable of behavioural-Intention is significantly correlated with actual behaviour. In the case of this research, actual behaviour could not be measured due to the use of the simulator being mandatory for the students (see Chapter 2, Section 2.6.3 for a discussion on the issues of measuring mandatory behaviours). However, the strength of the behavioural-Intention to behaviour pathway found in previous studies provides support for measuring behavioural Intention (Sutton 1998). Explanation of the behaviour is considered to have occurred if one or more of the antecedents of

Satisfaction or behavioural Intention are significantly correlated with Satisfaction and behavioural Intention (Ajzen and Madden 1985). This claim can be further strengthened by seeing if any of the antecedent variables are actual predictors of Satisfaction or Intention. This can be done by using regression and structural equation modeling; both of which were carried out in this research.

Prediction of behaviours can be useful even if the reasons for the behaviour remain unexplained. For example, behavioural-prediction models could focus on predicting which students are least likely to use a particular learning device. This would allow the identification of a population of individuals for whom a targeted intervention could be based. However, more power could be provided if the model can also explain behaviour. In the case described above, by also explaining why some students do not wish to use a particular simulator not only can the students themselves be identified but the targeted intervention can be informed by the explanatory side of the model, therefore identifying both who should be targeted and also how they should be targeted (Sutton 1998). This has the potential to increase the success of any such interventions.

1.3.2 The reasons for measuring student perceptions of dental simulators

Measuring student perceptions of dental simulators provides two sets of information. Firstly, what are the students' perceptions of a virtual-reality based and a plastic-based dental simulator and what variables contribute to these perceptions and secondly, how are these variables causally related to behavioural-Intention and therefore subsequent behaviour.

In terms of the initial understanding of the perceptions students hold towards these two types of dental simulator, this information can be used to improve the design and implementation of dental simulators to increase the chance of students being satisfied with the dental simulator. As well as providing knowledge that may be of use to the development of simulators, the results from this study could also help to inform the implementation of simulators into dental courses. By knowing which variables contribute to a student's positive perceptions of simulators, educational establishments can ensure that they emphasize the appropriate variables when introducing simulators to students. For example, if Subjective Norms is found to be positively associated with Satisfaction, then ensuring that tutors are positive towards the use of a simulator could help to increase student Satisfaction with the simulator.

The information gained from this research could also assist with the overall assessment of simulators in general. For example, student perceptions of a simulator could be used as part of the evaluation of a particular simulator. Although levels of student perceptions are not the sole criteria for assessing a simulator as an educational resource, it is still however an important consideration as it could impact upon their level of engagement with the simulation exercises and can potentially impact upon their performance (Levett-Jones, McCoy et al. 2011). Having a valid and empirically tested instrument for measuring student perceptions of simulators would allow testing of student perceptions of other simulators in different medical-based fields.

Knowledge of the relationship between Satisfaction with a simulator and behavioural-Intention was also developed by this research. Behavioural-Intention refers to the degree to which an individual intends to carry out a certain behaviour. It is hypothesized that the higher the behavioural-Intention, the greater the chance the individual will actually carry out the behaviour. This behavioural pathway forms the basis for many behavioural-prediction models including the Theory of Planned Behaviour (Ajzen and Madden 1985) and the Technology Acceptance Model (Davis 1985) which are the two theoretical models used in this study (see Chapter 2 for a detailed discussion of the two models). The Intention to Behaviour pathway does have empirical evidence to support it. For example, in a meta analysis of Theory of Planned Behaviour studies, Intention was shown to have an average correlation with behaviour of .47 (Armitage and Conner 2001). This is consistent with previous meta-studies, which found average correlations between Intention and behaviour to be .45 (Ajzen 1991) and .48 (Sutton 1998).

If it were found that Satisfaction is related to behavioural-Intention, then by extension Satisfaction would also be related to behaviour, i.e. if an individual is satisfied with a dental simulator they will have a high behavioural-Intention to use that dental simulator which means they will have a high likelihood of actually using the dental simulator. As educational establishments are to be expected to want students to use any learning technologies or systems they introduce, they would therefore want students to be satisfied with the technology or system to increase their usage of the system. It is possible that some variables that contribute to the affective response of Satisfaction will also act directly on behavioural-Intention and actual behaviour. These variables may still contribute to an individual's level of Satisfaction but are also able to bypass Satisfaction to act on Behavioural-Intention and actual behaviour directly. Knowing which variables are able to act directly on behavioural-Intention and behaviour would help to explain why there are occasions where individuals have low levels of Satisfaction with an object or service but still intend to use it. For example, in the context of this research, students may feel influenced by the opinions of their tutors. If the students perceive that their tutors want them to use a particular simulator as part of their training, this may impact upon their behavioural Intention toward that simulator, even if they have not been entirely satisfied with the simulator themselves. This could potentially lead to the situation where Subjective Norms (a construct in the Theory of Planned Behaviour concerning what individual believe other people think they should do) impacts directly upon Behavioural Intention rather than Satisfaction.

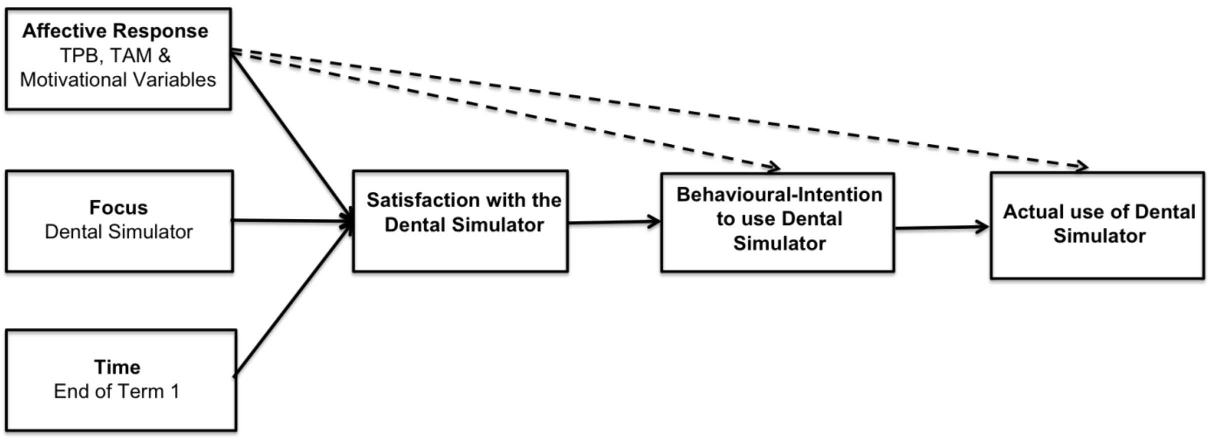


FIGURE 1-2 CONCEPTUAL FRAMEWORK FOR SATISFACTION , BEHAVIOURAL INTENTION AND ACTUAL USE OF A DENTAL SIMULATOR

1.3.3 Previous attempts to measure students' perceptions of simulators

There have been previous attempts to measure medical-based students' opinions of using simulators as part of their training, however the methods employed in such studies have varied widely. The exact justification for considering the students' perceptions of the simulators has also not always been expressly stated in these studies, with some researchers providing only a limited explanation as to why it was being measured. For example, in their study comparing the progressive performance of medical students and qualified surgeons using two different laparoscopic simulators, Sansregret et al. (2009) stated that 'measuring this variable [Satisfaction] as a factor of face validity seemed essential to our study'. The method used by Sansregret et al. to measure Satisfaction with a simulator in this study consisted of one-open ended question and one visual analog scale where participants were asked to rate their overall level of Satisfaction with the simulator on a range from zero to one hundred. Although providing a rough indicator of student Satisfaction with the simulator overall, it is hard to draw much more information from it than this as the questions do not provide enough scope for respondents or break down the construct of Satisfaction into its antecedent parts. This makes it difficult to see which constructs are affecting the student's level of Satisfaction and therefore reduces the ability to explain the levels of Satisfaction. Indeed, Sansregret et al. acknowledge themselves that user Satisfaction in this case would be measured more precisely by the use of a multi-choice questionnaire.

An approach taken by some studies into student perceptions of simulators is to focus on the overall learning experience of the students rather than on the simulator itself. Engum et al. (2003) investigated the effectiveness of a virtual reality simulator and a traditional, plastic-based simulator for teaching nursing students how to place an intravenous-line. The perceptions component consisted of five questions that utilised a five-point Likert scale. The items used were:(1) the teaching methods used in this class are helpful, (2) this class provides a variety of learning materials, (3) I enjoy the format in which this class is offered, (4) the teaching materials in this class are motivating, and (5) the way this class is taught is consistent with the way I like to learn. Although providing an overview of the student's perceptions of their learning experience, it does not address the student's direct opinions of the simulator as an object itself. The questions also cover a broad range of variables, for example 'the teaching materials in this class', which makes it harder to differentiate exactly what role the simulator itself is playing in the formation of the student's perceptions. Although the entire experience of using the simulator is likely to factor into a students' sense of Satisfaction with using a simulator, if one is concerned with the students' perceptions of the simulator, then it is important that at least some questions focus directly on the simulator and the student's interaction with it. (See Chapter 2, Section 2.2 for an explanation).

Other researchers have chosen to focus on the students' perceptions of what they feel they have learnt after using the simulator. For example, Seybert et al. (2008) conducted a study on a human patient simulators' impact on pharmaceutical students' level of Satisfaction and achievement of course objectives. The measurement used consisted of a small number of items administered using a five-point Likert scale. The items focused mainly on students' perceptions of their ability and confidence in carrying out the course objectives e.g. 'how confident are you in your ability to interpret a basic electrocardiogram?' The questions were administered before and after the students used the simulator in question. Although the perceived learning outcomes of the students are important factors, they are unlikely to provide a full picture of a student's level of Satisfaction with a simulator. This may be because students may feel they have learnt something after using a simulator but may not have enjoyed the experience of using the simulator itself. Additionally, it does not help to differentiate between simulators that student's rate as being equal in terms of learning outcomes. Finally, students are not always accurate in their assessments of their own ability and so may be mistaken in their praise or criticism of a particular simulator. Therefore, although it is valuable to consider a student's perception of how well the simulator achieved its intended learning outcomes (see Chapter 2 Section 2.4) it should not be the sole factor used to determine students' level of Satisfaction with simulators.

In terms of the simulators being used in this research (the mannequin-head simulator and the hapTEL simulator), no studies were found that focused solely on dental students' perceptions of the mannequin-head simulator. In the case of virtual-reality simulators, one study was found that focused on the dental students' overall Attitude towards a virtual-reality dental simulator. However, this study by Ben Gal et al. (2000) was based on a small number of students using a simulator on a one off basis for the sole purpose of providing an initial evaluation of the simulator. Twelve students used the simulator for fifteen minutes in order to perform five tasks. A questionnaire with seven questions was then completed that asked the participants to rank on a Likert scale various aspects of the simulator's usefulness and realism. For example, 'to what extent can the simulator be useful in self-training of manual skills in dentistry?'

This leads to the importance of not only considering dental students' perceptions of simulators but dental students' perceptions of using a simulator as part of their studies. Not only is this important in terms of bridging a gap in the knowledge but it is also important for theoretical reasons. Behavioural-prediction research has found that more accurate predictions of individual's future behaviour can be made when they are asked to consider not an object on its own but using an object in order to carry out a particular behaviour (Fishbein and Ajzen 1975). It is also possible that there will be a difference in opinions towards a simulator between individuals who use a simulator simply in order to evaluate it and those who use a simulator as a part of their training. Students who use a simulator as an educational tool are likely to have more frequent and longer encounters with it. This will increase their specific knowledge regarding the simulator enabling them to form more stable opinions (See Chapter 2, Section 2.6.1). There is also some evidence that levels of student performance when using a simulator may impact upon their levels of Satisfaction. Generally, if students do well in a course or a particular task they often display higher levels of Satisfaction than students who do not perform as well (Svanum and Aigner 2011). For students who are using a simulator as part of their studies, this level of perceived performance may affect their Satisfaction levels. For example, a student who feels that they have not achieved as well as they would have liked may attribute some of the blame to the simulator itself, consequently lowering their Satisfaction with the simulator. This impact of perceived performance is more likely to be a factor for students who are using a simulator as an integral part of a course as opposed to students who are merely evaluating a simulator.

As well as individual studies looking at student perceptions of simulators there have also been attempts to create measures specifically designed for eliciting students' perceptions of simulators. The most relevant of these are the Simulation Design Scale Student Version, the Student Satisfaction and Self-Confidence in Learning Scale, both developed by the National League for Nursing (NLN 2011) and the Satisfaction with Simulation Experience Scale (Levett-Jones, McCoy et al. 2011). All of these measures are designed to specifically measure nursing students' Satisfaction with using a simulator as part of their training. These scales have demonstrated reliability (with Cronbach's alphas above .70 for all sub-scales) and have been utilised by researchers looking at nursing students' Satisfaction with a variety of different simulators (Kardong-Edgren and Starkweather 2008; Hoadley 2009; Reese, Jeffries et al. 2010). However, two issues exist with these measures that the present study will attempt to address. The first issue is that both the Simulation Design Scale Student Version and the Student Satisfaction and Self-Confidence in Learning Scale are acknowledged to be a measure of nursing students' Satisfaction with simulation as opposed to a measure of their Satisfaction with a particular simulator. This means they encompass the whole simulation experience not just the simulator itself. Although this method has some benefits in that it is able to fully capture the experience of students and their perceptions of it, it consequently loses some of its ability to differentiate between the wider experience of the simulation exercise and the simulator itself.

There is also the further issue of whether a model designed for sole use by nursing students would translate into other medical disciplines. This translation is theoretically possible but would need to be empirically tested in order to state confidently that the measure can be applied over diverse student populations and simulators. Dental students may not judge simulators by exactly the same criteria as other health-based students. For example, dental students are trained in manual dexterity skills from very early on in their dental studies. The same is not always true of medical and nursing students, who are often trained in manual skills further along in their studies (Luck, Reitemeier et al. 2000). Additionally, the majority of countries do not require dentists to undergo any further compulsory clinical training, unlike doctors who often have to undergo many years of further clinical training after they have graduated (Quinn, Keogh et al. 2003). However, in the UK all practising dentists are required to undergo five training days per year to learn about the latest clinical treatments. This could lead to dental students viewing the acquisition of manual skills during their undergraduate training as highly important and something they desire to develop quickly. Consequently, this may affect their Attitudes towards any simulators designed to teach manual dexterity skills. Therefore, it would be beneficial to develop a measure specifically for dental students.

1.4 Overview of research

This section presents the previous work conducted by the author as part of a Master's project, the final aims, objectives and research questions for this research and a summary of the remaining thesis chapters.

1.4.1 The hapTEL project and the Masters research

This research was situated within the hapTEL Project based at King's College London dental school. The aim of the hapTEL project was to design, build and evaluate a virtual reality, haptic–based dental simulator that could be used as a training tool for dental students.

One aim of the hapTEL project was to measure dental students' Attitudes towards using ICT and haptic devices as part of their studies. In order to do this, a Theory of Planned Behaviour questionnaire was developed (Appendix 1A) and administered to 100 first–year undergraduate dental students in 2008. The purpose was to investigate whether students who held negative Attitudes towards any form of ICT would also hold negative Attitudes towards a virtual-reality simulator.

In 2009-2010 the author conducted a study as part of a Masters in Research programme situated within the hapTEL project (Green 2010). This masters study built on the previous work conducted by the hapTEL project by looking at student Attitudes towards virtual-reality and traditional dental simulators in general. This was achieved by developing and administering a Theory of Planned Behaviour Questionnaire in 2009 that focused on students using the hapTEL simulator and the traditional simulator in order to practise cavity preparation (Appendix 1B).

Although producing results that provided an initial insight into students' Attitudes towards virtual-reality and traditional simulators, it was felt by the author that the Theory of Planned Behaviour did not provide a sufficient exploration of the factors that affect student acceptance of simulators. After a review of relevant literature the Technology Acceptance Model and general motivational models were identified as being useful and valid additions to the Theory of Planned Behaviour in this context. Consequently, a new questionnaire was developed in 2010 that incorporated constructs from the Theory of Planned Behaviour, the Technology Acceptance Model and general motivational models.

1.4.2 Aims, objectives and research questions

Although previous literature has shown the importance of measuring students' perceptions of dental simulators (Section 1.2. and 1.3) there is lack of research that investigates the factors around this area. Therefore, the aim of this research was to establish the different variables that can be used to measure and explain dental students' perceptions of a plastic-based and a virtual-reality based task-trainer dental simulator. This research therefore also aimed to design and develop a questionnaire based on the Theory of Planned Behaviour, the Technology Acceptance Model and general motivational models. The questionnaire was administered to a large group of dental undergraduate students, which aimed to inform the basis of developing an initial understanding of the levels of behavioural-Intention and Satisfaction with the two dental simulators and a theoretical model of the factors that affect dental students' behavioural-Intention and Satisfaction with dental simulators.

By fulfilling these aims the following research questions were addressed.

1.5 Research questions

Q1) What are the dental students initial perceptions' of the hapTEL simulator and the mannequin-head simulator before they have had first-hand experience using them?

Q2) How are the dental students' initial perceptions of the simulators related to the students' levels of anticipated Satisfaction and initial Intention to use?

Q3) What are the dental students perceptions of the hapTEL simulator and the mannequin-head simulator after they have had first-hand experience using them?

Q4) How are the dental students' perceptions related to their levels of Satisfaction and Intention to use?

Q5) Is gender a moderator of either Satisfaction with or Intention to use the hapTEL simulator and the mannequin-head simulator?

Q6) Is computer experience a moderator of either Satisfaction with or Intention to use the hapTEL simulator and the mannequin-head simulator?

1.5.1 Overview of thesis

This thesis is organized into seven chapters.

- Chapter 2 discusses the Theory of Planned Behaviour and the Technology Acceptance Model and motivational variables along with the issues regarding the use of these models for this research.
- Chapter 3 sets out the methods for the development of the questionnaires and worksheets used in the two empirical studies and the approaches taken regarding data analysis.
- Chapter 4 presents the results from the two empirical studies carried out for the hapTEL simulator and the mannequin-head simulator.
- Chapter 5 presents the results from the qualitative data collected for the hapTEL simulator and the mannequin-head simulator.
- Chapter 6 discusses the results from the hapTEL simulator and mannequin-head simulator with reference to the original aims, objectives, research questions and hypotheses of this study.
- Chapter 7 discusses the strengths, implications and limitations of this research along with suggested areas for future research.

2 Using the Theory of Planned Behaviour, the Technology Acceptance Model and Motivational Models to Measure and Explain Dental Students' Intention to use Dental Simulators

2.1 Introduction

This research uses the Theory of Planned Behaviour and the Technology Acceptance Model as the theoretical frameworks for measuring and explaining dental students perceptions of two different dental simulators. The Theory of Planned Behaviour and the Technology Acceptance Model are both examples of behavioural prediction models. Behavioural-prediction models seek to both predict and explain the behaviour of individuals (Rawstorne, Jayasuriya et al. 2000). In the case of this research the behaviour in question is the Intention to use the dental simulators by the students. This Intention to use is formed by their perceptions of the dental simulators.

The Theory of Planned Behaviour attempts to link an individual's Intention to carry out a behaviour with their subsequent actual behaviour (Ajzen and Madden 1985). The Technology Acceptance Model is based upon the Theory of Planned Behaviour and specifically seeks to measure an individual's Intention to use a particular technology. This chapter provides an overview of both the Theory of Planned Behaviour and the Technology Acceptance Model along with reasons for their selection for this research. The efficacy of both models is then discussed in terms of their ability to predict and explain behaviours in general.

Theoretical considerations related to using the Theory of Planned Behaviour and the Technology Acceptance Model for this research are presented. Finally, constructs not included in the original Theory of Planned Behaviour or Technology Acceptance Model but which have been added to the models in previous studies are explained along with the reasons for deciding to include them in this research.

2.2 The Theory of Planned Behaviour

The Theory of Planned Behaviour was developed by Ajzen (1991) as a general model for predicting behaviours that are within the volitional control of the individual. It was built upon a previous model, the Theory of Reasoned Action, also developed by Ajzen. The Theory of Planned Behaviour stipulates that the more an individual intends to carry out a behaviour, the more likely they are to carry out that behaviour. As discussed in Section Chapter 1, Section 1.3.1 the relationship between Intention and behaviour has been empirically shown to have a strong correlation for a variety of different behaviours. In the Theory of Planned Behaviour Ajzen claims that there are three determinants of an individual's Intention to carry out a behaviour. These are Attitude, Subjective Norms and Perceived Behavioural Control.

Within the Theory of Planned Behaviour Attitude is defined as the degree of favourableness held by an individual toward and object or behaviour (Fishbein and Ajzen 1975). Attitude is comprised of two components: behavioural beliefs and evaluations of the beliefs. Behavioural beliefs refer to the individuals beliefs about the consequences of carrying out a behaviour. Evaluation refers to the individual's positive or negative judgment about those consequences. Subjective Norms is defined as the degree to which an individual perceives that other people whose opinion they value feel they should carry out a behaviour. Subjective Norms are comprised of two components, normative beliefs and motivation to comply. Normative beliefs refers to how much an individual perceives that a particular person or group of people think they should carry out the behaviour in question. Motivation to comply refers to how important that person or group of peoples view is to the individual. Perceived Behavioural Control is defined as the extent to which an individual believes they are able to carry out a behaviour. Perceived Behavioural Control is comprised of two components, control beliefs and control belief power. Control beliefs refer to factors that may hinder an individual from carrying out a behaviour and control belief powers refers to the strength the individual feels the powers have to control the behaviour in question.

According to Ajzen, these three variables determine an individual's Intention to carry out a behaviour. This level of Intention will then in turn either increase or decrease the likelihood of the individual carrying out the behaviour, i.e. the higher the level of Intention, the more likely it is the individual will carry out the behaviour. It should be noted however that Intention is not claimed to be the sole determinant of whether an individual carries out a behaviour. It is possible that an individual can hold a high Intention to carry out a behaviour but still does not actually carry out the behaviour (the reverse can also be true, with an individual holding a low Intention to carry out a behaviour but still carrying out the behaviour). This can occur because other factors impede or bypass an individual's Intention to carry out a behaviour. The Theory of Planned Behaviour hypothesizes that Perceived Behavioural Control is one such factor.

As well as acting as a variable that helps to determine an individual's level of Intention, Perceived Behavioural Control is also thought to act directly on behaviour as well. This means that Perceived Behavioural Control can have both an indirect effect on behaviour through Intention and also a direct effect on behaviour, bypassing Intention completely. This is thought to occur because individuals are unlikely to carry out behaviours they perceived to be difficult for them to perform, even if they have a high Intention towards carrying out the behaviour in general. Figure 2.1 shows a representation of the Theory of Planned Behaviour.

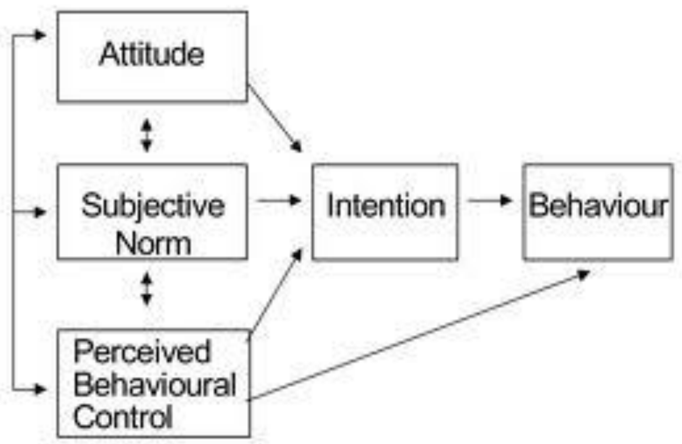


FIGURE 2-1 THE THEORY OF PLANNED BEHAVIOUR

As mentioned previously, Perceived Behavioural Control is the degree to which an individual feels that they are able to carry out the behaviour in question. This is not the same as self-efficacy (which will be discussed in Section 2.4), which is the degree to which an individual feels that they have the skills and capabilities needed to be able to carry out the behaviour. The distinguishing factor between Perceived Behavioural Control and self-efficacy is that Perceived Behavioural Control focuses on external factors that are often beyond the control of the individual. For example, having access to the equipment needed to perform the behaviour would be an example of Perceived Behavioural Control.

2.3 The Technology Acceptance Model

Davis (1985) developed the Technology Acceptance Model as an extension of the Theory of Reasoned Action (see previous section). The Technology Acceptance Model was designed to specifically look at individuals' acceptance of information systems and was originally developed and tested with computer-based software and applications and its most common use was to test the acceptance of computers and computer-based applications by workers in organizational settings (Davis 1985) . However the Technology Acceptance Model has been used in a broad range of contexts including educational studies. The Technology Acceptance Model has been empirically tested and validated by numerous studies since its creation and it remains one of the most popular technology acceptance models in use today (Roca, Chiu et al. 2006; Holden and Karsh 2010).

Davis claims that two constructs, Perceived Usefulness and Perceived Ease of Use, contribute to an individual's Intention towards using an information system. (Davis originally included Attitude toward the system in the Technology Acceptance Model but it was found that there was no significant relationship between Attitude and Intention so it was removed.) This Intention towards using the system is then in turn a major contributor of whether the individual actually uses that information system. Within the Technology Acceptance Model Perceived Usefulness is defined as the degree to which an individual believes an information system will improve their performance and Perceived Ease of Use is defined as the degree to which an individual believes using an information system will be free from effort.

As well as having a direct effect on Intention to use an information system, Perceived Ease of Use is also postulated to have a direct effect on Perceived Usefulness. This is due to the fact that a system which appears to be free from effort is likely to be viewed as easier to use by the individual and therefore more likely to be useful to them (Davis, Bagozzi et al. 1989) Figure 2.2 shows a representation of the Technology Acceptance Model.

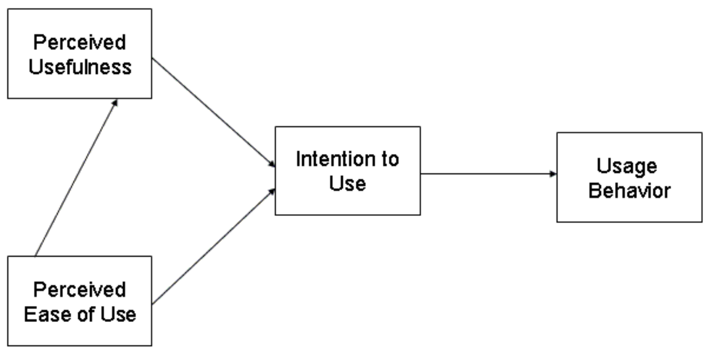


FIGURE 2-2 TECHNOLOGY ACCEPTANCE MODEL

2.4 Variables other than those included in the original Theory of Planned Behaviour and Technology Acceptance Model

The Theory of Planned Behaviour and the Technology Acceptance Model were developed in order to both predict and explain individuals' behaviours, and although research has found the predictive powers of both models to range from moderate to good (see Chapter 2, Section 2.5 for more information), the evidence for the explanatory power for each model is less conclusive. The reason for this lower level of explanatory power may lie in the absence of a crucial variable from the models that impacts upon behavioural Intention (Davis and Venkatesh 1996) as discussed below.

Thuring and Mahlke (2008) argue that previous technology acceptance research has focused too much on issues surrounding usefulness and usability, leaving more affective factors such as emotional responses and the cognitive processes of the individuals neglected. They claim that the reasons individuals favor one technology over another is not always just down to instrumental factors but also factors such as the perceived quality of the system and the emotional response of the individual toward the system. Similarly, Dillon (2001) argued that as well as usability, factors such as the aesthetics of a system can influence individuals' perceptions of a technology. These ideas can be expanded by considering the role that affective elements play in terms of the individual themselves, particularly regarding their level of motivation in using the technology.

In terms of motivation, two distinct types can be considered; intrinsic motivation and extrinsic motivation (Vellerand 1997). Intrinsic motivation refers to the degree of perceived enjoyment held by individuals whilst undertaking an activity (Chiu and Wang 2008). On the other hand, extrinsic motivation refers to the motivation to perform an activity in order to attain a particular outcome. The distinction between intrinsic motivation and extrinsic motivation is the formers emphasis on achieving a particular goal whereas intrinsic motivation considers how enjoyable the activity is in its own right regardless of its performance enhancing values.

Research into the design and acceptance of technology has begun to consider both intrinsic and extrinsic motivation of intended users (Thompson, Compeau et al. 2006). For example, Agarwal and Karahanna (2000) wanted to examine the holistic experience of individuals using a technology. To achieve this they incorporated cognitive absorption into the Technology Acceptance Model and found that it impacted significantly on behavioural Intention, Perceived Usefulness and Perceived Ease of Use. The next section therefore presents the additional motivational variables that have been used in this study along with their hypothesised impact.

Mastery Goals

Elliot and Murayama (2008) defined goals as a "conceptualized aim that one is committed to that serves as a guide for future behaviour" (p. 614). Mastery Goals are one form of goals and are usually related to achieving a specific aim or objective in a course.

Mastery Goals have been linked to other motivational variables including Task Value and Interest as well as self-efficacy and persistence (Printrich 2000). The study by Yi and Hwang (2003) on the use of web-based information systems found that goals were positively associated with application self-efficacy at .27** (** = significant at the .001 level) This relationship was also found in the study by Sins and Joolingen (2008) that looked at students' completing online collaborative tasks. Self-efficacy and Mastery Goals in that study were found to be significantly associated with each other (.59**). Suggestions for the reasons behind this relationship have included the idea that students who are have high levels of self-efficacy will be inclined to take on challenging learning tasks and persist when faced with difficulties in their learning. They are also more likely to set themselves more stretching goals (Diseth 2011).

There has also been previous empirical research linking Mastery Goals with Interest, however the direction of causality was not established, i.e. it was not clear whether having Mastery Goals at the start of the learning experience led to an increase in the individual's Interest in the learning experience or vice versa (Harackiewicz, Barron et al. 2008). In terms of behavioural Intention, there have been few studies that found a direct link between Mastery Goals and behavioural Intention for student populations however some studies have found a link between Mastery Goals and behavioural Intention for teacher populations e.g. Gorozidis and Papaioannou (2011).

Cognitive absorption

Agarwal and Karahanna (2000) define cognitive absorption as "a state of deep involvement" and theorise it to be a multi-dimensional construct consisting of separate elements that combine to produce an individual's overall level of cognitive absorption. They suggest the following sub-components of cognitive absorption:

Focused immersion: The ability to ignore other attention-seeking demands due to being fully engaged with an activity.

Temporal displacement: Being unable to register the passage of time whist undertaking an activity.

Heightened enjoyment: Finding the undertaking of an activity pleasurable. (ref)

Control: The users belief that they are in charge of the activity

Curiosity: The extent to which the activity stimulates the individual's level of curiosity

In terms of this research, cognitive absorption has been measured using temporal displacement, focused immersion and heightened enjoyment. It was decided not to include control, as this was likely to be measured by the variables Perceived Behavioural Control, or curiosity, as this was likely to be measured by the variable Interest (see next section).

Several studies have found that when cognitive absorption is included in the Technology Acceptance Model it has a positive impact on both Perceived Ease of Use and Perceived Usefulness. Roca et al. (2006) used an extended version of the TAM in order to investigate students continuance Intention towards an e-learning service. They used structural equation modeling to analyse the relationships between the variables and found that cognitive absorption (composed of FI, TD and HE) was significantly related to both Perceived Ease of

Use and Perceived Usefulness, although the relationship to Perceived Ease of Use was stronger at .31** compared to Perceived Usefulness at .12**. Similarly, Saade and Bahli (2005) added cognitive absorption to the TAM in their study on student acceptance of an Internet learning system. The results were again derived by structural equation modeling and showed cognitive absorption to have a significant effect on both Perceived Ease of Use, at .24** and Perceived Usefulness, at .36**. The study by Agarwal and Karahanna (2000) also produced corresponding results. Their study looked at university students' perceptions of the World Wide Web. They found that cognitive absorption had a significant effect on Perceived Ease of Use at .58* (* = significant at the .005 level) and Perceived Usefulness at .52**. The study by Yi and Hwang (2003) that attempted to predict the use of Blackboard (a web-based classroom management system) by students produced similar results, with cognitive absorption having a positive relationship with both Perceived Ease of Use at .41** and Perceived Usefulness at .50***. However the cognitive absorption construct in their study only included measures for heightened enjoyment (HE). In this study cognitive absorption was measured by heightened enjoyment, focused immersion and temporal displacement.

Interest

Hidi (2006) defined Interest as a 'critical motivational variable that influences learning and achievement'. Hidi divides Interest into two distinct types, individual Interest and situational Interest. Individual Interest is an enduring Interest that develops more slowly over time whereas situational Interest is a product of the environment and is therefore externally triggered. Situational Interest can in turn be divided into two forms, 'catch' situational Interest refers to the initial Interest sparked by a topic or activity whilst 'hold' situational Interest refers to a longer-lasting state of Interest that may eventually (but not necessarily) become an individual Interest.

It can be argued that Interest crosses over into the variable of cognitive absorption (see previous section). For example, Agarwal and Karahanna's (2000) sub-component of cognitive absorption called 'curiosity' could be considered to be synonymous with the variable of Interest. However in this study those sub-components of cognitive absorption are not being used.

For student populations, it is possible that both situational and individual Interest can play a part in shaping their Intention to engage in certain behaviours associated with simulators. For example, students with an individual Interest in computers may be more likely to use a virtual-reality simulator than an individual who holds no individual Interest in computers. Additionally, a student's Interest may be 'sparked' by a particular virtual reality simulator, leading to then developing a situational Interest in using that simulator even though they may have held no previous Interest in the area.

The subject matter of dentistry would be likely to feature in the students' individual Interest owing to students studying a subject for which they have developed a sustained individual Interest. However, it is important to separate the Interest of the wider context within which the behaviour occurs and the Interest in the behaviour itself. In the case of this research, that means dental students using either a virtual-reality simulator or a traditional plastic-based simulator in order to learn basic cavity preparation skills. Students are likely to hold a relatively high level of Interest towards the topic of cavity preparation. However, in order to want to carry out the behaviour of using the simulator in order to learn cavity preparation skills then it is important for a level of situational Interest to be developed. This situational Interest would be triggered initially by the students desire to use the simulator and may either be maintained, increased or reduced as they gain experience in using the simulator.

In order to capture this situational Interest the questions used will focused on the use of the simulator by the student. When the testing took place before the students had used the simulator then it was measuring catch situational Interest. When the testing takes place after the students have used the simulator, then it was measuring hold situational Interest.

Emotion

As discussed previously, the focus of many technology acceptance based studies has been on usability and usefulness as perceived by the user. However more attention is now being given to the emotional experiences of the user (Thuring and Mahlke 2008). In general educational terms, Arkkelin (2003) claims that positive emotions towards a learning tool can lead to gains in experience, self-efficacy and knowledge whilst negative emotions can lead to students avoiding the learning tool. Emotions can be measured in one of two ways. Respondents can be asked to report their perceived emotions by, for example, completing a questionnaire or physiological measures of emotions can be used that include for example heart rate or pupil responses (Thuring and Mahlke 2008). In this research the students were self-reporting their emotion via the questionnaire.

A number of studies have looked at the impact of emotion specifically within the Technology Acceptance Model. For example, Saade and Kira (2006) extended the Technology Acceptance Model to include both affect (emotion) and anxiety. They found that emotion affected Perceived Usefulness indirectly by acting through Perceived Ease of Use. However, positive emotions towards a learning device did not necessarily mean that students would be satisfied with it. Saade and Kira suggest that too much positive emotion may lower student Satisfaction with a learning technology owing to the "If I am having fun, then I must not be learning anything" line of thought.

Task Value

Chiu and Wang (2008) divided Task Value into four distinct types:

- Attainment value, concerns the importance given by the individual towards doing well on the task.
- Intrinsic value, concerns the enjoyment derived purely from carrying out the task.
- Utility value, refers to how much carrying out the task contributes to current and future goals of the individual.
- Cost value, concerns the negative aspects of carrying out a task in terms such as the amount of effort required, negative emotional experiences and time lost to other activities

Of the above aspects of Task Value, three can already be considered as having been measured by the other variables located within the models in this study Attainment value is synonymous with Mastery Goals, intrinsic value with emotion and cognitive absorption and utility value with Perceived Usefulness. The only aspect of Task Value not yet covered by any other variable is that of cost value. Within the definition of cost value, it can also be said that aspects such as effort expectancy and negative emotional experiences can be captured by the variables of Perceived Ease of Use and emotion. This leaves the aspect of time factors and the perceived value of a task in terms of the time spent on it by the student.

This factor of time has been found to be important in determining students' perceptions of learning technologies. In a study of 4,766 undergraduate students by Lonn and Teasley (2009), 45% chose 'efficiency (saves time)' as the most perceived valuable benefit of using a Learning Management System. In a study of information-seeking behaviour in undergraduates students, the most commonly cited criteria for selecting a mode of finding information was the amount of time it took to locate (Weiler 2004). Therefore this research also considered the role of cost Task Value. This was phrased in terms of whether the students felt that using the simulator in order to carry learn basic cavity preparation skills was a valuable use of their time and whether they felt their time could be better spent doing something else in order to learn those skills.

Self-efficacy

Self-efficacy refers to an individual's judgment of their own capabilities to carry out a set of actions required for a specific purpose (Teo 2009). Self-efficacy has only recently become an important consideration within technology acceptance models. Previously, the construct of Perceived Ease of Use within the Technology Acceptance Model was considered to be an adequate measure of an individual's perceived level of self-efficacy. This argument has been disputed owing to the inherently different nature of Perceived Ease of Use and self-efficacy. Perceived Ease of Use refers to the individual's perceptions about the technology itself whereas self-efficacy is an individual's judgment regarding themselves and how skilled they feel in using the technology (Straub 2009). This means that it is possible for an individual to believe that a technology is in theory easy to use but that they themselves do not currently posses the required skills needed to use the technology.

Self-efficacy with regards to people using technology may however be multi-faceted. Technology is not always isolated from wider knowledge and skill sets. Johnson et al. (2000) claim that in order to develop a particular skill, two separate components must be mastered. These are 1) knowledge regarding how to perform the procedure and 2) the manual dexterity required to perform the procedure. This is also likely to be true for simulators. For example, dental students using a simulator as part of their studies have to master both the skills of using the physical device itself and also the skills needed to complete the task set by the simulator to the necessary standard. In the case of the two simulators in the study, the students need to understand the concepts and have mastered the skills for drilling a cavity in a tooth. This idea is supported by LeBlanc et al. (2004) who claim that the ability to restore damage in teeth caused by carious lesions relies on the student mastering both the knowledge of the procedure and the associated manual dexterity skills.

This separation of self-efficacy can therefore be placed into two categories, self-efficacy regarding the technology (how much the students believe that they have the ability to use the simulator correctly and effectively) and self-efficacy regarding the task (how much they students believe they have the ability to perform well on the task they are presented with). Task self-efficacy may be impacted partially by technology self-efficacy (as an individual who perceives that they have low object self-efficacy may well believe that they do not also posses the skills needed to complete the task as they will be impeding their own completion of the task by their inability to use the object), but it does not necessarily imply that the two constructs will be highly correlated.

Although self-efficacy is a distinct construct from Perceived Ease of Use it is still possible that a relationship exists between the two constructs. The greater an individual feels able to successfully use a technology the more likely they are to perceive the technology as easy to use. Similarly, if an individual believes that a technology is easy to use, they are more likely to feel a greater sense of self-efficacy with regards to using that technology. Self-efficacy has also been shown to have an effect on other constructs such as Interest and emotion. For example, increased self-efficacy has been shown to reduce an individual's negative emotions and increase their Interest in the task they are completing (Hidi 2006).

System Quality

Seddon (1997, p. 246) provided a broad definition of System Quality which consisted of,

"whether or not there are 'bugs' in the system, the consistency of the user interface, ease of use, quality of documentation, and sometimes, quality and maintainability of the program code."

This definition can cover a wide range of evaluative judgments made by an individual so it is possible to consider System Quality as a broad evaluation of the system by the individual. There is also some overlap between this definition of System Quality and some constructs already found with the Technology Acceptance Model. For example, ease of use in the definition of System Quality has a clear parallel with the construct of Perceived Ease of Use in the Technology Acceptance Model. It is also possible that perceived System Quality would be affected by aesthetic aspects of a system (Thuring and Mahlke 2008).

Wixom and Todd (2005) integrated System Quality into an extended Technology Acceptance Model and found that it impacted significantly on user Satisfaction (.56**). This effect was also found in the study by Roca, Chiu et al (2006) where System Quality was significantly related to Satisfaction .27** (although System Quality was broken down into sub-components of System Quality in the Roca study). It is possible that System Quality acts through Satisfaction rather than acting directly through Intention as this variable is more closely related to the Expectancy Disconfirmation Theory (see Chapter 2, Section 2.6.1).

Satisfaction

Before considering the definition of Satisfaction in the context of dental simulators it is helpful to consider the general definition of Satisfaction. There has been considerable research into the construct of Satisfaction, most of which has originated from the marketing and information systems domains. However, despite this extensive pool of research there has not been a consensus regarding the exact definition of the construct of Satisfaction. Giese and Cote (2000) conducted a review of the literature on Satisfaction and found a number of different definitions in use. This was also found in a more recent study on Satisfaction with and Intention to use IT, conducted by Deng, Turner et al. (2010). The lack of a clear definition of Satisfaction is problematic as it hinders the development of context specific definitions of Satisfaction, impedes the choice or development of measures of Satisfaction, and prevents the comparison of results from different studies where varied definitions of Satisfaction have been used.

Recognising the lack of a consensus regarding the precise definition of Satisfaction, both in general and in specific contexts, Giese and Cote (2000) developed a framework for defining Satisfaction. They conceptualised Satisfaction (and dissatisfaction) as having three key components, 1) a summary affective (emotional) response, 2) within a specified time-point or duration, 3) directed towards a focus such as an object or service. From this framework, context specific definitions of Satisfaction can be developed. Giese and Cote specify that the three components of Satisfaction need to be fully detailed by the researcher in order for the definition of Satisfaction to be adequate. Based on the Giese and Cote framework the definition of Satisfaction for this research is,

"a summary affective response of varying intensity toward the (haptel/mannequin-head) simulator following use for one term for the purpose of developing clinical skills in drilling a cavity in a tooth."

This definition can be visualised using the following diagram.

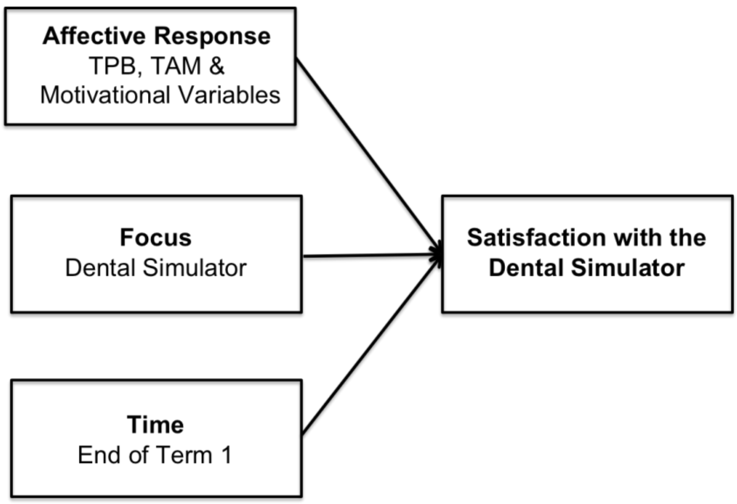


FIGURE 2-3 CONCEPTUAL FRAMEWORK FOR SATISFACTION

The focus point of the Satisfaction was the hapTEL simulator or the mannequin-head simulator. As the research was concerned with the students' overall level of Satisfaction with the simulators, the focal point did not need to be specified further. The affective response was hypothesised to be developed from the variables found within the Theory of Planned Behaviour (TPB), the Technology

Acceptance Model (TAM) and general motivational models. The time-specific point of determination for the Satisfaction the students felt with the two simulators was the end of the first term of the first-year, undergraduate dental curriculum.

Although Satisfaction in this definition is conceptualized as an affective (i.e. emotional) response, this does not mean that cognitive elements did not play a part in the formation of Satisfaction. The key point is that Satisfaction itself is an affective response, but both affective and cognitive components are the base on which Satisfaction is formed. This separation of Satisfaction as a separate construct from the components which lead to Satisfaction formation is related to the idea that behavioural-prediction models should show the ability to both predict and explain behaviour.

2.5 Efficacy of the Theory of Planned Behaviour and the Technology Acceptance Model

There have been a number of studies that have assessed the efficacy of the Theory of Planned Behaviour and the Technology Acceptance Model at predicting and explaining behaviours. These studies have typically consisted of meta-analysis of several Theory of Planned Behaviour or Technology Acceptance Model studies in order to see the strength of the relationships between behavioural-Intention and actual behaviour (if actual behaviour has been measured) and between the other variables in the model. The support for both models has usually been quite strong. A meta-analysis of the Theory of Planned Behaviour found that behavioural Intention predicted actual behaviour at .43 and that Attitude, Subjective Norms and Perceived Behavioural Control explained 44% of the variation in behavioural Intention (McEachan, Conner et al. 2011). Similar findings were also found in another meta-analysis of the Theory of Planned Behaviour. In that study behavioural Intention was found to explain 42% of the variation in actual behaviour whist Attitude, Subjective Norms and Perceived Behavioural Control explained 51%, 41% and 46% of the variation in behavioural Intention respectively (Cooke and French 2008). However both these studies were looking at the use of the Theory of Planned Behaviour in predicting health-based behaviours. No meta-analysis studies could be found that looked solely at educational-based behaviours.

There has been some criticism of the Theory of Planned Behaviour, however, in terms of its ability to predict behaviour and the variables it uses to predict behaviour. Sniehotta, Presseau et al. (2014) criticised the Theory of Planned Behaviour in terms of its validity in explaining variations in behaviour and its utility in providing comparable data from different experimental tests. They identified a number of studies where it was found that variables other than those included in the Theory of Planned Behaviour had a greater ability to predict behaviour, for example habitat strength (Gardner, Bruijn et al. 2011), nudging (Marteau, Ogilvie et al. 2011) and planning (Carraro and Gaudreau 2013). However, these studies did take place in health-behaviour research (a popular field for Theory of Planned behaviour studies) so the results may not remain consistent when used in an educational context with a student population. Sniehotta, Presseau et al. do state that the Theory of Planned Behaviour is most predictive when used with samples of young people or students when testing a behaviour over a short-time period. The sample in this research consisted of students engaging in a behaviour over one academic term and will provide further support of whether the variables from the Theory of Planned Behaviour predict behaviour in an educational context.

Sniehotta, Presseau et al. also critique the use of 'modified' or 'extended' versions of the Theory of Planned Behaviour. These occur when researchers add additional variables, usually contextual variables, to the existing model to take into account other factors that may influence the behaviour being studied (and was the method adopted in this research). They argue that this process undermines the Theory of Planned Behaviour itself by suggesting that the model on its own is not robust enough to predict behaviour and can make comparisons between different studies more difficult. In a commentary on their paper however, Conner (2014) criticises this view and suggest that taking into account additional contextual variables may help to explain specific behaviours and to help target interventions for the population being studied.

Ajzen, (2014) creator of the Theory of Planned Behaviour, responded to the critique by Sniehotta, Presseau et al. and argued that the Theory of Planned Behaviour has been found to predict behavioural Intentions from Attitudes, Subjective Norms and Perceived Behavioural Control (a fact acknowledged by the Sniehotta, Presseau et al paper) but Ajzen does agree that the link between Behavioural Intentions and actual behaviour has been less conclusive due to the existents of additional factors that may prevent people from carrying out behaviours that they have the Intention to carry out. Additionally Ajzen states that the Theory of Planned Behaviour was designed to predict and explain behaviour and not act as a model for behavioural change, therefore Sniehotta, Presseau et al criticisms of the Theory of Planned Behaviour in this regard are unjustified. However, Ajzen does suggest that the variables in the Theory of Planned Behaviour and any additional variables added to the model by researchers could act as a beginning point for the design of interventions to target the variables found to predict behavioural Intention. In the case of this research, knowing which additional variables contribute to a students' perception of simulators could assist in the development of simulators and the implementation of simulators with students, increasing the likelihood of students wanting to use the simulators.

2.6 Issues with using the Theory of Planned Behaviour, Technology Acceptance Model and motivational variables for measuring and explaining dental students' Intention to use simulators in the context of this research

There are some issues regarding the use of the Theory of Planned Behaviour, Technology Acceptance Model and motivational variables in the context of this research, which the following section addresses.

2.6.1 Measuring student perceptions of the dental simulators before they have first-hand experience using them

The dental students' perceptions of the two dental simulators were measured after they had used the simulators for one term. However, another stage of testing occurred before the students had used either simulator. The purpose of this testing was to discover the students' initial perceptions of the simulators and to investigate whether initial perceptions can be measured before an individual has first-hand experience of using a simulator.

In order to achieve this two separate issues had to be addressed. Firstly, is it theoretically possible to measure an individual's perception of a simulator before that individual has first-hand experience using the simulator and secondly what substitute could be used for first-hand experience with a simulator in order to provide individuals with a level of knowledge regarding the simulator that they may base their opinions on.

In terms of whether it is theoretically possible to measure an individual's Intention to use a simulator before they have first-hand experience using it, there is evidence from different areas in support of this from both consumer and socio-psychological fields. Chiu et al (2008) emphasised the difference between initial use of a particular learning service, which they consider synonymous with the term acceptance, and the continued use of that learning service. Initial acceptance of a learning service is needed to ensure that some initial usage actually takes place. Without this, the learning service in question cannot create a continued Intention to use in individuals. This initial acceptance is likely to be based on information the students have gained before they have experience of using the learning service. This initial information may have come from, for example, their communication with other people who have used the service, their thoughts on the service based on their aesthetic judgments or comparisons they make to services they have already used.

Information systems research also supports the idea of individuals forming Attitudes about products that they themselves have not previously used. The Expectancy Disconfirmation Theory suggests that individuals form initial expectations about products or services before they have experience with them. After use of the products or services, the individual will then have a degree of Satisfaction with the product or service, which will then in turn impact upon on their decision as to whether to continue using the product or service (Roca, Chiu et al. 2006).

This concept of being able to form Attitudes about an object that you have not had direct experience with is also supported by research on Attitudes in general. Ajzen argues that individuals form Attitudes as soon as they are exposed to an object (though these Attitudes may not be stable and are liable to change as the individual gains more experience with an object). Behavioural decision theory suggests that in the absence of specific knowledge regarding a behaviour, individuals will use relevant general knowledge they have about similar behaviours in order to form beliefs about the unfamiliar behaviour. As the individual gains experience of the behaviour in question, these beliefs are adjusted according to the new specific knowledge but are not completely replaced.

Additionally, Davis, creator of the Technology Acceptance Model, found that it was possible to introduce individuals to a pre-prototype device and still gain predictive measures of their intended behaviour toward that device (Davis and Venkatesh 2004). The only construct that Davis claimed could not be predicatively measured at the pre-usage stage was Perceived Ease of Use, which he explained could only be stably measured after individuals had actual hands-on experience with the device.

To explain how individuals are able to form opinions about objects they have not used themselves Venkatesh (2000) proposed a framework for the anchoring and adjustment of individuals' perceptions of computer-based systems. Prior to having direct experience with the target system, individuals anchor their beliefs about the system on their general beliefs about computers. These general beliefs then influence their perceptions of the target system. For example, if an individual holds positive Attitudes towards computers in general, then they are likely to hold positive Attitudes towards computer-based systems. After they have gained some experience with using the system, these initial perceptions are then adjusted based on their new knowledge of the system. In the case of this research, the students may anchor their initial perceptions of the dental simulators on other devices with which they are more familiar. As they gain experience with the simulators, these perceptions will be adjusted based on their new knowledge of the simulators.

Although the evidence presented above suggests that it is possible to measure perceptions of a simulator before individuals have first-hand experience using it, it is still necessary that they are familiar with the object in question so that they have some information upon which to base their initial judgments. In the case of behaviours involving the use of an object, one way of addressing the problem with unfamiliarity is to demonstrate the object via another medium, for example video demonstrations. Whether the use of alternative mediums is an acceptable substitute for hands-on experience is discussed below.

2.6.2 Substitutes for hands-on experience with using a device

It may not always be practically feasible to provide introductory training sessions on using the simulator to all students as the cost of running simulation exercises can be high and the ratio of simulators to students can be very small. The idea of being able to substitute real, hands-on experience with an alternative medium has been researched before. Davis (1985) creator of the Technology Acceptance Model validated the use of a video-tape presentation of a technology system as an alternative option to hands-on experience with the system. He identified a number of advantages of video demonstrations over hands-on experience including;

- The ability to present theoretical systems which do not physically exist at the present time in order to gauge opinions about which systems should be fully developed and how to improve them.
- If a prototype system does exist but is not completely finished, a video demonstration can showcase how the final product would actually look and feel.
- Video demonstrations are portable and therefore are able to be taken to sites where the full product can not, potentially increasing the number of individuals who are able to be shown the device at any one time
- The time taken to demonstrate the system is usually reduced if a video demonstration is used, again facilitating the number of individuals who can be shown the device and the number of devices.

Although these theoretical advantages exist, it is important to establish empirically that video demonstrations are a suitable alternative to hands-on experience with a device. Davis attempted to do this by conducting an empirical study of forty MBA students who were given either a video demonstration followed by a hands-on demonstration or just a hands-on demonstration of two computer packages. He found that the respondents who first had video-demonstrations of the computer packages were able to form accurate measures of their Attitudes, Perceived Usefulness, quality and behavioural expectations (their prediction of how often they would use the system) before they had hands-on experience with the system. Davis came to the conclusion that video demonstrations were an acceptable substitute for hands-on experience in studies utilising the TAM. The simulators used in this study were demonstrated to students via a short video and through printed materials. The details of how these media were delivered can be found in Chapter 3, Section 3.7.

2.6.3 Barriers in usage and mandatory usage contexts

Another issue with using behavioural prediction models in this research is the fact that the behaviour under investigation was mostly expected of the student as the use of the simulators were part of the curriculum although any student had the option not to use the hapTEL simulator if he or she didn't want to. However, since no student opted out of the research related activity, all the students in the study used both the hapTEL simulator and the mannequin-head simulator as part of their studies. Behavioural-prediction models usually investigate behaviours of which the user population,

a) has a choice over whether or not to carry out them out;

b) are in a position to carry out the behaviour should they want to

However, these two cases are not always present in behavioural-prediction research. In the case of this research, the students had to use the phantom head simulator being embedded within the first-year undergraduate dental curriculum and they all opted to use the hapTEL dental simulator as well which was considered as being part of their first year clinical skills curriculum. This does not mean, though, that behavioural-prediction models cannot be used in these contexts. Behavioural prediction models have previously been used to study behaviours that are mandatory for the user population to carry out (Rawstorne 2005). Although criticisms have been made of using behavioural prediction models to study compulsory behaviours, there is evidence that valid and reliable data can still be obtained in these situations. However, the dependent variable in mandatory usage contexts could not be the actual use of the system, as all the individuals would be using the system to some extent. As the dependent variables in the case of this research were Satisfaction and behavioural-Intention, this did not pose a problem. However, the issue of whether it is possible to measure behavioural-Intention in mandatory contexts still needed to be addressed.

In cases of non-volitional control (where the individual does not have complete control over whether or not to carry out the specified behaviour) behavioural-Intention can be used as a dependent variable. These non-volitional situations could be present in educational settings, where students may have little choice over issues such as how, where and when they study. By measuring their Intention to carry out the behaviour, it is possible to see how likely they would be to carry out the behaviour should it be voluntary. The strength of the behavioural-Intention to behaviour pathway is discussed in earlier in this chapter in Section 2.2 above.

It may at first appear to be an unnecessary step to measure students' Intention to carry out a behaviour that is compulsory. However, reasons exist for still being concerned with the Attitudes students hold towards mandatory behaviours and include,

1) **The behaviour in question may not always be compulsory**. Educational establishments adapt and change their courses, curricula and resources on a regular basis. A particular behaviour previously required of students may one day become voluntary. By considering the Intentions of students towards the behaviour whilst it is still compulsory can provide educational establishments with an indication of how likely students will be to carry out the behaviour if it becomes voluntary and what steps could be taken to ensure its success.
2) **Student Intention may be influenced by student Satisfaction.**

   As discussed above in Section 2.2, Intention to carry out a behaviour is the antecedent of actual behaviour. Satisfaction can in turn be an antecedent of Intention to carry out a behaviour. Seen in reverse, a low Intention to carry out a behaviour can indicate a low Satisfaction with carrying out a particular behaviour. This could be an indicator of a low

Satisfaction of the student with, for example, the overall course or the methods used to deliver the course. As higher education becomes increasingly marketised and institutions compete for students, low Satisfaction ratings can also have a negative impact on the reputation and subsequent intake of the educational establishment (Douglas, McClelland et al. 2008). If students do have a high Intention to carry out the behaviour, this could potentially be seen as an indicator of high levels of student Satisfaction regarding that behaviour. (However, in mandatory usage contexts it is important to consider the effects that cognitive dissonance theory may have on individuals' Attitudes. See Section 2.6.3 above).

In this study, Intention was used as the dependent variable instead of actual behaviour due to the fact that the students taking part were required to use the phantom head simulator and had opted to use the hapTEL simulator as well

2.6.4 Pre-existing Attitudes of the dental students towards technology

A final consideration to be addressed is the pre-existing Attitudes towards technology that are held by the dental students. Dentistry is a highly technologised profession, with dental students and qualified dentists required to use technological devices as part of their everyday training or working practices. It is therefore possible that the students who are drawn to dentistry as a profession will hold more positive Attitudes towards technology in general than the rest of population. These Attitudes towards technology could then impact upon their Attitudes towards any simulators they utilise in their studies.

However, this issue can be addressed by considering both dental students motivation for attending dental school and dental students Attitudes towards and experience of technology. A number of studies have been conducted in different countries in order to elicit the reasons that dental students choose to study dentistry. The motivations given by dental students are generally consistent between studies and fall into the categories of professional and financial benefits, working with and helping the public, the combination of scientific and artistic skills, and the flexibility and independence of the profession (Crossley and Mubarik 2002; Gallagher, Clarke et al. 2008; Hawley, Ditmyer et al. 2008; Kristensen, Netterstrom et al. 2009). The ability to work with technology on a regular basis or using new technologies is not a factor that appears in the literature in this area.

There is also the issue of previous technology experience by dental students. Although they may not cite reasons such as wishing to work with technology as a motivation for studying dentistry, they may still have gained more experience with using technology than their counterparts in other health-based professions. It is possible to gauge the level of technological experience dental students typically posses by looking at the work that has been conducted on dental students Attitudes towards computers and technology-enhanced learning. Researchers have regularly found that approximately 90% of dental students own a computer (Mattheos, Nattestad et al. 2002). These figures are similar to those found within more general student populations. For example, Kennedy (2008) surveyed 2120 first-year undergraduate students and found 89.5% to have unrestricted access to a desktop computer.

Overall, these studies suggest that dental students do not come to their undergraduate studies with significantly different Attitudes towards or experience with using computers or technology-enhanced learning in comparison to other student populations. However, the additional measures of computer experience included in this study (see Section 2.7.1) would also help to determine whether Attitudes towards technology generally are impacting on the dental students perceptions of the two simulators.

2.6.5 Measuring the dental students' perceptions of the two simulators at the same time

This research measured and explained student Intention to use two different simulators. However, a potential issue with measuring Intention to use two different simulators at the same time may be that the students engage in 'comparison behaviour'. Their perceptions of one simulator could potentially impact upon their perceptions of the other simulator. If students were exposed to only one of the simulators then this effect may not occur and students would potentially base their opinions just on their encounters with the simulator they had used. Although it is likely that the students' judgments of one simulator may affect their judgments of the other simulator, this is not necessarily a problem. This is because opinions of a device are often formed on the basis of the anchoring and adjustment principle. This principle claims that whenever an individual encounters a device with which they are unfamiliar, they utilise general information they posses in order to form an initial 'anchor' for their opinions towards that device (Venkatesh 2000) (see Section 2.6.1 above for more information on Attitudes towards unfamiliar behaviours). After using a device, individual then gain more specific system knowledge that can then form the basis of adjusted Attitudes. This means that the students' Intention to use a simulator has the potential to be altered at any time if they gain further information regarding simulators in general or about a specific simulator. Indeed, even if students only used one simulator as part of their training in the study, it is still possible that their level of Intention would be affected simply by the presence of another simulator.

For example, in an earlier study conducted by the author, students were assigned to use either the hapTEL simulator or the mannequin-head simulator for one term during the first year undergraduate course. A Theory of Planned Behaviour on using both the hapTEL simulator and the mannequin-head simulator was conducted at the beginning of the term, before students had used their assigned simulator, and again at the end of the term after they had used only their assigned simulator. Students in both the hapTEL and mannequin-head group showed significant changes in their opinion towards the simulator they had not used. This may have been caused by students using the simulator they had experience with as a basis of comparison for the simulator they had not used. It may also have been caused by students discussing the simulators they were using with other members of their year group, therefore affecting students' Attitudes towards the simulator they had not used. However this is not necessarily a problem as it merely reflects the students gaining more specific knowledge on which to base their opinions on, therefore moving away from using the more general anchoring knowledge that they relied upon before they had experience of using the device.

2.6.6 Measuring Intention rather than actual behaviour

This study involved measuring the dental students' Intention to use the two simulators with behavioural-Intention acting as the dependent variable (due to the behaviour in question being partly mandatory for the students to carry out). Although the aim of most behavioural-prediction models is generally considered to be its ability to predict the actual behaviours of individuals, (Rawstorne, Jayasuriya et al. 2000), this may not be as clear-cut when it comes to considering behaviours that involve the individual using a particular device. In such cases as these, the behaviour in question would be usage of the device by the individual. However, research within the information systems domain suggests that simply considering 'usage' of a device may not be a valid dependent variable. This is mainly due to the problems of both defining usage of an object and the difficulties associated with understanding the motivations behind usage of an object (Rawstorne 2005).

In terms of defining usage, what exactly constitutes usage of an object is a contentious issue. It could fall into a basic dichotomous measurement of whether the individual did or did not use the device. Alternatively, a more comprehensive measure could be taken of how often or for how long the individual used the device. Even if a consistent measure for individuals' usage of a device could be agreed upon, it may still fail to capture what the individual is thinking and feeling whilst using the device.

This leads onto a second issue regarding using actual usage of an object as a dependent variable. Just because an individual uses a device more frequently or for longer periods than another individual does not necessarily mean that those interactions were initiated from increased Satisfaction with the system. Potentially, increased usage could even be seen as a sign of frustration or lack of efficiency when using the system. Take for example two students who are using an e-learning platform in order to practise diagnosing dental x-rays. One student may only use the device on one occasion whereas the other student may use it on three separate occasions. However, the student who only used the device once may feel that they were able to interact with it in such a way as to maximise efficiency and productivity so as to achieve their learning goals in one session. The second student on the other hand may have found their interactions with the device frustrating and unhelpful. They may have felt that they had not achieved the required learning objectives they set themselves for the initial use of the device but were motivated by their Mastery Goals (see Section 2.4) to pursue use of the device again. This student may then subsequently feel that he/she has achieved his/her learning goals and cease use of the device or he/she may just 'give-up' as he/she feels the device is not meeting his/her needs. However, if we only considered the variable of 'usage', the second student would achieve higher ratings of usage than the first student and would be perceived as being more 'satisfied' with the service.

Although it is probable that individuals who do feel a greater sense of Satisfaction with a device will engage in greater usage of that device, the above example shows it is may not be valid to consider the actual usage of a device as the only dependent variable when measuring students' perceptions of a simulator. Those who are have positive perception of a device may exhibit a greater Intention to use the device again, which is a better indication of acceptance of a device by students.

As well as the above theoretical issues with the use of actual behaviour as a dependent variable, there are further concerns surrounding the use of actual behaviour when it is measured subjectively. Subjective measures of behaviour involve the individual self-reporting their behaviour. Self-report measures of behaviour are exposed to the same problems that are generic to all forms of self-reporting including respondents over-estimating or under-estimating their behaviour and even lying about the behaviours they have carried out. Behavioural prediction models frequently show much greater accuracy in predicting subjective measures of actual behaviour compared to objective measures of actual behaviour, (Turner, Kitchenham et al. 2010) suggesting that individuals may 'tailor' their responses to the subjective behaviour measures either consciously or unconsciously.

The claims put forward by cognitive dissonance theory supports this idea. Cognitive dissonance theory claims that individuals do not like to posses two inconsistent facets of related knowledge. Doing so creates a state of discomfort or 'dissonance'. Individuals can reduce this dissonance by changing one of the cognitive elements causing the conflict. According to the theory, knowledge of recent behaviour is the hardest element for individuals to change. Instead, they are more likely to change the Attitudes they hold in order to better 'fit' with their knowledge of their recent past behaviour (Gawronski and Strack 2004). If cognitive dissonance theory is correct, then measuring an individual's Intention to perform a behaviour and subjective measures of their current behaviour at the same time may produce inflated or reduced levels of Attitudes depending upon how often the individual has performed the behaviour under study recently. By asking individuals to consider their intended future use of a device, it may remove the issues associated with collecting Intention and actual use at the same time.

Despite this, the majority of studies looking at behaviour still use subjective measures of actual behaviour according to literature reviews of the Theory of Planned Behaviour and Technology Acceptance Model studies (Armitage and Conner 2001; Turner, Kitchenham et al. 2010). The reasons for this decision are typically practical rather than theoretical as it is often difficult or sometimes impossible to objectively measure actual behaviour of individuals. But replacing objective measures of actual behaviour with subjective measures of actual behaviour may in fact lead to inflated correlations between Intention and actual behaviour. Instead of replacing the unobtainable measure of objective actual behaviour with a measure that may not in fact be measuring the same construct, it is possible to reconsider the dependent variable in behavioural prediction models that involve the use of a particular device by an individual.

If there are difficulties with regards to obtaining and measuring actual behaviour, then the next best alternative for the dependent variable is Intention to carry out the behaviour rather than subjective measures of actual usage behaviours. As relying on subjective measures of actual behaviours will potentially produce an inflated relationship between Intention and behaviour it is best not to extrapolate the model to include measures of actual behaviour. Furthermore, by measuring behaviour at the same time the instrument is administered, the model is not showing the ability to predict future behaviour but rather its ability to explain current behaviour (Rawstorne, Jayasuriya et al. 2000). As discussed previously, behavioural models should show the power to both predict and explain behaviours.

2.7 Potential moderator effects of student Satisfaction with simulators

This study also considered two potential moderator effects of dental students' perceptions of the dental simulators. These two moderators are computer experience and gender. It was decided not to look at the effect of age (another common moderator of perceptions towards a technology) as the majority of the sample (approximately 86%) had an age of 18-21 meaning the sample size of individuals with higher ages was very low.

2.7.1 Computer experience as a moderator of students perceptions of the dental simulators

Measures of computer experience are frequently found within studies that utilise the Technology Acceptance Model due to the fact that the Technology Acceptance Model is commonly used to investigate behaviours involving computers. It is possible that the more computer experience an individual has, the more likely they are to have high levels of acceptance towards computers and computer-assisted devices, (although it is not clearly established whether more computer experience leads to positive Attitudes towards computers or positive Attitudes towards computers leads to greater computer experience) However, it may also be the case that the computer experience of individuals can affect their perceptions of simulators, particularly simulators that are perceived to be heavily 'computer-dependent' by the individual.

Computer experience is an ambiguous term with various definitions assigned to it. Some researchers regard it as simply a measure of time from when the individual first began using computers. Others consider it to be a measure of how frequently the individual currently uses computers. Another interpretation of computer experience is the diversity of computer applications and devices the individual utilises. Another more recent addition to the concept of computer experience is how individuals' feel whilst using computers.

This confusion over what exactly constitutes computer experience led Smith et al (1999) to emphasise the need for a clearer definition. Drawing on the work of Jones and Clark (1995), they claim that computer experience is a bi-dimensional construct comprised of two separate components, objective computer experience and subjective computer experience. Objective computer experience refers to any direct or indirect human-computer interaction and is broken down into two discrete categories, direct objective computer experience and indirect objective computer experience. Direct objective computer experience refers to the experience an individual has using a computer first-hand. Indirect objective computer experience refers to the computer experience an individual gains through secondary sources, e.g. reading about computers or observing others using computers. Subjective computer experience on the other hand focuses on how the individual thinks and feels whilst interacting with computers. This study has therefore incorporate aspects of both direct and indirect objective computer and subjective computer experience (See Chapter 3, Section 3.5.3 for more information). Previous computer experience and confidence with using computers are possible factors that may influence perceptions of simulators that utilise computers, however it is likely that this effect will be seen through self-efficacy rather than directly on Intention itself.

2.7.2 Gender as a moderator of students perceptions of the dental simulators

The majority of studies that have looked at student perceptions of simulators have not explicitly considered the role of gender. One potential reason for this may be the high prevalence of simulator studies occurring in the nursing field, which is predominately made up of female students, thus limiting the potential to study the effect of gender. This study also investigated how perceptions of simulators differed among male and female students. It is possible that the students overall Intention to use the simulators may differ because not only were the students judging certain variables differently but the variables which impact on Intention to use also differ for male and female students, as is explained below.

Some research has been conducted on male and female perceptions of technology using the Technology Acceptance Model. Earlier studies often found that Perceived Usefulness had a greater impact on Intention to use a technology for men than for women, whereas Perceived Ease of Use had a greater impact on Intention for women compared to men, see for example Venkatesh (2000), and Chorng-Shyong and Jung-Yu (2006). However, comparatively recent studies have found a shift, with Perceived Usefulness now showing a greater influence on Intention to use a technology for women compared to men, see, for example, Teo (2010). Teo suggests this move may be impacted by mens greater exposure to and usage of technology, thereby reducing the effect of Perceived Usefulness and increasing the effect of such factors as perceived enjoyment.

In this study, it is possible that the hapTEL simulator would be viewed as more of a 'technology' than the mannequin-head simulator, potentially causing gender differences to appear, particularly in terms of self-efficacy and intrinsic motivational variables. If there were differences found in how male and female students perceive the two simulators, then this information could be used to better inform both the design and implementation of dental simulators to ensure that high levels of acceptance exist for both male and female students.

3 Methods

The purpose of this research was to investigate first-year, undergraduate dental students' perceptions of two different dental simulators and the variables that affected their perceptions of the dental simulators. The principle method of data collection for this research was a questionnaire based on the Theory of Planned Behaviour and the Technology Acceptance Model. In addition to this questionnaire, a small quantity of qualitative data was collected via worksheets (Study 1) and the post-usage questionnaire (Study 2). This chapter outlines the study design for this research, the development of the questionnaire used in both studies, the procedures for operationalising the data collection, the approach to data analysis and the ethical considerations for this research.

3.1 Study design for Study 1 (2010-2011) and Study 2 (2011-2012)

3.1.1 Study 1

This research was situated within the larger hapTEL project (see Chapter 1, Section 1.4.1 for information regarding the hapTEL project). The overall hapTEL study took the form of a nonequivalent control group design (Campbell and Stanley 1963). This type of design involves having two different groups of participants, an experimental group and a control group. The experimental group receives the treatment being investigated in the research whilst the control group receives no treatment or the current, standard treatment (Trochim, 2006). In a nonequivalent control group design the groups are not sorted pre-experimentally into equivalent groups but instead come from naturally occurring groups, for example classes, schools, communities etc.

In this research, the naturally occurring groups were the applied dental skills (ADS) groups that the dental students were randomly assigned into by the dental school at the beginning of the academic year. Each ADS group consisted of approximately eight students. The total number of applied dental skills groups for the year one cohort was eighteen. The groups were labeled A1 through A9 and B1 through B9. Out of these ADS groups, the first three A groups and the first three B groups, (A1, A2, A3 and B1, B2 B3), were chosen to be hapTEL group (students who would use the hapTEL simulator in the first term) and the remaining groups (A4, A5, A6, A7, A8, A9 and B4, B5, B6, B7, B8, B9), were chosen as the mannequin-head group (students who would use the mannequin-head simulator in the first term). The mannequin-head group was the control group in this research as the mannequin-head simulator is the current, standard method of teaching at the dental school. The hapTEL group was therefore the experimental group.

3.1.2 Study 2

For the academic year 2011-2012, the hapTEL workstation was integrated into the year one undergraduate dental curriculum. This meant that all students used both the hapTEL simulator and the mannequin-head simulator during the first term of the year one undergraduate dental course, therefore students were not assigned to an experimental group and a control group as they had been in Study 1.

3.2 The Mannequin-head simulator and the hapTEL simulator.

Two different task-trainer dental simulators were used in this research. The mannequin-head simulator was a plastic based, non-dynamic simulator and the hapTEL simulator was a virtual-reality simulator with low fidelity haptics (see Chapter 1, Section 1.2.1 for an explanation of task-trainer simulators).

The mannequin-head simulator consisted of a synthetic mannequin-head installed in a conventional dental operating chair (Frasaco 2010). The teeth that are operated on are either plastic teeth or extracted teeth. See figure 3.1.

FIGURE 3-1 THE MANNEQUIN-HEAD SIMULATOR

The student sits at the mannequin-head simulator in the same manner they would if they were treating a real patient. The student has access to a working drill, foot-pedal, light source, and suction device. The student can choose to operate on a hand-held tooth or to use the mannequin-head. The mannequin-head has sets of plastic jaws that can be placed into the mannequin-head. This allows the student to operate in a similar position to the scenario of operating on a real patient. The student uses a real, working drill to perform the procedure. Another student typically acts as a dental nurse and assists the student who is acting as the dentist.

The mannequin-head simulators in this study were located in a dedicated clinical skills lab. The clinical skills lab was set up as a clinical workspace. Students had to observe health and safety rules whilst in the clinical skills lab. These included sanitising hands whilst entering and leaving the lab, wearing approved clothing and shoes, and using personal protective equipment (gloves, glasses, aprons) whilst carrying out any procedure. The clinical skills lab was staffed by dental nurses who provide equipment and support to the students.

The hapTEL simulator consisted of a 3D monitor, a haptic (force-feedback) device a dental drill, a dental foot pedal and a standard computer. The teeth that are operated on are computer-generated teeth. See figure 3.2.

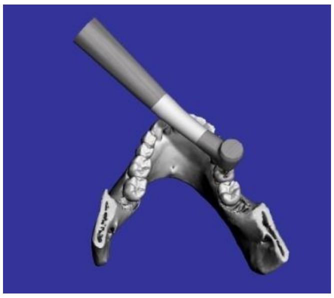


FIGURE 3-2 THE HAPTEL SIMULATOR

The student looks down onto a 3D monitor where either a single tooth or a full jaw is displayed. The student uses a dental drill that is connected to a haptic (force-feedback) device and is operated by a modified dental foot pedal. A computer-generated, collocated image of the dental drill appears on the screen allowing the student to drill the haptically enabled tooth. The haptic device enables the user to feel the tactile sensations that they would experience if they were drilling a real tooth. The student wears 3D glasses with head-tracking tags whilst using the simulator. This allows the student to view the images in 3D and for the simulator to track the position of the students head which adjusts the angle of the image on the screen. Whilst the drilling motion is switched on, the hapTEL simulator produces sounds that correspond to the type of drill the student has selected.

The hapTEL lab was located in a former computer room and therefore did not have all the features associated with a clinical skills lab. However, students were still required to wear personal protective equipment whilst carrying out procedures using the hapTEL simulator in order to encourage their learning of health and safety measures.

3.3 Use of the simulators by the students

This section outlines how the simulators were used by the students in Study 1 and Study 2.

3.3.1 Study 1

The year 1 cohort for the undergraduate dental course was divided into groups, one that would use the hapTEL simulator and one that would use the mannequin-head simulator (see Section 3.1.1 for more information). The students used their assigned simulator for three clinical skills sessions during the first term of the academic year. The students worked in pairs whilst performing various cavity preparations. Each session with the simulator lasted approximately one and a half hours.

3.3.2 Study 2

Each student in the first year of the undergraduate dental course was timetabled to use the hapTEL simulator for two clinical skills sessions during the first four weeks of the academic term. Each session lasted for one and a half hours. Approximately 22 students took part in each session. Students worked together in pairs with the hapTEL simulator for the whole of the session. For the remaining clinical skills sessions for the rest of the term, the students used the mannequin-head simulator. The students worked in pairs whilst performing various cavity preparations on plastic teeth.

3.4 Sample

The sample for both Study 1 and Study 2 was composed of first-year undergraduate dental students based at King's College London Dental School. The students who completed the pre-usage and post-usage questionnaires for the two studies in this research are outlined in the table below.

TABLE 3.1 SUMMARY OF DEMOGRAPHIC DATA FOR THE PARTICIPANTS OF STUDY ONE AND STUDY TWO

	Study 1 (2010-2011)		Study 2 (2011-2012)	
	Pre-usage Questionnaire	Post-usage questionnaire	Pre-usage Questionnaire	Post-usage questionnaire
Total	**123**	**119**	**127**	**119**
Male	47	46	54	51
Female	76	73	73	68

3.4.1 Study one

144 students enrolled in the first year of the undergraduate dental course. Of these students, 132 completed the pre-usage questionnaire. However, within this sample of 132 students were nine students who were repeating the first

year of the undergraduate dental course. This meant they had been students the previous academic year during another round of data collection for the hapTEL project, meaning they had experience of using both the hapTEL and the mannequin-head simulators. These students did not therefore meet the criteria for the pre-usage questionnaire (which required no previous usage of either simulator) so their results were not included in the data analysis for study one. This left a final sample size for the pre-usage questionnaire of 123 students. These 123 students were made up of 47 male students and 76 female students.

Of these 123 students, 119 completed the post-usage questionnaire. Students who completed the post-usage questionnaire but had not completed the pre-usage questionnaire were excluded from the data analysis as their responses may have been affected by the fact that they had not seen the questionnaire before. The students who completed the post-usage questionnaire were made up of 46 male and 73 female students.

3.4.2 Study two

144 students enrolled in the first year of the undergraduate dental course. Of these students 135 completed the pre-usage questionnaire. Within this sample of 135 students were 8 students who were repeating the first year of the undergraduate dental course. As for Study 1, these students' results were excluded from the data analysis (see previous section for an explanation). This left a final sample size for the pre-usage questionnaire of 127 students. These 127 students were made up of 54 male students and 73 female students.

Of these 127 students, 119 completed the post-usage questionnaire. As for study one, students who completed the post-usage questionnaire but had not completed the pre-usage questionnaire were excluded from the data analysis as their responses may have been affected by the fact that they had not seen the questionnaire before. The students who completed the post-usage questionnaire were made up of 51 male and 68 female students.

3.5 Development of the questionnaire

The questionnaire that was used in this research was developed over a period of two years (see Chapter 1, Section 1.4.1). The questionnaire was based on the Theory of Planned Behaviour and the Technology Acceptance Model (See Chapter 2, Sections 2.5-2.8 for details of the two models). A smaller study conducted in 2009-2010 as part of a masters dissertation (Green 2010) involved the development of a Theory of Planned Behaviour questionnaire in order to investigate dental students Attitudes towards haptic and traditional devices for teaching dental skills. Based on the work conducted in that study and reviews of relevant literature the questionnaire was modified and extended to include additional variables from the Technology Acceptance Model and motivational models. This section outlines the development of the questionnaire and the methodological considerations regarding its construction.

3.5.1 Questionnaire used in Pilot study 2009-2010

In the 2009-2010 study (see Chapter 1, Section 1.4.1 for more information) a Theory of Planned Behaviour questionnaire was conducted into dental students' Attitudes towards using ICT, haptic simulators and mannequin-head simulators in their dental studies. The first step in conducting a Theory of Planned Behaviour questionnaire is to conduct an elicitation study. An elicitation study involves interviewing a comparable group to the population who will complete the questionnaire in order to derive common salient beliefs about the behaviour being studied (Fishbein & Ajzen, 1975).

The elicitation study was carried out in September 2009. The population used for the elicitation study consisted of twenty-two postgraduate dental students. This is an acceptable sample size based on the recommended number of twenty-five (Francis, Eccles et al. 2004). The participants completed a sixteen-item, open-ended questionnaire which can be found in Appendix 3A.

The responses to the questions were analysed in order to draw out common themes for the variables found within the Theory of Planned Behaviour (Attitudes, Subjective Norms and Perceived Behavioural Control). These common themes were then used to inform the construction of the items included in the final Theory of Planned Behaviour questionnaire for the 2009-2010 study.

This questionnaire then formed the basis of the questionnaire used in Studies 1 and 2 for this research. The items used to measure the Theory of Planned Behaviour variables were modified so that they focused on the hapTEL simulator and the mannequin-head simulator specifically. Additionally items to measure the variables found within the Technology Acceptance Model and motivational variables were added to the questionnaire. The final questions used in the questionnaire are presented in the following section. All items, (apart from those measuring the Theory of Planned Behaviour variables) came from pre-existing, generic scales designed to measure those variables.

3.5.2 Items used in the final questionnaire

The items used in the final questionnaire came primarily from existing scales. This decision was made because these scales have already been shown empirically to have acceptable levels of reliability and validity and because use of the same scales aids comparisons between studies. However, the items used for the Theory of Planned Behaviour variables were devised from the elicitation study as recommended by Ajzen (see Section 3.5.1).

As will be discussed in Section 3.5.5, three items were used to measure each variable. The most common number of items used in studies utilising the Theory of Planned Behaviour and the Technology Acceptance Model is between three and five. The items in the questionnaire were chosen after a review of relevant studies, with the most commonly appearing items for each variable being selected. The items for the Theory of Planned Behaviour variables were chosen from the 2009-2010 questionnaire, with the items showing the highest level of prediction for behavioural Intention being selected. The exact items used for each variable are now presented.

Mastery Goals

Items taken from existing scales from Elliot and Murayama (2008)

- Mastering the material in the Introduction to Restorative Practice module is important to me

- My aim is to completely understand the material presented in the Introduction to Restorative Practice module

- I am striving to understand the content of the Introduction to Restorative Practice module as much as possible

Attitude

Items taken from scales used previously by the author in Masters research (Green 2010)

Using the (hapTEL dental simulator/mannequin-head dental simulator) in the Introduction to Restorative Practice module is...

- Harmful……Beneficial
- Bad…….Good
- Worthless….Useful

Subjective Norms

Items taken from scales used previously by the author in Masters research (Green 2010)

- My tutors think that I should use the (hapTEL dental simulator/mannequin-head simulator) in the Introduction to Restorative Practice Module
- The other students on my course think that I should use the (hapTEL dental simulator/mannequin-head dental simulator) in the Introduction to Restorative Practice module

- Doing what the tutors on my course think I should do is important to me
- Doing what the other students on my course think that I should do is important to me

Perceived Ease of Use

Items taken from existing scales from Davis (1985)

- Learning to operate the (hapTEL dental simulator/mannequin-head dental simulator) will be easy for me
- It will be easy for me to become skilful at using the (hapTEL dental simulator/mannequin-head dental simulator)
- Using the (hapTEL dental simulator/mannequin-head dental simulator) will be clear, understandable and straightforward.

Perceived Usefulness

Items taken from existing scales from Daivs (1985)

- Using the (hapTEL dental simulator/mannequin-head dental simulator) will improve my performance in the Introduction to Restorative Practice Module
- The (hapTEL dental simulator/mannequin-head dental simulator) will be useful to me in the Introduction to Restorative Practice Module
- I will do better in the Introduction to Restorative Practice Module if I use the (hapTEL dental simulator/mannequin-head dental simulator)

Self-Efficacy-task

Items taken from existing scales from Yi (2003)

- I am confident that I can complete the learning tasks presented on the (hapTEL dental simulator/mannequin-head dental simulator) to a high standard
- I have the ability to do well on the learning tasks presented on the (hapTEL dental simulator/mannequin-headdental simulator)
- I am confident that I can master the learning tasks presented on the (hapTEL dental simulator/mannequin-head dental simulator)

Self-Efficacy-technology

Items taken from existing scales from Yi (2003)

- I am confident that I can use the (hapTEL dental simulator/mannequin-head dental simulator) with little help from others
- I am confident that I can use the (hapTEL dental simulator/mannequin-head dental simulator) even if I had never used a system like it before
- I posses the skills needed to be able to use the (hapTEL dental simulator/mannequin-head dental simulator)

Perceived Behavioural Control

Items taken from scales used previously by the author in Masters research (Green 2010)

- I feel in control when using the (hapTEL dental simulator/mannequin-head dental simulator)
- How I use the (hapTEL dental simulator/mannequin-head dental simulator) in my learning is up to me
- I am confident that I could have access to the (hapTEL dental simulator/mannequin-head dental simulator) if I wanted to

Task-value cost

Items taken from existing scales from Chiu (2008)

- Using the (hapTEL dental simulator/mannequin-head dental simulator) is a good use of my time
- I achieve more in the same amount of time by using the (hapTEL dental simulator/mannequin-head dental simulator) instead of other learning methods
- I could do more important things with my time than instead of using the (hapTEL dental simulator/mannequin-head dental simulator)

Emotion

Items taken from existing scales from Perugini (2001)

- I feel excited about using the (hapTEL dental simulator/mannequin-head dental simulator)
- I feel worried about using the (hapTEL dental simulator/mannequin-head dental simulator)

- I feel happy about using the (hapTEL dental simulator/mannequin-head dental simulator)

Interest

Items taken from existing scales from Harackiewicz (2008)

- I am Interested in using the (hapTEL dental simulator/mannequin-head dental simulator)
- I am looking forward to using the (hapTEL dental simulator/mannequin-head dental simulator)
- I am fascinated by the thought of using the (hapTEL dental simulator/mannequin-head dental simulator)

Cognitive absorption-Temporal displacement

Items taken from existing scales from Roca (2006)

- Time goes by quickly when using the (hapTEL dental simulator/mannequin-head dental simulator)
- It is easy to lose track of time when using the (hapTEL dental simulator/mannequin-head dental simulator)
- It is easy to spend longer on the (hapTEL dental simulator/mannequin-head dental simulator) than I intended

Cognitive Absorption-Focused immersion

Items taken from existing scales from Roca (2006)

- I am able to block out distractions when using the (hapTEL dental simulator/mannequin-head dental simulator)
- When I use the (hapTEL dental simulator/mannequin-head dental simulator) I am absorbed in the task I am doing
- I am immersed in what I am doing when using the (hapTEL dental simulator/mannequin-head dental simulator)

Cognitive Absorption-Heightened enjoyment

Items taken from existing scales from Roca (2006) and Hsu (2004)

Using the (hapTEL dental simulator/mannequin-head dental simulator) is…

- Enjoyable
- Fun
- Boring

System Quality

Items taken from existing scales from Chiu (2008)

- The quality of the (hapTEL dental simulator/mannequin-head dental simulator) is be high
- Compared to other learning systems, the (hapTEL dental simulator/mannequin-head dental simulator) is of a higher standard

- The quality of the (hapTEL dental simulator/mannequin-head dental simulator) is as high as other learning systems I have used

Satisfaction

Items taken from existing scales from Roca (2006)

- I am pleased with the performance of the (hapTEL dental simulator/mannequin-head dental simulator)
- I am satisfied with my overall experience of using the (hapTEL dental simulator/mannequin-head dental simulator)
- The (hapTEL dental simulator/mannequin-head dental simulator) served my learning needs well

Intention

Items taken from existing scales from Roca (2006) and Chiu (2008)

- If I had the choice I would use the (hapTEL dental simulator/mannequin-head dental simulator) on a regular basis
- I want to use the (hapTEL dental simulator/mannequin-head dental simulator) in the future
- I would recommend the (hapTEL dental simulator/mannequin-head dental simulator) to others

The variables included on the questionnaire will also be grouped together in the following categories during the data analysis and discussion to aid comparison between the different factors affecting behavioural Intention.

- Ease of use: Perceived Ease of Use, System Quality, Self-Efficacy Task and Self-Efficacy Technology
- External factors: Perceived Behavioural Control and Subjective Norms
- Extrinsic motivation: Mastery Goals , Attitude and Perceived Usefulness
- Intrinsic motivation: Cognitive Absorption Temporal Displacement, Cognitive Absorption Heightened Enjoyment, cognitive absorption focused immersion, emotion and Interest

3.5.3 Measuring computer experience of respondents

As discussed in Chapter 2, Section 2.7.1, previous computer experience may have been a contributory factor of students' perceptions of the two simulators, particularly if the simulator was perceived to be heavily computer-dependent by the respondent. In order to take account of this potential effect, it was decided to include a measure of previous computer experience. However, as this research was not focused solely on student Attitudes towards computers but on student perceptions of virtual-reality simulators and traditional simulators, it was decided that the scope of the questions should be broader in order to include student experience with both computers and general technological devices. This approach has also been adopted by other researchers investigating computer experience of students for example Kennedy (2008).

As discussed in Chapter 2, Section 2.7.1, computer experience can be broken down into objective computer experience and subjective computer experience, so questions were included to measure both of these components. In order to measure objective computer experience, respondents were asked to indicate whether they owned certain technological devices. In order to avoid ambiguity, each of the items were followed by a specific example of that technological device, for example, *hand-held computer games console e.g. Nintendo DS.*

The items included were;

- **Laptop computer**
- **Desktop computer**
- **PDA**
- **Touch-screen mobile device**
- **Stylus-assisted mobile device**
- **Computer games console**
- **Hand-held computer games console**
- **Digital music player**

The second question for objective computer experience asked respondents to indicate how frequently they had used particular computer applications and software in the previous two months. These included;

- **Word processing**
- **Email**
- **Spreadsheets**
- **Databases**
- **Web searches**
- **Blogs/chat rooms**
- **Social network sites**
- **Computer programming**
- **Computer gaming**
- **Website design**

- **Photo editing**
- **Music and film download**

A two-month time scale was used as the respondents were mostly comprised of individuals who had recently attended schools or colleges before coming to the University. As such, it is possible that they would have used technology frequently as part of their studies. As the pretesting questionnaire was conducted in late September and early October, the use of a two-month scale would have limited the time frame to the summer holiday and the beginning of the academic year at the university. This would increase the likelihood of measuring how often the individuals usually use technology without the potential of it being inflated by their use of technology for academic purposes.

A seven-point Likert scale was used to measure the frequency of use. The scale was end-response only labelled anchored with ‘never’ and ‘everyday’ (see Section 3.3.4 for an explanation of the choice of Likert scale). An eighth option, labelled NA, was also provided for respondents who had never used the software or application.

Subjective computer experience was measured by two questions. Firstly, respondents were asked to rate their perceived level of skill in using the applications and software from the previous question. A seven-point, end-response only labelled Likert scale was used anchored with ‘very low skilled’ and ‘very highly skilled’. Secondly, respondents were asked to rate their perceived confidence in using new technologies. A seven-point, end-response only labelled Likert scale was used anchored with 'not confident' and 'very confident'.

3.5.4 Pilot study

The final questionnaire was piloted with nine second-year undergraduate dental students. Second-year undergraduate dental students were chosen as they are a comparable group to the students who would complete the final questionnaire. The results were analysed in terms of reliability for the scales, all of which were found to be of an acceptable level.

3.5.5 Number of items per variable

A total of three items were used in order to measure each of the variables included in the questionnaire apart from Subjective Norms which used four (see Section 3.3.6 for a detailed explanation). This number was lower than those used in the original studies for the Theory of Planned Behaviour and Technology Acceptance model but is comparable to other studies that have utilised the Theory of Planned Behaviour to investigate student Attitudes towards learning devices such as those conducted by Roca (2006), Liao et al. (2007) and Yu (2010).

A smaller number of items per variable were chosen in order to reduce the cognitive load of participants completing the questionnaire. As the students' perceptions of the two dental simulators were investigated using one questionnaire, an increase in the number of items per variable to five would have increased the total number of items in the questionnaire from 114 to 160. Studies have shown that response quality decreases as the length of a questionnaire increases (Galesic and Bosnjak 2009). Given that previous research has taken place with smaller numbers of item per variable and that the reliability and validity of individual items are well established in the literature it was decided that reducing the number of items per variable to three was an acceptable compromise to avoid increased cognitive loads on participants that may have resulted in less valid data.

3.5.6 Response format for the questionnaire-Likert scales

The response format for the questionnaire took the form of a Likert scale. This is a popular method for behavioural-prediction studies and the recommended method for Theory of Planned Behaviour and Technology Acceptance Model questionnaires (Davis 1985; Ajzen 2006). A Likert scale involves respondents selecting their level of agreement with a statement using a pre-defined linear scale. The main decisions regarding Likert scale construction; are how many points will be on the scale, will a neutral mid-point be included and how will the points on the scale be labeled. The options chosen for the Likert scale construction in this research are presented along with explanations for the choices.

Rationale for using a seven-point, extreme response labeled only Likert Scale

A seven-point Likert scale was chosen for the questionnaire. This length was chosen for a number of reasons. Firstly, the most commonly used lengths for Likert scales are five point scales and seven point scales (Preston and Colman 2000). Secondly, it was considered that a seven-point Likert scale would provide the best balance between information gain and cognitive load for the participant. According to Weijters et al. (2010) the crucial issue with Likert scales is ensuring maximum transfer of information whilst reducing the cognitive demands of respondents as much as possible. By increasing the number of response categories on a Likert scale you increase the degree of detail that is provided by the respondent. However, the disadvantage of this increased detail is the increased cognitive load placed onto respondents. It is also not entirely clear whether continuing to increase the number of response categories will lead to increased gains in information. For example, research has found that increasing the number of response categories from two to five points strongly increases information gains but continuing to expand the scale from five to ten points produces only moderate information gains (Weijters, Cabooter et al. 2010)

The balance between increased information gains for the researcher and lower cognitive demands for the participant tends therefore to favour a scale of five or seven points. For student populations, a scale of seven points is generally recommended due to the increased cognitive capabilities and experience with responding to questionnaires typically found among students (Weijters, Cabooter et al. 2010), therefore the decision was taken to use a seven-point Likert scale.

Rationale for using a Likert scale with a mid-point

By using a scale with an odd number of points, in this case seven, the scale ends up containing a mid-point. When midpoints occur in Likert scales they are usually treated by researchers and respondents as a 'neutral' point, implying indifference or ambivalence towards the item in question (Cohen, Manion et al. 2000). Some researchers argue that the inclusion of a midpoint simply provides respondents with an easy way out of actually answering the question. By not including a neutral stance you effectively force the respondent to indicate some level of agreement or disagreement with the item. However, critics of this method emphasise the importance of truly indifferent or ambivalent individuals having an option to express this view. There are also methodological implications of not including a midpoint. Individuals who hold a neutral stance do not have positive or negative evaluations regarding the item in question. When no midpoint is offered they are likely to randomly shift their answer to either the positive or negative end of the scale, therefore leaving the actual distribution of responses unaffected. The same is not true however of individuals who hold ambivalent views. They are likely to weigh up the positive and negative evaluations they hold towards the item in question and make a final decision based on their assessment of what is the most important attribute of the item (Nowlis, Kahn et al. 2002). If this also resulted in random shifts by ambivalent respondents to either the positive or negative side of the scale then there would again be no change in the distribution of responses. However, research has suggested that rather than there being an equal chance of participants responding either negatively or positively towards the item, there is actually a much greater likelihood that they will respond in a negative manner (O'Muircheartaigh, Krosnick et al. 2000). By being forced to choose a side, the respondents may experience task-related frustration which is then reflected onto the item they are answering, leading them to respond to the item negatively (Weijters, Cabooter et al. 2010). This will cause a shift in responses towards the negative end of the scale that does not accurately reflect the opinions of the respondents. This evidence indicates that it may therefore be detrimental to not include a mid-point in a Likert scale. Therefore, it was decided that using a seven-point Likert scale was still acceptable as the use of an odd numbered scale meant the inclusion of a mid-point which was considered methodologically advantageous.

Rational for using an extreme response labeled scale

The Likert scale used in this research only had labels for the extreme response (end-point) categories. Typically, Likert scales either use a label for every category, for example,

1	2	3	4	5
very bad	bad	neutral	good	very good

Or use labels for only the end-point categories for example,

1	2	3	4	5
very bad				very good

Additionally, there is the option of leaving the middle point unlabelled in an extreme response labeled scale or adding a label that indicates the neutral/ambivalent nature of the middle point.

There are advocates of using a verbal label for all the response categories on a Likert scale as they argue that it helps to improve respondents' interpretation of the scale as they do not have to attach their own meanings to each of the response categories. It also means that all of the respondents will be using the same point of reference for each of the response categories. However, this idea that category labels will create standardisation among respondents has been disputed. Even with label categories such as 'good', there is no guarantee that what one individual considers 'good' is the same as another individual (Cummins and Gullone 2000). There is also evidence that labeling all response categories can actually be detrimental to the data collected (Weijters, Cabooter et al. 2010). For scales longer than five points, there is the added problem of finding enough salient verbal labels for each of the response categories. As a seven-point Likert scale was being used it was decided to only label the end-point categories and the mid point-category as it was felt that there would be little gain from assigning a verbal name to each category in terms of the quality of the data collected and that it might actually be detrimental to the data if overly detailed labels had to be found for some of the categories.

3.5.7 Question wording

The questions were written in the tense appropriate to the timing of the questionnaire. The pre-usage questionnaire employed future tense whilst the post-usage questionnaire employed present tense. For example,

- **Pre-usage questionnaire**

Using the (haptic dental simulator/traditional dental simulator) will be a good use of my time

- **Post-usage questionnaire**

Using the (haptic dental simulator/traditional dental simulator) is a good use of my time

This mode of question writing has been utilised by other studies that have adopted testing at more than one time, for example Venkatesh et al. (2003).

3.6 Qualitative Data: Worksheets and post-usage questionnaire

A small quantity of qualitative data was also collected in this research in order to enrich the quantitative data derived from the questionnaire and potentially to provide additional insights into the students' experience of using the dental simulators.

For Study 1, this data was collected via worksheets that were completed by students during their clinical skills sessions after they had used either the mannequin-head simulator or the hapTEL simulator. The worksheets were part of the wider hapTEL project and included questions regarding the procedure the students had carried out and an evaluation of their performance (see the following section for more information about how the qualitative data was collected). The questions for this research were included on these worksheets. The students completed one worksheet for each of the three clinical skills sessions they attended. One question was asked on each worksheet. The questions are presented below.

1.*Describe your initial experience of using the (mannequin-head/hapTEL) simulator*

2. *Compare your experience of using the (mannequin-head/hapTEL) simulator in this session with your experience last session*

3.*Describe your overall experience of using the (mannequin-head/hapTEL) simulator*

For study two, the qualitative data was collected via the post-usage questionnaire. An open-ended question was included on both the mannequin-head simulator and the hapTEL simulator. The question asked students if they had any comments they wished to make about the simulator.

3.7 Procedures for administering the questionnaire and worksheets

The questionnaire was designed as a web-based survey that was placed on Free Online Surveys. A web-based survey can be set-up so that participants are unable to submit the survey if they have left any questions unanswered. This therefore removes the problem of missing data. Web-based surveys have been found to produce equally valid and reliable data compared to paper based surveys in numerous studies (Eaton, Brener et al. 2010; Hardré, Crowson et al. 2010; Touvier, Mejean et al. 2010; Shervin, Dorrwachter et al. 2011). The exact procedures for administering both the questionnaire and the worksheets used in Study 1 and Study 2 are outlined below.

3.7.1 Study one

The questionnaire was administered during a larger testing session that was part of the hapTEL project. The testing session involved students undertaking psychometric tests in manual dexterity and spatial reasoning. As discussed in Chapter 2, Section 2.2, it is important for individuals to hold some level of knowledge toward a behaviour or object in order to form an opinion about that behaviour or object. This meant that students had to be aware of both the hapTEL simulator and the mannequin-head simulator. In order to do this, a verbal explanation of both simulators was provided at the beginning of the psychometric sessions along with a short video. (see Chapter 2, Section 2.6.2 for information on using video demonstrations as a substitute for hands-on experience). Further information regarding the simulators was also provided in the form of a booklet on the hapTEL project and within the questionnaire itself, where written and photographic information was provided regarding the simulators. Students were also invited to ask any questions they had regarding the two simulators. After being provided with this information, the students were asked to log-on to a website where they were able to complete the questionnaire.

At the end of the first term, the students completed the questionnaire again. At this stage, students had only used their assigned simulator (either the mannequin-head simulator or the hapTEL simulator) for the first term. Students only answered questions regarding the simulator they had used. The questionnaire was again administered during the larger psychometric testing sessions.

For Study 1, students completed the worksheets containing the questions for the qualitative data during their regular clinical skills session. The classes took the form of an instructor led lecture followed by an activity that students completed either on the hapTEL simulator or the mannequin-head simulator. The tasks the students undertook on the hapTEL simulator and the mannequin-head simulator were made as comparable as possible. Once the students had completed the activity they were asked to complete a worksheet that reflected on their experiences during that session (see previous section). These worksheets were collected in at the end of the session and analysed (see Section 3.8). The worksheets were matched to each participant by the code assigned to them that the students wrote onto the worksheet (see Section 3.7.4)

3.7.2 Study two: 2011-2012

Unlike Study 1, the students in Study 2 completed the questionnaire in the first of their clinical skills sessions (before they used the hapTEL simulator). The students were informed about both the hapTEL simulator and the mannequin simulator in the same way as study one (see previous section). Owing to the limited number of simulators in the hapTEL lab (twelve), it was necessary for half of the students to complete the pre-usage questionnaire on paper whilst the other half completed it online (the hapTEL simulators had access to the internet, allowing half of the students to complete the questionnaire online). The method used (online or paper) to complete the questionnaire was noted for each student in order to check that results had not been affected by using either a paper-based or a web-based questionnaire.

At the end of the term, students completed the post-usage questionnaire during the end-of –term assessment activates for the clinical skills course. As there were sufficient numbers of computers available in the clinical skills lab, all of the students were able to complete the post-usage questionnaire online.

3.7.3 Treatment of missing values

For Study 1, all of the students completed an online version of the questionnaire therefore there were no missing values for either the pre-usage or post-usage questionnaire. This was due to the fact that the online version of the questionnaire can be set up in such a way that it cannot be submitted if there are any questions left unanswered.

For Study 2, approximately half of the participants completed a paper version of the pre-usage questionnaire whilst the other half completed an online version of the questionnaire (see previous section for an explanation). The online version of the questionnaire could not be submitted if there were missing responses to any of the questions. Therefore all the questionnaires that were completed online had no missing values. However, a small number of the paper-based questionnaires did contain some missing values. It was decided to replace the missing values with the overall mean for that item so that statistical analysis could still take place using all the available data.

Using the overall mean score is one method for replacing missing values. The advantage of this method is that it does not change the mean of the item itself. Replacing missing values with the item mean is an acceptable method if the amount of missing data is less than 5% of the total data (Field 2009). In the case of this study, there were 127 participants and 99 items on the questionnaire, resulting in a total data size of 12,573 values. The total number of missing values was 25, meaning that the amount of missing data was 0.20%. This is below the accepted size for replacing missing data values with the overall mean score for that item so it was decided that replacing missing values with the overall item mean was acceptable.

3.7.4 Coding participant data

For study one, each participant was assigned a unique three-character numeric code. Participants wrote this code onto the Pre-Usage and Post-Usage questionnaires and all of the worksheets they completed. This code allowed data from the Pre-Usage and Post-Usage questionnaires and worksheets to be matched for each participant.

For study two, each participant wrote their student number on the questionnaire (either online or paper-based they completed). This enabled the Pre-Usage and Post-Usage questionnaires to be matched for each participant.

3.8 Procedures for data analysis of the questionnaire and respondent completed worksheets

This section outlines how the quantitative data and qualitative data was analysed.

3.8.1 Statistical analysis of the questionnaire data

The data from the questionnaire was analysed using the statistical computer packages SPSS version 20 and AMOS version 20. The following statistical procedures were carried out:

- **Basic descriptive statistics**

This was used to examine the means and standard deviations of the variables included on the questionnaire.

- **Reliability of individual items and scales**

This was used to determine whether the individual items used for each variable in the questionnaire are consistently measuring that variable. Cronbach's alpha was used, with .7 and above considered to show an acceptable level of reliability.

- **Regression, Ordinary Least Squares (OLS)**

This was used to determine the extent to which the variables where related to the Satisfaction and Intention as well as the overall variance in Satisfaction and behavioural Intention that was attributable to the variables. The regression was assessed using the R^2 value, and the individual beta values for the variables.

- **Structural Equation Modeling**

A structural equation model was developed for the hapTEL simulator pre-usage questionnaire, hapTEL simulator post-usage questionnaire, mannequin-head simulator pre-usage questionnaire and mannequin-head simulator post-usage questionnaire. Structural equation modeling is a statistical method that allows causal relationships to be established based on theory and then tested using a confirmatory approach (Byrne 2010)

The variables used in the structural equation model were selected from the variables that were found to impact significantly on either anticipated Satisfaction /Satisfaction and/or behavioural Intention. The models were constructed based on the known theory regarding the variables and how the variables are related to each other. Variables which were found to be insignificant were removed from the final structural equation model, known as post hoc model fitting (Byrne 2010).

The goodness-of-fit for the proposed models were measured using the indices show in table 3.2. Another popular model fit index that is often used for structural equation modeling is the RMSEA. However, this study did not use the RMSEA as it is not recommended for models with a small number of degrees of freedom (Kenny 2011). In the case of this research the degrees of freedom was 2 therefore it was decided to not use the RMSEA as a measure of model fit.

Table 3.2 Model Fit Indices for Structural Equation Modeling

Model fit indices	*Recommended value*
χ^2	≤5, non-significant
χ^2/df	≤5
TLI	≤9
CFI	≤9
NFI	≤9

3.8.2 Analysis of the qualitative data: Worksheets and post-usage questionnaire

The qualitative data from the worksheets (Study 1) and post-usage questionnaire (Study 2) was analysed using thematic analysis in order to identity common themes among the data.

3.9 Research ethics

The hapTEL project obtained ethical approval from the King's College London ethics committee, reference CREC/06/07-22. All participants in the study were provided with an information sheet outlining the research and their requested involvement (Appendix 3B). If the students agreed to participate in the research they were asked to complete a consent form (Appendix 3C) indicating which parts of the research they agreed to take part in.

In study one, an ethical concern of the hapTEL project was the opportunity for the students to use the two different dental simulators. It was important that neither group of students (the hapTEL group or the mannequin group) had any advantages or disadvantages compared to the other group in terms of their learning. This meant that the students needed to have the opportunity to use both of the dental simulators as part of their training. Therefore, after the data collection period was completed, the students attended sessions where they were able to use the simulator that they had not used in the first term. For study two, all students used both dental simulators as part of their training for the first term so this was not an ethical concern.

4 Results from the Quantitative Analysis for Study 1 and Study 2

4.1 Introduction

This chapter presents the results from the questionnaires conducted in Study 1 and Study 2 for the hapTEL simulator and the mannequin-head simulator. The students in both studies completed two questionnaires-a pre-usage questionnaire at the beginning of the first term of the year one undergraduate dental curriculum and a post-usage questionnaire at the end of the first term.

The students had no prior experience with using either the hapTEL simulator or the mannequin-head simulator before completing the pre-usage questionnaire at the beginning of the term in both Study 1 and Study 2. The students in Study 1 then used either the hapTEL simulator or the mannequin-head simulator for one term before completing the post-usage questionnaire for that simulator at the end of the first term. The students in Study 2 used the hapTEL simulator at the beginning of the first term and then the mannequin-head simulator at the end of the first term. The students in Study 2 then completed the post-usage questionnaire at the end of the first term after having used both simulators. (For a detailed breakdown of Study 1 and Study 2 see Chapter 3, Section 3.1).

The quantitative data from Study 1 and Study 2 was combined in order to create a larger sample size that would allow for additional statistical tests to be carried out and to increase the reliability of the results obtained. The results were able to be combined as there were no significant differences in the overall mean scores for the variables between the two cohorts, therefore it was justifiable to combine the two year groups into one final cohort.

The final sample size for both the pre-usage hapTEL questionnaire and the mannequin-head simulator pre-usage questionnaire was 250 (for Study 1 n=123, for Study 2 n=127). The final sample size for the hapTEL simulator post-usage questionnaire was 165 (for Study 1 n=46, for Study 2 n=119) The final sample size for the mannequin-head simulator post-usage questionnaire was 196 (for Study 1 n=77 , for Study 2 n=119) for a detailed breakdown of the sample demographics see Chapter 3, Section 3.4).

4.1.1 Reliability of the items on the questionnaire

Cronbach's alpha was used to assess the reliability of the items on the questionnaire, with a value of .7 or above indicating acceptable reliability (Field 2009). Table 4.1 shows the levels of reliability for the pre-usage questionnaire variables. Table 4.2 shows the levels of reliability for the post-usage questionnaire variables.

Table 4-1 Cronbach's alphas for the scales included on the pre-usage questionnaire

Variable	hapTEL Simulator	Mannequin-head Simulator
*Mastery Goals	.92	
Attitude	.92	.95
Perceived Usefulness	.92	.94
Task Value	.70	.76
Subjective Norms	**.68**	.70
Perceived Behavioural Control	.87	.89
Self-Efficacy Task	.92	.93
Perceived Ease of Use	.85	.91
Self-Efficacy Technology	.78	.82
Cognitive Absorption Temporal Displacement	.84	.86
Cognitive Absorption Focused Immersion	.93	.94
System Quality	.76	.82
Interest	.92	.95
Cognitive Absorption Heightened Enjoyment	.92	.89
Emotion	.77	.78
Satisfaction	.93	.93
Intention	.91	.92

***The variable of Mastery Goals was measured once as it is a universal measure**

Table 4-2 Cronbach'a alphas for the scales included on the post-usage questionnaire

Variable	hapTEL Simulator	Mannequin-head Simulator
*Mastery Goals	.92	
Attitude	.94	.95
Perceived Usefulness	.95	.95
Task Value	.88	.81
Subjective Norms	**.61**	**.62**
Perceived Behavioural Control	.82	.90
Self-Efficacy Task	.94	.94
Perceived Ease of Use	.89	.90
Self-Efficacy Technology	.79	.87
Cognitive Absorption Temporal Displacement	.92	.91
Cognitive Absorption Focused Immersion	.94	.96
System Quality	.84	.78
Interest	.96	.92
Cognitive Absorption Heightened Enjoyment	.93	.92
Emotion	.82	.84
Satisfaction	.94	.97
Intention	.94	.95

***The variable of Mastery Goals was measured once as it is a universal measure**

All variables showed acceptable levels of reliability apart from Subjective Norms for the pre-usage questionnaire for the hapTEL simulator (.68) and the post-usage questionnaire for both the hapTEL simulator (.61) and the mannequin-head simulator (.62). The levels of reliability for this variable were slightly below the accepted level of reliability .7. This may be because the students at this stage of the course had not developed an appreciation of the opinions of the tutors and students on their course. A further Cronbach's alpha was carried out to show the reliability if each item was excluded. The results showed that excluding Subjective Norms items 1, 2 and 3 lowered the reliability statistic. However excluding item 4 improved the reliability to .74. Therefore item 4 (The students on my course think I should use the haptel/mannequin-head simulator) was excluded from the Subjective Norms variable and from further analysis.

4.2 Results from the pre-usage questionnaire: Students' anticipated Satisfaction and initial Intention to use the simulators

This section presents the results from the pre-usage questionnaire for the hapTEL simulator and the mannequin-head simulator. The results from this section will address the following research questions:

Research questions:

Q1) What are the dental students initial perceptions' of the hapTEL simulator and the mannequin-head simulator before they have had first-hand experience using them?

Q2) How are the dental students' initial perceptions of the simulators related to the students' levels of anticipated Satisfaction and initial Intention to use?

4.2.1 Statistical tests carried out on the data from the questionnaires

The following statistical tests were carried out: (See to Chapter 3, Section 3.8 for more information regarding the statistical testing carried out for Study 1 and Study 2).

- Basic descriptive statistics-Section 4.2.2
- Correlation analysis-section-Section 4.2.4
- Independent and paired samples t-tests-Section 4.2.3 and 4.2.5
- OLS Regression-Section 4.2.6
- Structural equation modeling-Section 4.2.7

4.2.2 Descriptive statistics for the variables in the pre-usage questionnaire

This section presents the descriptive statistics for all items on the pre-usage questionnaires for the hapTEL simulator and the mannequin-head simulator. The overall mean, the standard deviation and the levels of skew and kurtosis for each variable were calculated in order to assess the strength of each variable at the pre-usage stage and to gauge whether the data for each variable were normally distributed.

The overall mean for each variable was calculated by summing the scores for each item that was used to measure the variable. Three items were used to measure each variable using a seven-point Likert scale, therefore the overall mean for each variable could range from three to twenty-one. An overall mean score greater than twelve indicates a positive overall response to that variable. An overall mean score of less than twelve indicates a negative overall response to that variable. An overall mean score of twelve indicates a neutral or ambivalent overall response to that variable (see Chapter 3, Section 3.5.6 for an explanation of the Likert scale used in this study).

Skew and kurtosis were calculated to show the overall shape of the distribution for each variable and to assess if the distribution falls into the acceptable range for a normal distribution (a normal distribution is required for parametric statistical testing to be carried out).

Table 4.3 shows the descriptive statistics for the variables on the hapTEL simulator pre-usage questionnaire. Table 4.4 shows the descriptive statistics for the variables on the mannequin-head simulator pre-usage questionnaire.

Table 4-3 Descriptive statistics for the variables on the hapTEL pre-usage questionnaire (n=250)

Variable	Mean	Standard Deviation	Skew	Kurtosis
Mastery Goals	19.10	2.87	-2.31	7.74
Attitude	17.87	3.04	-.81	-.22
Perceived Usefulness	16.41	3.18	-.27	-.71
Task Value	15.26	2.85	-.17	-.52
Subjective Norms	15.45	2.85	-.09	-.27
Perceived Behavioural Control	14.30	2.60	.50	-.06
Self-Efficacy Task	16.03	2.97	-.29	-.07
Perceived Ease of Use	13.03	2.77	-.07	1.26
Self-Efficacy Technology	13.58	3.24	-.05	.38
Cognitive Absorption Temporal Displacement	14.56	3.10	.088	-.07
Cognitive Absorption Focused Immersion	15.54	3.11	-.16	.02
System Quality	14.82	3.06	-.07	.02
Interest	18.18	3.19	-1.28	1.84
Cognitive Absorption Heightened Enjoyment	17.38	3.99	-.78	.94
Emotion	16.36	3.11	-.51	.64
Satisfaction	15.16	3.19	-.40	.55
Intention	15.51	3.35	-.11	-.20

All of the variables for the hapTEL simulator pre-usage questionnaire had positive overall responses. The highest overall mean score was for Mastery Goals , which had a mean of 19.10 (maximum possible was 21) The lowest overall mean score was for Perceived Ease of Use, which had a mean of 13.03.

Some variables had positive overall mean scores that were close to twelve (indicating an ambivalent or neutral response). These variables were Perceived Ease of Use, which had a mean of 13.03, and Self-Efficacy Technology, which had a mean of 13.58. The response towards these variables may be due to the difficulty students had with judging how easy they feel a technology would be to use (and therefore also their ability to use the technology) before they had first-hand experience using it. This is consistent with previous research by Davis, (1985) and will be discussed in more detail in Chapter 6, Section 6.2.

All of the variables for the hapTEL pre-usage questionnaire had standard deviations between 2 and 3. The variable with the highest standard deviation was Subjective Norms, at 3.47. The variable Perceived Behavioural Control had the lowest standard deviation at 2.60.

All the variables for the hapTEL pre-usage questionnaire showed negative values for skew apart from Perceived Behavioural Control and Cognitive Absorption Temporal Displacement, indicating that the responses to these variables were skewed towards the positive end of the Likert scale whereas Perceived Behavioural Control and Cognitive Absorption Temporal Displacement were skewed towards the negative end of the Likert scale. This suggests that at the pre-usage stage students are less positive or less confident about making judgments for the variables Perceived Behavioural Control and Cognitive Absorption Temporal Displacement compared to the other variables on the questionnaire.

For the hapTEL pre-usage questionnaire the kurtosis values for Attitude, Perceived Usefulness, Task Value, Subjective Norms, Perceived Behavioural Control, Self-Efficacy Task, Cognitive Absorption Temporal Displacement, and Intention all showed some negative kurtosis, which indicates that the values for these variables are clustered more around the mean value than the tail ends of the distribution. This means fewer students selected the end-responses Likert categories for these variables. The values for Perceived Ease of Use, Self-Efficacy Technology, Cognitive Absorption Focused Immersion, System Quality, Interest, Cognitive Absorption Heightened Enjoyment, Emotion and Satisfaction all showed some positive kurtosis, indicating that the values for these variables were clustered more around the tail ends of the distribution. This could suggest that students find it harder to make a judgment about the variables leading to more responses being clustered around a neutral mean value, for example Perceived Ease of Use (13.03).

The values for skew and kurtosis were also used to determine if each variable had a normal distribution. For the pre-usage questionnaire all of the variables apart from Mastery Goals had a skew and kurtosis value within a range of +/-2, which is considered an acceptable level for a normal distribution. This indicates that the data is suitable for further parametric statistical testing.

For Mastery Goals, the skew value is -2.314 and the kurtosis value is 7.738. These values indicate that the scores for the variable Mastery Goals are heavily skewed towards the positive end of the Likert scale. This means that the majority of the students selected the positive Likert scale categories (numbers five, six or seven). The distribution for Mastery Goals cannot be considered normal due to its extreme asymmetry. This asymmetry prevents the use of further, parametric statistical testing (as parametric tests require a normal distribution). However, the overall mean value can still be considered and will be discussed in Chapter 6, Section 6.2 along with methods that could be adopted in order to develop a Mastery Goals scale that does not suffer from extreme-end bias (Chapter 7, Section, 7.4.7).

Table 4-4 Descriptive statistics for the variables on the mannequin-head pre-usage questionnaire (n=250)

Variable	Mean	Standard Deviation	Skew	Kurtosis
Mastery Goals	19.10	2.87	-2.31	7.74
Attitude	17.41	3.49	-.48	-1.03
Perceived Usefulness	16.88	3.26	-.27	-1.08
Task Value	15.97	3.02	.10	-1.00
Subjective Norms	15.61	3.64	-.01	-.24
Perceived Behavioural Control	14.64	2.94	.17	-.23
Self-Efficacy Task	16.03	3.06	-.10	-.30
Perceived Ease of Use	13.52	3.03	.12	.85
Self-Efficacy Technology	14.10	3.29	.01	.06
Cognitive Absorption Temporal Displacement	14.74	3.18	.36	-.56
Cognitive Absorption Focused Immersion	15.63	3.17	.02	-.87
System Quality	14.84	2.96	.30	-.51
Interest	17.31	3.45	-.55	-.79
Cognitive Absorption Heightened Enjoyment	17.02	3.37	-.44	-.81
Emotion	16.53	3.31	-.24	-.81
Satisfaction	16.01	3.02	-.03	-.87
Intention	16.19	3.37	-.08	-.89

All of the variables for the mannequin-head simulator pre-usage questionnaire had positive overall responses. The highest overall mean score was for Mastery Goals , which had a mean of 19.10. The lowest overall mean score was for Perceived Ease of Use, which had a mean of 13.52. However, as with the hapTEL simulator, the variables of Perceived Ease of Use and Self-Efficacy Technology had overall means close to twelve, indicating that students may also found it difficult judging how easy the mannequin-head simulator would be to use before they had first-hand experience using it.

All of the variables for the mannequin-head pre-usage questionnaire had standard deviations between 2 and 4. The variable with the highest standard deviation was Subjective Norms, at 3.64. The variable Mastery Goals had the lowest standard deviation at 2.87. (Mastery Goals was measured once for both the hapTEL simulator and the mannequin-had simulator therefore the value is the same for both simulators).

For the mannequin-head simulator pre-usage questionnaire the skew values for the variables Task Value, Perceived Behavioural Control, Perceived Ease of Use, Self-Efficacy Technology, Cognitive Absorption Temporal Displacement, Cognitive Absorption Focused Immersion and System Quality were positive, indicating that the responses to these variables were skewed towards the negative end of the Likert scale. All the remaining variables had skew values that were negative, indicating that the responses to these variables were skewed towards the positive end of the Likert scale.

For the mannequin-head simulator questionnaire the kurtosis values for Perceived Ease of Use and Self-Efficacy Technology showed some positive kurtosis, indicating that the values for these variables are clustered more around the mean value than the tail ends of the distribution. This means fewer students selected the end-responses Likert categories for these variables. The kurtosis values for all the remaining variables showed some negative kurtosis, indicating that the values for these variables were clustered more around the tail ends of the distribution. The values for skew and kurtosis for all of the variables on the mannequin-head simulator pre-usage questionnaire are within a range of +/-2, which is considered acceptable levels for a normal distribution (apart from Mastery Goals which is explained in the previous section). This indicates that the data is suitable for further, parametric statistical testing.

Summary

All of the variables on the pre-usage questionnaire for both the hapTEL simulator and the mannequin-head simulator had positive overall responses. This indicates that the students were initially receptive to using both of the simulators at the start of the term. The highest overall mean score for both the hapTEL simulator and the mannequin-head simulator was for Mastery Goals , at 19.10. This may be due to students being able to judge this variable more confidently as it related to their own personal goals. There may also be additional issues regarding how this variable is measured, which will be addressed in Chapter 7 section 7.4.7.

The lowest overall mean score for both the hapTEL simulator and the mannequin-head simulator was Perceived Ease of Use at 13.03 and 13.52. This score is still positive but it falls very close to the neutral or ambivalent of 12. Students may have difficulty in judging the Perceived Ease of Use of a simulator before their first hand-experience using it. This was also found by Davis' (1985) study when he originally developed the TAM. The variable of Self-Efficacy Technology was also found to be close to the neutral point for both the hapTEL simulator and the mannequin-head simulator. This is likely to be due to the same factors that effect the students' perception of the ease of use of the simulators. All of the other overall mean scores for the hapTEL simulator and mannequin-head simulator fell between 14 and 19.

allowed for further parametric statistical testing.

4.2.3 Paired samples t-test for the hapTEL simulator and the mannequin-head simulator for the pre-usage questionnaire

A paired-samples t-test was carried out to see if there were any significant differences between the mean scores of the variables for the hapTEL simulator and the mannequin-head simulator pre-usage questionnaire. Table 4.5 shows the results from the t-test.

Table 4-5 Results from the t-test comparing the overall mean scores of the variables for the hapTEL simulator and the mannequin-head simulator (n=250)

Variable	Variable	Mean Difference	Significance
Sig. higher for hapTEL simulator	**Attitude** **Interest** **Cognitive Absorption Heightened Enjoyment**	**.467** **.868** **.364**	**.038*** **.000**** **.045***
Sig. higher for mannequin-head simulator	**Perceived Usefulness** **Task Value** **Perceived Behavioural Control** **Perceived Ease of Use** **Self-Efficacy Technology** **Satisfaction** **Intention**	**-.468** **-.711** **-.342** **-.481** **-.516** **-.848** **-.676**	**.026*** **.001*** **.025*** **.007*** **.003*** **.000**** **.002***
No sig. difference	Subjective Norms Self-Efficacy Task Cognitive Absorption Temporal Displacement Cognitive Absorption Focused Immersion System Quality Emotion	-.164 .000 -.176 -.088 -.017 -.172	.250 1.000 .311 .631 .939 .288

**** Significant at the .01 level**
*** Significant at the .05 level**

Note: A positive mean difference score indicates that the hapTEL simulator had a higher overall mean score. A negative mean difference score indicates that the mannequin-head simulator had a higher overall mean score.

The variables Attitude, Cognitive Absorption Heightened Enjoyment and Interest had significantly higher mean scores for the hapTEL simulator compared to the mannequin-head simulator. The variables Perceived Usefulness, Task Value, Perceived Behavioural Control, Perceived Ease of Use, Self-Efficacy Technology, Anticipated Satisfaction and Intention had significantly higher mean scores for the mannequin-head simulator compared to the hapTEL simulator. There was no significant difference between the mean scores of the variables Subjective Norms, Self-Efficacy Task, Cognitive Absorption Temporal Displacement, Cognitive Absorption Focused Immersion, System Quality and Emotion. These results indicate that students have a higher level of intrinsic motivation for the hapTEL simulator compared to the mannequin-head simulator before they have used the simulators. However, they initially perceive the mannequin-head simulator as easy to use and more useful. These results will be discussed in more detail in Chapter 6, Section 6.2.

Summary

At the pre-usage stage, the students had a significantly higher level of intrinsic motivation to use the hapTEL simulator compared to the mannequin-head simulator. However, the students initially viewed the mannequin-head simulator as being more useful and easier to use as well as having a significantly higher level of anticipated Satisfaction and Initial Intention to use. This could indicate the importance of variables that measure aspects of usefulness and ease of use as being important determinants of Satisfaction and Initial Intention. This will be discussed in Chapter 6, Section 6.3.

4.2.4 Correlation of variables with anticipated Satisfaction and Initial Intention for the pre-usage questionnaire

This section presents the results of the correlations between the variables included on the pre-usage questionnaire with the variables of anticipated Satisfaction and Initial Intention to use the simulators.

- Table 4.6 shows the results of the correlation analysis for Anticipated Satisfaction with the hapTEL simulator.
- Table 4.7 shows the results of the correlation analysis for Initial Intention to use the hapTEL simulator.
- Table 4.8 shows the results of the correlation analysis for Anticipated Satisfaction with the mannequin-head simulator.
- Table 4.9 shows the results of the correlation analysis for Initial Intention to use the mannequin-head simulator.

Table 4-6 Correlations of the predictor variables with anticipated Satisfaction for the hapTEL simulator pre-usage questionnaire (n=250)

Variable	*Satisfaction*
Mastery Goals	.16*
Attitude	.42**
Perceived Usefulness	.53**
Task Value	.51**
Subjective Norms	.43**
Perceived Behavioural Control	.13*
Self-Efficacy Task	.41**
Perceived Ease of Use	.23**
Self-Efficacy Technology	.28**
Cognitive Absorption Temporal Displacements	.31**
Cognitive Absorption Focused Immersion	.53**
System Quality	.68**
Interest	.57**
Cognitive Absorption Heightened Enjoyment	.62**
Emotion	.51**

****Correlation is significant at the .01 level**
***Correlation is significant at the .05 level**

For the hapTEL simulator pre-usage questionnaire there were;

- Moderate, highly significant correlations between Anticipated Satisfaction and the variables Attitude (.42**), Perceived Usefulness (.53**), Task Value (51**), Subjective Norms (.43**), Self-Efficacy Task (.41**), Cognitive Absorption Focused Immersion (.53**), System Quality

(.68**), Interest (.57**), Cognitive Absorption Heightened Enjoyment (.62**) and Emotion (.51**).

- Weak, highly significant correlations between Anticipated Satisfaction and the variables Self-Efficacy Technology (.28**) Perceived Ease of Use (.23**) and Cognitive Absorption Temporal Displacement (.31**).
- Weak, significant correlations between Anticipated Satisfaction and the variables Perceived Behavioural Control (.13*) and Mastery Goals (.16*).

Table 4-7 Correlations of the predictor variables with anticipated Satisfaction for the mannequin-head simulator pre-usage questionnaire (n=250)

Variable	*Satisfaction*
Mastery Goals	.25**
Attitude	.55**
Perceived Usefulness	.68**
Task Value	.60**
Subjective Norms	.49**
Perceived Behavioural Control	.15*
Self-Efficacy Task	.38**
Perceived Ease of Use	.23**
Self-Efficacy Technology	.29**
Cognitive Absorption Temporal Displacement	.37**
Cognitive Absorption Focused Immersion	.44**
System Quality	.39**
Interest	.45**
Cognitive Absorption Heightened Enjoyment	.53**
Emotion	.47**

****Correlation is significant at the .01 level**
***Correlation is significant at the .05 level**

For the mannequin-head simulator pre-usage questionnaire there were;

- Moderate, highly significant correlations between Anticipated Satisfaction and the variables Attitude (.55**), Perceived Usefulness (.68**), Task Value (.60**), Subjective Norms (.49**), Cognitive Absorption Focused Immersion (.44**), Interest (.45**), Cognitive Absorption Heightened Enjoyment (.53**) and Emotion (.47**).

- Weak, highly significant correlations between Anticipated Satisfaction and the variables Mastery Goals (.25**), Self-Efficacy Task (.38**), Perceived Ease of Use (.23**), Self-Efficacy Technology (.29**), Cognitive Absorption Temporal Displacement (.37**) and System Quality (.39**).
- Weak, significant correlation between Anticipated Satisfaction and Perceived Behavioural Control (.15*).

Table 4-8 Correlations of the predictor variables with initial Intention to use the hapTEL simulator pre-usage questionnaire (n=250)

Variable	*Intention*
Mastery Goals	.20**
Attitude	.50**
Perceived Usefulness	.60**
Task Value	.53**
Subjective Norms	.48**
Perceived Behavioural Control	.20**
Self-Efficacy Task	.32**
Perceived Ease of Use	.19**
Self-Efficacy Technology	.23**
Cognitive Absorption Temporal Displacements	.40**
Cognitive Absorption Focused Immersion	.51**
System Quality	.57**
Interest	.62**
Cognitive Absorption Heightened Enjoyment	.64**
Emotion	.57**

****Correlation is significant at the .01 level**
***Correlation is significant at the .05 level**

For the hapTEL simulator pre-usage questionnaire there were;

- Moderate, highly significant correlations between Intention and the variables Attitude (.50**), Perceived Usefulness (.60**), Task Value (.53**), Subjective Norms (.48**), Cognitive Absorption Focused Immersion (.51**), System Quality (.57**), Interest (.62**), Cognitive Absorption Heightened Enjoyment (.64**) and Emotion (.57**).

- Weak, highly significant correlations between Intention and the variables Mastery Goals (.20**), Perceived Behavioural Control (.20**), Self-Efficacy Task (.32**), Perceived Ease of Use (.19**), Self-Efficacy Technology (.23**) and Cognitive Absorption Temporal Displacement (.40**).

Table 4-9 Correlations of the predictor variables with Initial Intention to use the mannequin-head simulator pre-usage questionnaire (n=250)

Variable	*Intention*
Mastery Goals	.22**
Attitude	.64**
Perceived Usefulness	.70**
Task Value	.70**
Subjective Norms	.54**
Perceived Behavioural Control	.20**
Self-Efficacy Task	.31**
Perceived Ease of Use	.11
Self-Efficacy Technology	.17**
Cognitive Absorption Temporal Displacement	.44**
Cognitive Absorption Focused Immersion	.37**
System Quality	.27**
Interest	.38**
Cognitive Absorption Heightened Enjoyment	.44**
Emotion	.47**

****Correlation is significant at the .01 level**

For the mannequin-head simulator pre-usage questionnaire there were;

- Moderate, highly significant correlations between Initial Intention and the variables Attitude (.22**), Perceived Usefulness (.70**), Task Value (.70**), Subjective Norms (.54**), Cognitive Absorption Temporal Displacement (.44**), Cognitive Absorption Heightened Enjoyment (.44**) and Emotion (.47**).
- Weak, highly significant correlations between Initial Intention and Mastery Goals (.22**), Perceived Behavioural Control (.20**), Self-

Efficacy Task (.31**), Self-Efficacy Technology (.17**), Cognitive Absorption Focused Immersion (.37**), System Quality (.27**) and Interest (.38**).

- No significant correlation between Initial Intention to use the mannequin-head simulator and Perceived Ease of Use.

Summary

For the hapTEL simulator there were moderate, highly significant correlations between Anticipated Satisfaction and the variables Attitude, Perceived Usefulness, Task Value, Subjective Norms, Self-Efficacy Task, Cognitive Absorption Focused Immersion, System Quality, Interest, Cognitive Absorption Heightened Enjoyment and Emotion. For the Initial Intention there were moderate, highly significant correlations with the variables Perceived Usefulness, Task Value, Subjective Norms, Cognitive Absorption Focused Immersion, System Quality, Interest, Cognitive Absorption Heightened Enjoyment and Emotion. All other variables showed only weak correlations with either Anticipated Satisfaction or Initial Intention.

For the mannequin-head simulator there were moderate, highly significant correlations between Anticipated Satisfaction and the variables Attitude, Perceived Usefulness, Task Value, Subjective Norms, Cognitive Absorption Focused Immersion, Interest, Cognitive Absorption Heightened Enjoyment and Emotion. For Initial Intention there were moderate, highly significant correlations with the variables Attitude, Perceived Usefulness, Task Value, Subjective Norms, Cognitive Absorption Temporal Displacement, Cognitive

Absorption Heightened Enjoyment and Emotion. All other variables showed only weak correlations with either Anticipated Satisfaction or Initial Intention.

This indicates that at the pre-usage stage the majority of the variables correlated with either Anticipated Satisfaction or Initial Intention apart from the variables that students may have had difficulty in judging at the pre-usage stage e.g. Perceived Ease of Use and Perceived Behavioural Control.

4.2.5 Regression of variables with anticipated Satisfaction and Initial Intention for the pre-usage questionnaire

The variables from the pre-usage questionnaire were regressed with anticipated Satisfaction and Initial Intention for both the hapTEL simulator and the mannequin-head simulator in order to determine which variables could predict Anticipated Satisfaction or Initial Intention.

- Table 4.10 shows the results from the regression analysis for Anticipated Satisfaction with the hapTEL simulator.
- Table 4.11 shows the results from the regression analysis for Initial Intention to use hapTEL simulator.
- Table 4.12 shows the results from the regression analysis for Anticipated Satisfaction with the mannequin-head simulator.
- Table 4.13 shows the results from the regression analysis for Initial Intention to use mannequin-head simulator.

Table 4-10 Results from regression analysis for the hapTEL simulator pre-usage questionnaire for the variable Anticipated Satisfaction (n=250)

Variable	*B*	*Significance*
Mastery Goals	-.064	.153
Attitude	-.055	.333
Perceived Usefulness	**.149**	**.028***
Task Value	.058	.316
Subjective Norms	**.123**	**.016***
Perceived Behavioural Control	-.019	.658
Self-Efficacy Task	.049	.345
Perceived Ease of Use	.037	.452
Self-Efficacy Technology	.049	.325
Cognitive Absorption Temporal Displacement	-.045	.352
Cognitive Absorption Focused Immersion	**.120**	**.026***
System Quality	**.402**	**.000****
Interest	.044	.505
Cognitive Absorption Heightened Enjoyment	**.250**	**.001***
Emotion	-.068	.348

**** Significant at the .01 level**
*** Significant at the .05 level**
Note: R^2 = .614

For the hapTEL simulator the adjusted R^2 value for the regression model for Anticipated Satisfaction was .614, indicating that the variables included in the model explain approximately 61% of the variation in Anticipated Satisfaction for the hapTEL simulator. The variables Perceived Usefulness, Subjective Norms, Cognitive Absorption Focused Immersion and Cognitive Absorption Heightened Enjoyment were significant predictors of Anticipated Satisfaction at the .05 level and System Quality was a significant predictor of Anticipated Satisfaction at the .01 level. All other variables were not significant predictors of Anticipated Satisfaction.

Table 4-11 Results from the regression analysis for the hapTEL simulator pre-usage questionnaire for the variable Initial Intention (n=250)

Variable	*B*	*Significance*
Mastery Goals	-.014	.754
Attitude	.051	.365
Perceived Usefulness	**.148**	**.030***
Task Value	.057	.318
Subjective Norms	.052	.309
Perceived Behavioural Control	.069	.113
Self-Efficacy Task	**-.131**	**.012***
Perceived Ease of Use	-.024	.628
Self-Efficacy Technology	.043	.387
Cognitive Absorption Temporal Displacement	.085	.077
Cognitive Absorption Focused Immersion	.068	.209
System Quality	.102	.072
Interest	.111	.092
Cognitive Absorption Heightened Enjoyment	.124	.102
Emotion	.095	.183
Satisfaction	**.249**	**.000****

**** Significant at the .01 level**
*** Significant at the .05 level**
***Note:* $R^2 = .621$**

For the hapTEL simulator the adjusted R^2 value for the regression model for Intention was .621, indicating that the variables included in the model explain approximately 62% of the variation in Intention to use the hapTEL simulator. The variables Perceived Usefulness and Self-Efficacy Task were found to be significant predictors at the .05 level of Intention to use the hapTEL simulator and the variable Anticipated Satisfaction was found to be a significant predictor of Initial Intention at the .01 level.

Table 4-12 Results from the regression analysis for the mannequin-head simulator pre-usage questionnaire for the variable Anticipated Satisfaction (n=250)

Variable	*B*	*Significance*
Mastery Goals	.024	.572
Attitude	-.046	.498
Perceived Usefulness	**.234**	**.008***
Task Value	-.026	.712
Subjective Norms	.042	.447
Perceived Behavioural Control	.086	.078
Self-Efficacy Task	**.123**	**.029***
Perceived Ease of Use	**.153**	**.004***
Self-Efficacy Technology	-.041	.418
Cognitive Absorption Temporal Displacement	.060	.282
Cognitive Absorption Focused Immersion	-.062	.322
System Quality	**.186**	**.003***
Interest	.109	.170
Cognitive Absorption Heightened Enjoyment	**.234**	**.004***
Emotion	.016	.840

**** Significant at the .01 level**
*** Significant at the .05 level**
Note: $R^2 = .610$

For the mannequin-head simulator the adjusted R^2 value for the regression model for Anticipated Satisfaction was .610, indicating that the variables included in the model explain approximately 61% of the variation in Anticipated Satisfaction with the mannequin-head simulator. The variables Perceived Usefulness, Self-Efficacy Task, Perceived Ease of Use, System Quality and Cognitive Absorption Heightened Enjoyment were found to be significant predictors of Anticipated Satisfaction with the mannequin-head simulator at the .05 level. The remaining variables were not found to be significant predictors of Anticipated Satisfaction with the mannequin-head simulator.

Table 4-13 Results from the regression analysis for the mannequin-head simulator pre-usage questionnaire for the variable Initial Intention (n=250)

Variable	*B*	*Significance*
Mastery Goals	-.002	.956
Attitude	**.125**	**.033***
Perceived Usefulness	.026	.737
Task Value	.108	.084
Subjective Norms	.022	.653
Perceived Behavioural Control	-.021	.619
Self-Efficacy Task	-.059	.236
Perceived Ease of Use	-.039	.404
Self-Efficacy Technology	.075	.091
Cognitive Absorption Temporal Displacement	**.105**	**.031***
Cognitive Absorption Focused Immersion	-.036	.515
System Quality	**.144**	**.009***
Interest	.058	.407
Cognitive Absorption Heightened Enjoyment	-.079	.272
Emotion	**.252**	**.000****
Satisfaction	**.328**	**.000****

**** Significant at the .01 level**
*** Significant at the .05 level**
Note: R^2 = .705

The adjusted R^2 value for the regression model for Intention was .705, indicating that the variables included in the model explain approximately 71% of the variation in Intention to use the mannequin-head simulator. The variables Attitude, Cognitive Absorption Temporal Displacement and System Quality were found to be significant predictors of Intention to use the mannequin-head simulator at the .05 level and the variables Emotion and Anticipated Satisfaction were found to be significant predictors at the .01 level. The remaining variables were not found to be significant predictor of Intention to use the mannequin-head simulator.

Summary

All of the regression models explained between 61 and 71% of the variation in Anticipated Satisfaction and Intention to use the hapTEL simulator and the mannequin-head simulator. For the hapTEL simulator, the variables Perceived Usefulness, Subjective Norms, Cognitive Absorption Focused Immersion, Cognitive Absorption Heightened Enjoyment and System Quality significantly predicated Anticipated Satisfaction and the variables Perceived Usefulness, Self-Efficacy Task, and Anticipated Satisfaction predicted Initial Intention. For the mannequin-head simulator the variables Perceived Usefulness, Self-Efficacy Task, Perceived Ease of Use, System Quality and Cognitive Absorption Heightened Enjoyment were significant predictors of Anticipated Satisfaction and the variables Attitude, Cognitive Absorption Temporal Displacement, System Quality, Emotion and Anticipated Satisfaction were significant predictors of Initial Intention.

The only variables found to be predictors for the both the hapTEL simulator and the mannequin-head simulator were Perceived Usefulness, Cognitive Absorption Heightened Enjoyment and System Quality, which were all significant predictors of Anticipated Satisfaction for the hapTEL simulator and the mannequin-head simulator, and Anticipated Satisfaction, which was found to be a significant predictor of Initial Intention to use the hapTEL simulator and the mannequin-head simulator. This suggests that at the pre-usage stage, although there are some commonalties, the students are using different factors to help them decide if they want to use the hapTEL simulator and the mannequin-head simulator. This section will be discussed in more detail in Chapter 6, section 6.2.

4.2.6 Structural equation modelling for the pre-usage questionnaire

The variables that were found to be significant predictors of either Anticipated Satisfaction or Initial Intention were used in the structural equation modeling (SEM) analysis. This model shows which variables are significantly related to each other by the paths between the variables. SEM consists of two components, the measurement model, which assess the reliability of the individual items used on the questionnaire, and the structural model, which assess the relationships between the variables included in the model. AMOS version 20 was used to carry out the structural equation modeling. The method chosen was maximum likelihood. This is the most common method of structural equation modeling (Byrne 2010) .

The hapTEL simulator

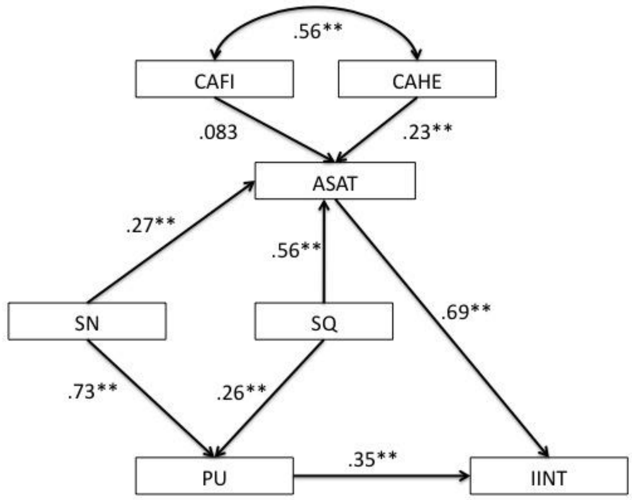
For the hapTEL simulator pre-usage questionnaire the variables Subjective Norms, System Quality, Perceived Usefulness, Cognitive Absorption Focused Immersion and Cognitive Enjoyment Heightened Enjoyment were used in the structural equation model along with the predicted variables Anticipated Satisfaction and Intention. These variables were chosen as they were found to be significant predictors of either Anticipated Satisfaction or Initial Intention in the regression analysis for the pre-usage questionnaire.

Measurement model

The final model for the hapTEL simulator pre-usage questionnaire included 21 items underlying the 7 variables from the pre-usage questionnaire (Subjective Norms, System Quality, Perceived Usefulness, Cognitive Absorption Focused Immersion, Cognitive Enjoyment Heightened Enjoyment, Anticipated Satisfaction and Initial Intention). All the items loaded onto the underlying variables at the recommended level of .7 or higher apart from the items Subjective Norms 2 and Subjective Norms 3 which loaded slightly below the recommended level at .668 and .693 respectively.

Structural model

The final structural model for the hapTEL pre-usage questionnaire is shown in Figure 4.1.



Key
SN: Subjective Norms, PU: Perceived Usefulness, SQ: System Quality, CAFI: Cognitive Absorption Focused Immersion, CAHE: Cognitive Absorption Heightened Enjoyment, ASAT: Anticipated Satisfaction, IINT: Initial Intention

FIGURE 4-1 STRUCTURAL EQUATION MODEL FOR THE HAPTEL SIMULATOR PRE-USAGE QUESTIONNAIRE

(n=250)

All the paths in the structural equation model were found to be highly significant apart from the path between Anticipated Satisfaction and Cognitive Absorption Focused Immersion, which was found to be .242. This may have been caused by the high level of covariance between Cognitive Absorption Focused Immersion and Cognitive Absorption Heightened Enjoyment, which was .56**.

The only variables found to impact directly on Initial Intention were Perceived Usefulness at .35**, and Anticipated Satisfaction at .67**. Subjective Norms (.73**) and System Quality (.26**) acted directly on Anticipated Satisfaction and indirectly on Initial Intention through Perceived Usefulness. Cognitive Absorption Focused Immersion (.083) and Cognitive Absorption Heightened Enjoyment (.23**) acted directly on Anticipated Satisfaction and indirectly on Initial Intention through Anticipated Satisfaction.

Table 4.14 shows the model fit indices for the hapTEL simulator pre-usage questionnaire. All the model fit indices were at acceptable levels apart from the NFI value, which was slightly below the recommended value of .9 and above at .898. This suggests that the model is a good fit for the data. The results from this section will be discussed in Chapter 6, Section 6.3.

Table 4-14 Structural equation modeling fit indices for the hapTEL simulator pre-usage questionnaire model

Model fit indices	Recommended value	Value for Model
χ^2/df	≤5	2.568
CFI	>9	.935
TLI	>9	.924
NFI	>9	.898

CFI: *Comparative fit index. Compares the covariances of the hypothesized model and the null-hypothesis model*
TLI*: Tucker Lewis index. Compares the* χ^2 *of the hypothesized model and the null-hypothesis model independent of sample size*
****NFI:*** *Normed-fit index. Compares the* χ^2 *of the hypothesized model and the null-hypothesis model*

The mannequin-head simulator

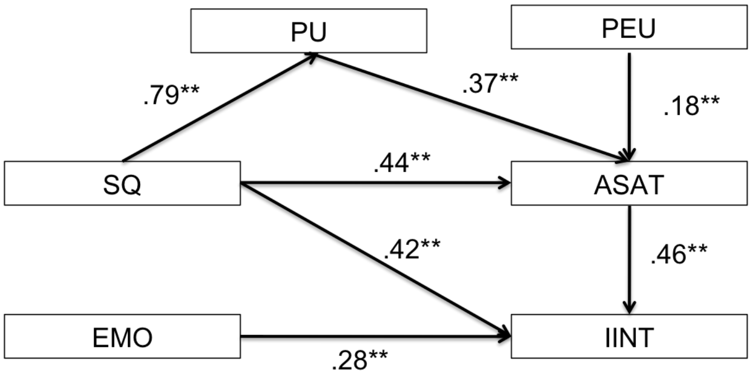
For the mannequin-head simulator pre-usage questionnaire the variables Perceived Ease of Use, System Quality, Perceived Usefulness, and Emotion were used in the structural equation model along with the predicted variables Anticipated Satisfaction and Initial Intention. These variables were chosen as they were found to be significant predictors of either Anticipated Satisfaction or Intention in the regression analysis for the pre-usage questionnaire

Measurement model

The final model for the mannequin-head simulator pre-usage questionnaire included 18 items underlying the 6 variables (Perceived Ease of Use, System Quality, Perceived Usefulness, Emotion, Anticipated Satisfaction and Initial Intention). All the items loaded onto the underlying variables at the recommended level of .7.

Structural model

The final structural model for the mannequin simulator pre-usage questionnaire is shown in Figure 4.2.



Key
PU: Perceived Usefulness, PEU: Perceived Ease of Use, SQ: System Quality, ASAT: Anticipated Satisfaction, IINT: Initial Intention

FIGURE 4-2 STRUCTURAL EQUATION MODEL FOR THE MANNEQUIN-HEAD SIMULATOR PRE-USAGE QUESTIONNAIRE

(n=250)

All the paths in the structural equation model were found to be highly significant. The variables found to impact directly on Intention were System Quality at .42**, Emotion at .28** and Anticipated Satisfaction at 46**. Perceived Ease of Use (.18**), System Quality (.44**) and Perceived Usefulness (.37**) acted directly on Anticipated Satisfaction and indirectly on Initial Intention through Anticipated Satisfaction.

Table 4.15 shows the model fit indices for the mannequin-head simulator pre-usage questionnaire. All the model fit indices were at acceptable levels apart from the NFI value, which was slightly below the recommended value of .9 and above at .875. The results from this section will be discussed in Chapter 6, Section 6.3.

Table 4-15 Structural equation modeling fit indices for the mannequin-head simulator pre-usage questionnaire

Model fit indices	Recommended value	Value for Model
χ^2/df	≤5	2.687
CFI	>9	.917
TLI	>9	.901
NFI	>9	.875

CFI: *Comparative fit index. Compares the covariances of the hypothesized model and the null-hypothesis model*

TLI*: Tucker Lewis index. Compares the χ^2 of the hypothesized model and the null-hypothesis model independent of sample size*

****NFI:*** *Normed-fit index. Compares the χ^2 of the hypothesized model and the null-hypothesis model*

Summary

All of the paths in the both of the structural equation models were significant apart from the path between Cognitive Absorption Focused Immersion and Anticipated Satisfaction for the hapTEL simulator pre-usage questionnaire. The strongest relationships were between the variables Subjective Norms and Perceived Usefulness for the hapTEL simulator (.73**) and System Quality and Perceived Usefulness for the mannequin-head simulator (.79**). The weakest relationships were between the variables Cognitive Absorption Heightened Enjoyment and Anticipated Satisfaction for the hapTEL simulator (.23) and Perceived Ease of Use and Anticipated Satisfaction for the mannequin-head simulator (.18**). The model fit indices showed that both of the models were a good fit for the data.

4.3 Results from the post-usage questionnaire

This section presents the results from the post-usage questionnaire for the hapTEL simulator and the mannequin-head simulator. The results from this section will address the following research questions:

Research questions:

Q3) What are the dental students perceptions of the hapTEL simulator and the mannequin-head simulator after they have had first-hand experience using them?

Q4) How are the dental students' perceptions related to their levels of Satisfaction and Intention to use?

4.3.1 Statistical tests carried out on the data from the post-usage questionnaires

As for the pre-usage questionnaire the following statistical tests were carried out:

- Basic descriptive statistics-Section 4.3.2
- Correlation analysis-Section 4.3.4
- Independent and paired samples t-tests-Section 4.3.3 and 4.3.5
- Regression-Section 4.3.6
- Structural equation modeling-Section 4.3.7

For reliability results for the pre-usage and post-usage questionnaire see section

4.3.2 Descriptive statistics for the variables in the post-usage questionnaire

This section presents the descriptive statistics for all items on the post-usage questionnaires for the hapTEL simulator and the mannequin-head simulator. The descriptive statistics consist of the overall mean, the standard deviation and the levels of skew and kurtosis for each variable. These statistics will be used to measure student Satisfaction with and Intention to use the simulators after they have had first hand-experience using the simulators. The strength and relationship between each of the variables at the post-usage stage will be also assessed and compared to the strength and relationship of the variables at the pre-usage stage.

As with the pre-usage questionnaire the overall mean for each variable was calculated by summing the scores for each item that was used to measure the variable. As three items were used for each variable, with a seven-point Likert scale, this overall mean could range from three to twenty-one. An overall mean score greater than twelve indicates a positive overall response to that variable. An overall mean less than twelve indicates a negative overall response to that variable. An overall mean score of twelve indicates a neutral or ambivalent overall response to that variable.

Skew and kurtosis were calculated to show the overall shape of the distribution for each variable and to assess if the distribution falls into the acceptable range for a normal distribution (A normal distribution is required for parametric statistical testing to be carried out).

Table 4.16 shows the descriptive statistics for the hapTEL simulator questionnaire. Table 4.17 shows the descriptive statistics for the mannequin-head simulator questionnaire.

Table 4-16 Descriptive statistics for the variables on the hapTEL simulator post-usage questionnaire (n=165)

Variable	Mean	Standard Deviation	Skew	Kurtosis
Mastery Goals	19.18	2.90	-2.83	11.20
Attitude	12.24	4.30	.09	-.44
Perceived Usefulness	11.06	4.51	.19	-.65
Task Value	9.62	4.19	.29	-.30
Subjective Norms	16.54	3.34	.37	.84
Perceived Behavioural Control	12.49	2.81	-.03	.58
Self-Efficacy Task	14.05	3.89	-.57	.26
Perceived Ease of Use	12.59	4.09	-.19	-.38
Self-Efficacy Technology	13.46	3.69	-.31	-.06
Cognitive Absorption Temporal Displacement	13.29	4.34	.07	-.67
Cognitive Absorption Focused Immersion	14.41	5.06	.23	-.82
System Quality	10.77	3.45	-.76	-.46
Interest	10.57	4.30	-.16	-.56
Cognitive Absorption Heightened Enjoyment	11.31	4.64	.32	-.65
Emotion	11.34	4.78	.47	-.55
Satisfaction	10.10	3.62	-.12	.32
Intention	9.29	4.12	.26	-.62

For the hapTEL post-usage questionnaire the variables Subjective Norms, Perceived Behavioural Control, Self-Efficacy Task, Self-Efficacy Technology, Cognitive Absorption Temporal Displacement and Cognitive Absorption Focused Immersion had positive overall responses for the hapTEL simulator post-usage questionnaire. Some variables had positive overall mean scores that were close to twelve (indicating an ambivalent or neutral response). These variables were Attitude, Perceived Behavioural Control and Perceived Ease of Use. The variables Perceived Usefulness, Task Value, System Quality, Interest, Cognitive Absorption Heightened Enjoyment, Emotion, Satisfaction and Intention had negative overall responses for the hapTEL simulator. The highest overall mean score for the hapTEL simulator post-usage questionnaire was for the variable Mastery Goals, which had a mean of 19.18. The lowest overall mean score was for the variable Intention, which had a mean of 9.29.

For the hapTEL post-usage questionnaire all of the variables had standard deviations between 2 and 5. The variable with the highest standard deviation was Cognitive Absorption Focused Immersion, at 5.06. The variables Mastery Goals and Satisfaction had the lowest standard deviations at 2.90. The standard deviations indicate greater variability in responses for the post-usage questionnaire compared to the pre-usage. In total, all of the variables apart from Satisfaction had a higher standard deviation for the post-usage questionnaire compared to the pre-usage questionnaire.

For the hapTEL simulator post-usage questionnaire the kurtosis values for Mastery Goals, Subjective Norms, Perceived Behavioural Control, Self-Efficacy Task, Satisfaction all showed some positive kurtosis, which indicates that the values for these variables are clustered more around the mean value than the tail ends of the distribution. This means fewer students selected the end-responses Likert categories for these variables. The values for Attitude, Perceived Usefulness, Perceived Ease of Use, Self-Efficacy Technology, Cognitive Absorption Focused Immersion, Cognitive Absorption Temporal Displacement, System Quality, Interest, Cognitive Absorption Heightened Enjoyment, Emotion and Intention all showed some negative kurtosis, indicating that the values for these variables were clustered more around the tail ends of the distribution.

Similar to the pre-usage questionnaire, Mastery Goals had a high skew and kurtosis value, with a skew value of -2.83 and a kurtosis value of 11.20. These values indicate that again the scores for the variable Mastery Goals are heavily skewed towards the positive end of the Likert scale and therefore cannot be considered normal due to its extreme asymmetry. As with the pre-usage questionnaire this means that further, parametric statistical testing cannot be used (as parametric tests require a normal distribution). See Chapter 7, Section 7.4.7 for a discussion along with methods that could be adopted in order to develop a Mastery Goals scale that does not suffer from extreme-end bias.

For the hapTEL post-usage questionnaire the values for skew and kurtosis for all of the variables, apart from Mastery Goals, are within a range of +/-2, which is considered an acceptable level for a normal distribution. This indicates that the data is suitable for further, parametric statistical testing.

Table 4-17 Descriptive statistics for the variables on the mannequin-head simulator post-usage questionnaire (n=196)

Variable	Mean	Standard Deviation	Skew	Kurtosis
Mastery Goals	19.18	3.51	-.63	-.88
Attitude	18.40	3.54	-.39	-1.06
Perceived Usefulness	18.14	3.39	-.06	-1.06
Task Value	17.70	3.42	-.03	-.50
Subjective Norms	19.93	3.65	.13	-.32
Perceived Behavioural Control	12.55	3.36	-.08	-.59
Self-Efficacy Task	17.26	3.00	-.02	1.06
Perceived Ease of Use	15.80	3.10	-.06	.18
Self-Efficacy Technology	16.47	3.08	.22	-.67
Cognitive Absorption Temporal Displacement	16.58	3.72	-.08	-.93
Cognitive Absorption Focused Immersion	17.52	3.29	.17	-.65
System Quality	16.79	3.38	-.71	-.67
Interest	18.02	3.25	-.57	-.69
Cognitive Absorption Heightened Enjoyment	17.87	3.14	-.30	-1.00
Emotion	16.89	3.25	-.12	-.97
Satisfaction	17.73	3.49	-.23	-.85
Intention	18.25	3.36	-.11	-.28

For the mannequin-head simulator post-usage questionnaire all the variables had positive overall responses for the mannequin-head simulator. The highest overall mean score for the mannequin-head simulator post-usage questionnaire was for the variable Subjective Norms, at 19.93. The lowest overall mean score was for the variable Perceived Behavioural Control, at 12.55.

For the mannequin-head simulator post-usage questionnaire all of the variables had standard deviations between 2 and 5. The variable with the highest standard deviation was Cognitive Absorption Focused Immersion, at 5.06. The variables Mastery Goals and Satisfaction had the lowest standard deviations at 2.90. The standard deviations indicate greater variability in responses for the post-usage questionnaire compared to the pre-usage. In total, eleven variables had a higher standard deviation for the post-usage questionnaire compared to the pre-usage questionnaire.

For the mannequin-head simulator post-usage questionnaire the kurtosis values for Mastery Goals, Attitude, Perceived Usefulness, Task Value, Subjective Norms, Perceived Behavioural Control, Self-Efficacy Technology, Cognitive Absorption Temporal Displacement, Cognitive Absorption Focused Immersion, System Quality, Interest, Cognitive Absorption Heightened Enjoyment, Emotion, Satisfaction and Intention all showed some negative kurtosis, which indicates that the values for these variables are clustered more around the mean value than the tail ends of the distribution. This means fewer students selected the end-responses Likert categories for these variables. The values for Perceived Ease of Use and Self-Efficacy Task showed some positive kurtosis, indicating that the values for these variables were clustered more around the tail ends of the distribution.

For the mannequin-head simulator post-usage questionnaire the values for skew and kurtosis for all of the variables, apart from Mastery Goals, are within a range of +/-2, which is considered an acceptable level for a normal distribution. This indicates that the data is suitable for further, parametric statistical testing.

Summary

All of the variables on the post-usage questionnaire for the mannequin-head simulator had positive overall responses. For the hapTEL post-usage questionnaire the variables Mastery Goals, Subjective Norms, Self-Efficacy Task and Cognitive Absorption Focused Immersion had positive overall mean scores whilst Attitude, Perceived Behavioural Control and Perceived Ease of Use had overall mean scores that were close to the neutral or ambivalent point of 12. All the other variables for the hapTEL simulator had negative overall mean scores. This indicates that the students were more receptive to using the mannequin-head simulator at the end of the term compared to the hapTEL simulator.

The highest overall mean score for both the hapTEL simulator and the mannequin-head simulator was for Mastery Goals, at 19.18. As with the pre-usage questionnaire, this may be due to students being able to judge this variable more confidently as it relates to their own personal goals and the issues regarding how this variable is measured (see Chapter 7, Section 7.2.4). The lowest overall mean score for the hapTEL simulator was Intention at 9.29. The lowest overall mean score for the mannequin-head simulator was Perceived Behavioural Control at 12.55 This score is still positive but it falls very close to the neutral or ambivalent of 12.

The values for standard deviation, skew and kurtosis were generally higher on the post-usage questionnaire compared to the pre-usage questionnaire for most of the variables, indicating more variation in responses between students at the post-usage stage. The values for skew and kurtosis for the post-usage questionnaire did allow for further parametric statistical testing.

4.3.3 Paired samples t-test comparing overall mean scores for the hapTEL simulator and the mannequin-head simulator post-usage questionnaire

A paired-samples t-test was carried out to see if there were any significant differences between the mean scores of the variables for the hapTEL simulator and the mannequin-head simulator post-usage questionnaire. Table 4.14 shows the results from the t-test.

Table 4-18 Results from the t-test comparing the mean scores of the variables for the hapTEL simulator and mannequin-head simulator on the post-usage questionnaire (n=238)

Variable	Mean Difference	Significance
Attitude	**-6.46**	**.000***
Perceived Usefulness	**-7.47**	**.000***
Task Value	**-9.06**	**.000***
Subjective Norms	**-4.26**	**.000***
Perceived Behavioural Control	-.23	.525
Self-Efficacy Task	**-3.24**	**.000***
Perceived Ease of Use	**-3.50**	**.000***
Self-Efficacy Technology	**-2.92**	**.000***
Cognitive Absorption Temporal Displacement	**-3.15**	**.000***
Cognitive Absorption Focused Immersion	**-3.07**	**.000***
System Quality	**-7.18**	**.000***
Interest	**-8.14**	**.000***
Cognitive Absorption Heightened Enjoyment	**-7.05**	**.000***
Emotion	**-7.11**	**.000***
Satisfaction	**-7.90**	**.000***
Intention	**-9.08**	**.000***

*** Significant at the .01 level**

Note: All variables had a higher overall mean score for the mannequin-head simulator

All of the variables apart from Perceived Behavioural Control showed a significant difference between the mean scores for the hapTEL simulator and the mannequin-head simulator. The mannequin-head simulator had significantly higher mean scores for all variables except Perceived Behavioural

Control (the score for Perceived Behavioural Control was higher for the mannequin-head simulator but was not significant).

Compared to the pre-usage questionnaire three variables, Attitude, Interest and Cognitive Absorption Heightened Enjoyment, changed from being significantly higher for the hapTEL simulator to being significantly higher for the mannequin-head simulator. Six variables, Subjective Norms, Self-Efficacy Task, Cognitive Absorption Temporal Displacement, Cognitive Absorption Focused Immersion, System Quality and Emotion changed from showing no significant difference to being significantly higher for the mannequin-head simulator.

Summary

At the post-usage stage, all of the variables apart from Perceived Behavioural Control had a significantly higher overall mean score for the mannequin-head simulator compared to the hapTEL simulator. This shows that at the post-usage stage the students were significantly more receptive to using the mannequin-head simulator rather than the hapTEL simulator. The variables that had been significantly higher for the hapTEL simulator on the pre-usage questionnaire (Attitude, Interest, Cognitive Absorption Heightened Enjoyment) had changed to being significantly higher for the mannequin-head simulator. This could act as 'disconfirmation' (see Chapter 2, Section 2.6.1) for the students and subsequently lead to lower levels of Satisfaction and Intention to use. This will be discussed in Chapter 6, Section 6.2.

4.3.4 Correlation of variables with Satisfaction and Intention for the post-usage questionnaire

This section presents the results of the correlations between the variables included on the post-usage questionnaire with the variables of Satisfaction and Intention.

- Table 4.19 shows the results of the correlation analysis for Satisfaction with the hapTEL simulator.
- Table 4.20 shows the results of the correlation analysis for Intention to use the hapTEL simulator.
- Table 4.21 shows the results of the correlation analysis for Satisfaction with the mannequin-head simulator.
- Table 4.22 shows the results of the correlation analysis for Intention to use the mannequin-head simulator.

Table 4-19 Correlations of the predictor variables with Satisfaction for the hapTEL simulator post-usage questionnaire (n=165)

Variable	*Satisfaction*
Mastery Goals	.11
Attitude	.63**
Perceived Usefulness	.67**
Task Value	.69**
Subjective Norms	.40**
Perceived Behavioural Control	.04
Self-Efficacy Task	.57**
Perceived Ease of Use	.50**
Self-Efficacy Technology	.51**
System Quality	.68**
Interest	.72**
Cognitive Absorption Heightened Enjoyment	.70**
Cognitive Absorption Temporal Displacements	.45**
Cognitive Absorption Focused Immersion	.49**
Emotion	.74**

**** Significant at the .01 level**
*** Significant at the .05 level**

For the hapTEL simulator post-usage questionnaire there were:

- Moderate, highly significant correlations between Satisfaction and the variables Attitude (.42**), Perceived Usefulness (.53**), Task Value (51**), Subjective Norms (.40**), Self-Efficacy Task (.41**), Cognitive Absorption Focused Immersion (.53**), System Quality (.68**), Interest (.57**), Cognitive Absorption Heightened Enjoyment (.62**) and Emotion (.51**).
- Weak, highly significant correlations between Satisfaction and the variables Self-Efficacy Technology (.28*) and Cognitive Absorption Temporal Displacement (.31**).
- Weak, significant correlations between Satisfaction and the variables Perceived Behavioural Control (.13*) and Mastery Goals (.16*).

Table 4-20 Correlations of the predictor variables with Intention to use the hapTEL simulator for the post-usage questionnaire (n=165)

Variable	*Intention*
Mastery Goals	.09
Attitude	.72**
Perceived Usefulness	.74**
Task Value	.78**
Subjective Norms	.62**
Perceived Behavioural Control	.22**
Self-Efficacy Task	.47**
Perceived Ease of Use	.37**
Self-Efficacy Technology	.36**
System Quality	.69**
Interest	.83**
Cognitive Absorption Heightened Enjoyment	77**
Cognitive Absorption Temporal Displacements	.51**
Cognitive Absorption Focused Immersion	.43**
Emotion	.79**

**** Significant at the .01 level**
*** Significant at the .05 level**

For the hapTEL simulator post-usage questionnaire there were:

- Strong, highly significant correlations between continued Intention and the variables Attitude (.72**), Perceived Usefulness (.74**), Task Value (78**), Interest (.83**), Cognitive Absorption Heightened Enjoyment (.77**) and Emotion (.79**).
- Moderate, highly significant correlations between continued Intention and the variables Subjective Norms (.62**), Self-Efficacy Task (.47**) System Quality (.69**), Cognitive Absorption Focused Immersion (.43**) and Cognitive Absorption Temporal Displacement (.51**).
- Weak, highly significant correlations between continued Intention and the variables Perceived Behavioural Control (.22*) Perceived Ease of Use (.37**) and Self-Efficacy Technology (.36**)
- No significant correlations between continued Intention and Mastery Goals (.09)

Table 4-21 Correlations of the predictor variables with Satisfaction for the mannequin-head simulator post-usage questionnaire (n=196)

Variable	*Satisfaction*
Mastery Goals	.30
Attitude	.51**
Perceived Usefulness	.69**
Task Value	.68**
Subjective Norms	.55**
Perceived Behavioural Control	.01
Self-Efficacy Task	.64**
Perceived Ease of Use	.63**
Self-Efficacy Technology	.59**
Cognitive Absorption TD	.50**
Cognitive Absorption FI	.70**
System Quality	.43**
Interest	.75**
Cognitive Absorption HE	.84**
Emotion	.29**

**** Significant at the .01 level**
*** Significant at the .05 level**

For the mannequin-head simulator post-usage questionnaire there were:

- Strong, highly significant correlations between Satisfaction and the variables Cognitive Absorption Focused Immersion (.70**), Interest (.75**) and Cognitive Absorption Heightened Enjoyment (.84)
- Moderate, highly significant correlations between Satisfaction and the variables Attitude (.51**), Perceived Usefulness (.69**), Task Value (.68**), Subjective Norms (.55**), Self-Efficacy Task (.64**), Perceived Ease of Use (.63**), Self-Efficacy Technology (.59**) Cognitive Absorption Temporal Displacement (.50**) and System Quality (.43**)
- A weak, highly significant correlation between Satisfaction and Emotion (.29**)
- There was no significant correlation between Satisfaction and Mastery Goals (.30) or Perceived Behavioural Control (.01)

Table 4-22 Correlations of the predictor variables with Intention to use the mannequin-head simulator for the post-usage questionnaire (n=196)

Variable	*Intention*
Mastery Goals	.31**
Attitude	.53**
Perceived Usefulness	.66**
Task Value	.76**
Subjective Norms	.87**
Perceived Behavioural Control	.04
Self-Efficacy Task	.54**
Perceived Ease of Use	.51**
Self-Efficacy Technology	.51**
Cognitive Absorption TD	.57**
Cognitive Absorption FI	.74**
System Quality	.72**
Interest	.79**
Cognitive Absorption HE	.82**
Emotion	.24**

**** Significant at the .01 level**
*** Significant at the .05 level**

For the mannequin-head post-usage questionnaire there were;

- Strong, highly significant correlations between continued Intention and the variables Task Value (.76**), Subjective Norms (.87**), Cognitive Absorption Focused Immersion (.74**), System Quality (.72**) Interest (.79**), and Cognitive Absorption Heightened Enjoyment (.82**)
- Moderate, highly significant correlations between continued Intention and the variables Attitude (.53**), Perceived Usefulness (.66**) Self-Efficacy Task (.54**) Perceived Ease of Use (.51**), Self-Efficacy Technology (.51**) and Cognitive Absorption Temporal Displacement (.57**).
- Weak, highly significant correlations between continued Intention and the variables Perceived Behavioural Control (.22*) Perceived Ease of Use (.37**) and Self-Efficacy Technology (.36**)

- No significant correlations between continued Intention and Mastery Goals (.09)

Summary

For the hapTEL simulator there were moderate, highly significant correlations between Satisfaction and the variables Attitude, Perceived Usefulness, Task Value Subjective Norms, Self-Efficacy Task, Cognitive Absorption Focused Immersion, System Quality, Interest, Cognitive Absorption Heightened Enjoyment and Emotion. These results were also found on the pre-usage questionnaire. For Intention there were strong to moderate, highly significant correlations with the variables Attitude, Perceived Usefulness, Task Value, Subjective Norms, Self-Efficacy Task, System Quality, Cognitive Absorption Focused Immersion, Cognitive Absorption Heightened Enjoyment, Interest, Cognitive Absorption Heightened Enjoyment and Emotion. All other variables showed only weak correlations with either Satisfaction or Intention.

For the mannequin-head simulator there were strong to moderate, highly significant correlations between Satisfaction and the variables Attitude, Perceived Usefulness, Task Value, Subjective Norms, Self-Efficacy Task, Perceived Ease of Use, Self-Efficacy Technology, Cognitive Absorption Focused Immersion, Cognitive Absorption Temporal Displacement, System Quality, Interest, Cognitive Absorption Heightened Enjoyment. For Intention there were strong to moderate, highly significant correlations with the variables Attitude, Perceived Usefulness, Task Value, Subjective Norms, Self-

Efficacy Task, Perceived Ease of Use, Self-Efficacy Technology, Cognitive Absorption Temporal Displacement, Cognitive Absorption Focused Immersion, System Quality, Interest and Cognitive Absorption Heightened Enjoyment. All other variables showed only weak correlations with either Satisfaction or Intention.

4.3.5 Paired-samples t-test comparing the mean scores for the pre-usage and post-usage questionnaire

A paired samples t-test was carried out in order to compare the mean scores for the variables on the pre-usage questionnaire with those on the post-usage questionnaire. These results would be used to see how students' perceptions of the two simulators change after they have experience of using them.

- Table 4.23 shows the results for the hapTEL simulator.
- Table 4.24 shows the results for the mannequin-head simulator.

Table 4-23 T-test comparing the overall mean scores of the variables for the pre-usage and post-usage questionnaire for the hapTEL simulator (n=165)

	Variable	Mean Difference	Significance
Sig. higher score for the pre-usage questionnaire	**Attitude**	**5.79**	**.000***
	Perceived Usefulness	**5.32**	**.000***
	Task Value	**5.67**	**.000***
	Subjective Norms	**3.10**	**.000***
	Perceived Behavioural Control	**1.82**	**.000***
	Self-Efficacy Task	**2.05**	**.000***
	Cognitive Absorption Temporal Displacement	**1.38**	**.000***
	Cognitive Absorption Focused Immersion	**1.26**	**.001***
	System Quality	**3.96**	**.000***
	Interest	**7.82**	**.000***
	Emotion	**5.29**	**.000***
	Satisfaction	**4.77**	**.000***
	Intention	**6.18**	**.000***
No sig. difference in overall mean score	Mastery Goals	.03	.911
	Perceived Ease of Use	.36	.276
	Self-Efficacy Technology	-.04	.913
	Cognitive Absorption Heightened Enjoyment	-.12	.684

***Significant at the .01 level**

Note :A positive score indicates that the variable had a higher score for on the pre-usage questionnaire. A negative score indicates that the variable had a higher score for the post-usage questionnaire

For the hapTEL simulator, the variables Attitude, Perceived Usefulness, Task Value, Subjective Norms, Perceived Behavioural Control, Self-Efficacy Task, Cognitive Absorption Temporal Displacement, Cognitive Absorption Focused Immersion, System Quality, Interest, Emotion, Satisfaction and Intention all had significantly higher mean scores on the Pre-Usage Questionnaire compared to the Post-Usage Questionnaire. The variables Mastery Goals and Perceived Ease of Use had higher mean scores for the Pre-Usage Questionnaire compared to the Post-Usage Questionnaire but the difference was not significant. The variables Self-Efficacy Technology and Cognitive Absorption Heightened Enjoyment had higher mean scores for the Post-Usage Questionnaire compared to the Pre-Usage Questionnaire but the difference was not significant.

Table 4-24 T-test comparing the overall mean scores of the variables for the pre-usage and post-usage questionnaire for the mannequin-head simulator (n=196)

	Variable	Mean Difference	Significance
Sig. higher mean score for the post-usage questionnaire	**Attitude**	**-.71**	**.032***
	Perceived Usefulness	**-.90**	**.001****
	Task Value	**-1.35**	**.017***
	Subjective Norms	**-.63**	**.000****
	Perceived Behavioural Control	**2.21**	**.000****
	Self-Efficacy Task	**-1.03**	**.000****
	Perceived Ease of Use	**-2.22**	**.000****
	Self-Efficacy Technology	**-2.40**	**.000****
	Cognitive Absorption Temporal Displacement	**-1.60**	**.000****
	Cognitive Absorption Focused Immersion	**-1.54**	**.000****
	System Quality	**-1.60**	**.000****
	Cognitive Absorption Heightened Enjoyment	**-.60**	**.031***
	Satisfaction	**-1.57**	**.000****
	Intention	**-1.77**	**.000****
No sig. difference in overall mean score	Mastery Goals	.030	.911
	Interest	-.37	.163
	Emotion	-.50	.054

****Significant at the .01 level**
***Significant at the .05 level**
Note: A positive score indicates that the variable had a higher score for on the pre-usage questionnaire. A negative score indicates that the variable had a higher score for the post-usage questionnaire

For the mannequin-head simulator, the variables Perceived Behavioural Control had a significantly higher mean score on the Pre-Usage Questionnaire compared to the Post-Usage Questionnaire. The variables Attitude, Perceived Usefulness, Task Value, Subjective Norms, Self-Efficacy Task, Perceived Ease of Use, Cognitive Absorption Temporal Displacement, Cognitive Absorption Focused Immersion, System Quality, Cognitive Absorption Heightened Enjoyment, Satisfaction and Intention all had significantly higher mean scores on the Post-Usage Questionnaire compared to the Pre-Usage Questionnaire. The variables Interest and Emotion had higher mean scores for the Post-Usage Questionnaire compared to the Pre-Usage Questionnaire but the difference was not significant.

4.3.6 Regression of variables with Satisfaction and Intention for the Post-Usage Questionnaire

The variables from the post-usage questionnaire were regressed with Satisfaction and Intention for both the hapTEL simulator and the mannequin-head simulator.

- Table 4.25 shows the results from the regression analysis for Satisfaction with the hapTEL simulator.
- Table 4.26 shows the results from the regression analysis for Intention to use hapTEL simulator.
- Table 4.27 shows the results from the regression analysis for Satisfaction with the mannequin-head simulator.
- Table 4.28 shows the results from the regression analysis for Intention to use mannequin-head simulator.

Table 4-25 Results from the regression analysis for the hapTEL simulator post-usage questionnaire for the variable Satisfaction (n=165)

Variable	*Beta*	*Significance*
Mastery Goals	.053	.301
Attitude	-.090	.350
Perceived Usefulness	**.254**	**.022***
Task Value	.174	.101
Subjective Norms	-.045	.471
Perceived Behavioural Control	-.092	.111
Self-Efficacy Task	.067	.352
Perceived Ease of Use	-.043	.571
Self-Efficacy Technology	**.161**	**.016***
Cognitive Absorption Temporal Displacement	-.021	.719
Cognitive Absorption Focused Immersion	.117	.060
System Quality	**.178**	**.019***
Interest	.077	.454
Cognitive Absorption Heightened Enjoyment	-.056	.319
Emotion	.181	.069

* **Significant at the .05 level**

Note: $R^2 = .654$

The adjusted R^2 value for the regression model for Satisfaction to use the hapTEL simulator was .654, indicating that the variables included in the model explain approximately 66% of the variation in Satisfaction with the hapTEL simulator. As is shown in table 4.25, the variables Perceived Usefulness, Self-Efficacy Technology and System Quality were found to be significant predictors of Satisfaction with the hapTEL simulator at the .05 level. The remaining variables were not found to be significant predictors of Satisfaction with the hapTEL simulator.

Table 4-26 Results from the regression analysis for the hapTEL simulator post-usage questionnaire for the variable Intention (n=165)

Variable	*Beta*	*Significance*
Mastery Goals	-.074	.059
Attitude	-.090	.420
Perceived Usefulness	.254	.452
Task Value	.174	.193
Subjective Norms	**-.045**	**.000****
Perceived Behavioural Control	**-.092**	**.004***
Self-Efficacy Task	.067	.261
Perceived Ease of Use	-.043	.841
Self-Efficacy Technology	.161	.615
Cognitive Absorption Temporal Displacement	-.021	.682
Cognitive Absorption Focused Immersion	**.117**	**.048***
System Quality	.178	.595
Interest	**.077**	**.000****
Cognitive Absorption Heightened Enjoyment	-.056	.610
Emotion	**.181**	**.025***
Satisfaction	**.160**	**.012***

**** Significant at the .01 level**
*** Significant at the .05 level**
Note:* R^2 *= .799

The adjusted R^2 value for the regression model for Intention to use the hapTEL simulator was .799, indicating that the variables included in the model explain approximately 80% of the variation in Intention to use the hapTEL simulator. As is shown in Table 4.26 the variables Perceived Behavioural Control, Cognitive Absorption Focused Immersion, Emotion and Satisfaction were found to be significant predictors of Intention to use the hapTEL simulator at the .05 level and the variables Subjective Norms and Interest were found to be significant predictors at the .01 level. The remaining variables were not found to be significant predictor of Intention to use the hapTEL simulator.

Table 4-27 Results from the regression analysis for the mannequin-head simulator post-usage questionnaire for the variable Satisfaction (n=196)

Variable	*Beta*	*Significance*
Mastery Goals	-.002	.962
Attitude	**-.134**	**.014***
Perceived Usefulness	**.161**	**.023***
Task Value	.099	.152
Subjective Norms	.012	.801
Perceived Behavioural Control	.012	.758
Self-Efficacy Task	.063	.306
Perceived Ease of Use	**.177**	**.003***
Self-Efficacy Technology	-.058	.342
Cognitive Absorption Temporal Displacement	.012	.799
Cognitive Absorption Focused Immersion	.133	.044
System Quality	-.011	.849
Interest	.003	.972
Cognitive Absorption Heightened Enjoyment	**.398**	**.000****
Emotion	.147	.096

**** Significant at the .01 level**
*** Significant at the .05 level**
Note: $R^2 = .756$

The adjusted R^2 value for the regression model for Satisfaction was .756, indicating that the variables included in the model explain approximately 76% of the variation in Satisfaction with the mannequin-head simulator. As is shown in Table 4.27 the variables Attitude, Perceived Usefulness and Perceived Ease of Use were found to be significant predictors of Satisfaction with the mannequin-head simulator at the .05 and the variable Cognitive Absorption Heightened Enjoyment was found to be a significant predictor at the .01 level. The remaining variables were not found to be significant predictors of Satisfaction with the mannequin-head simulator.

Table 4-28 Results from the regression analysis for the mannequin-head simulator post-usage questionnaire for the variable Intention (n=196)

Variable	*Beta*	*Significance*
Mastery Goals	-.074	.826
Attitude	-.090	.514
Perceived Usefulness	.254	.110
Task Value	**.174**	**.000****
Subjective Norms	-.045	.675
Perceived Behavioural Control	-.092	.572
Self-Efficacy Task	.067	.051
Perceived Ease of Use	-.043	.291
Self-Efficacy Technology	.161	.539
Cognitive Absorption Temporal Displacement	-.021	.106
Cognitive Absorption Focused Immersion	**.117**	**.001***
System Quality	.178	.132
Interest	.077	.356
Cognitive Absorption Heightened Enjoyment	**-.056**	**.012***
Emotion	.181	.892
Satisfaction	**.160**	**.000****

**** Significant at the .01 level**
*** Significant at the .05 level**
Note: R^2 = 816

The adjusted R^2 value for the regression model for Intention was .816, indicating that the variables included in the model explain approximately 82% of the variation in Intention to use the mannequin-head simulator. As is shown in Table 4.28 the variables Cognitive Absorption Focused Immersion and Cognitive Absorption Heightened Enjoyment were found to be significant predictors of Intention to use the mannequin-head simulator at the .05 level and the variables Task Value and Satisfaction were found to be significant predictors at the .01 level. The remaining variables were not found to be significant predictor of Intention to use the mannequin-head simulator.

Summary

All of the regression models explained between 66 and 82% of the variation in Satisfaction and Intention to use the hapTEL simulator and the mannequin-head simulator. For the hapTEL simulator, the variables Perceived Usefulness, Self-Efficacy Technology and System Quality significantly predicated Satisfaction and the variables Perceived Behavioural Control, Subjective Norms, Cognitive Absorption Focused Immersion, Interest, Emotion and Satisfaction predicted Intention. For the mannequin-head simulator the variables Attitude, Perceived Usefulness, Perceived Ease of Use and Cognitive Absorption Heightened Enjoyment were significant predictors of Satisfaction and the variables Cognitive Absorption Heightened Enjoyment, Cognitive Absorption Focused Immersion, Task Value and Satisfaction were significant predictors of Intention.

The only variables found to be predictors for the both the hapTEL simulator and the mannequin-head simulator were Perceived Usefulness, which was found to be a significant predictor of Satisfaction for the hapTEL simulator and the mannequin-head simulator, and Cognitive Absorption Focused Immersion and Satisfaction, which were both found to be significant predictors of Intention to use the hapTEL simulator and the mannequin-head simulator. As for the pre-usage stage this suggests that at the post-usage stage the students are using different factors to help them decide if they want to use the hapTEL simulator and the mannequin-head simulator. This section will be discussed in more detail in Chapter 6, Section 6.4.

4.3.7 Structural equation modelling for the post-usage questionnaire

As for the pre-usage questionnaire, the variables that were found to be significant predictors of either Satisfaction or Intention were used in the structural equation modeling (SEM) analysis. AMOS version 20 was used to carry out the structural equation modeling. The method chosen was maximum likelihood.

The hapTEL simulator

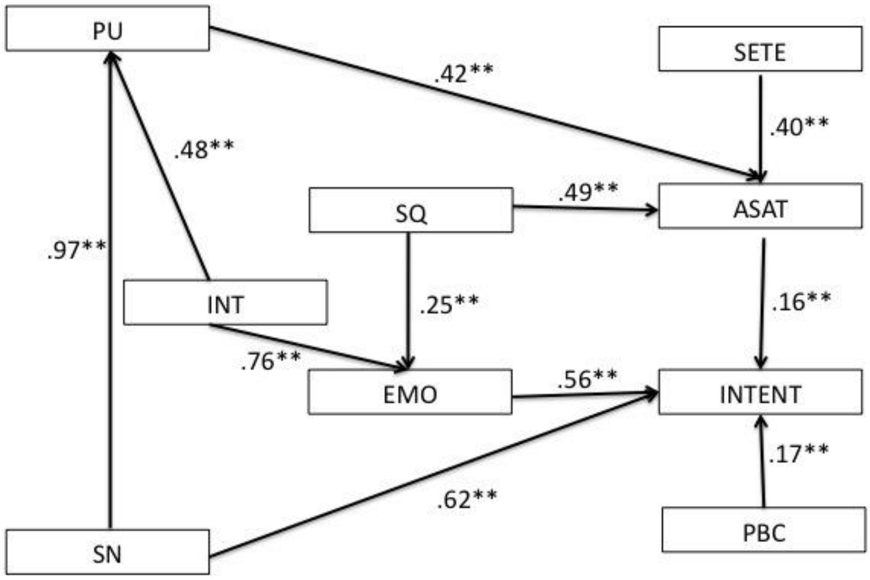
For the hapTEL simulator post-usage questionnaire the variables Subjective Norms, System Quality, Perceived Usefulness, Self-Efficacy Technology, Perceived Behavioural Control, Interest and Emotion were used in the structural equation model along with the predicted variables Satisfaction and Intention.

Measurement model

The final model for the hapTEL simulator post-usage questionnaire included 27 items underlying the 9 variables from the post-usage questionnaire (Subjective Norms, System Quality, Perceived Usefulness, Self-Efficacy Technology, Perceived Behavioural Control, Interest, emotion, Satisfaction and Intention). All the items loaded onto the underlying variable at the recommended level of .7 or higher apart from the item Emotion 3, which loaded slightly below the recommended level at .631.

Structural model

The final structural model for the hapTEL post-usage questionnaire is shown in Figure 4.3.



Key
SN: Subjective Norms, PU: Perceived Usefulness, INT: Interest, SETE: Self-efficacy Technology, SQ: System Quality, EMO: Emotion, PBC: Perceived Behavioural Control, SAT: Satisfaction, INTENT: Intention

FIGURE 4-3 STRUCTURAL EQUATION MODEL FOR THE HAPTEL SIMULATOR POST-USAGE QUESTIONNAIRE

(n=165)

All the paths in the structural equation model were found to be significant. The variables found to impact directly on Intention were Perceived Behavioural Control at .17*, Subjective Norms at .62**, Emotion at .56** and Satisfaction at .67**. The variables found to impact directly on Satisfaction were Self-Efficacy Technology at .40**, Perceived Usefulness at .42** and System Quality at .50**. Subjective Norms (.97**) and Interest (.48**) were also found to impact directly on Perceived Usefulness whilst System Quality was found to act on both Emotion and Interest at .25* and 91** respectively.

Table 4.29 shows the model fit indices for the hapTEL simulator Post-Usage Questionnaire. All the model fit indices were at acceptable levels apart from the NFI value, which was slightly below the recommended value of .9 and above at .854. This suggests that the model is a good fit for the data. The results from this section will be discussed in Chapter 6, Section 6.5.

Table 4-29 Structural equation modeling fit indices for the hapTEL simulator post-usage questionnaire model (n=165)

Model fit indices	Recommended value	Value for Model
χ^2/df	≤5	2.264
CFI	>9	.904
TLI	>9	.902
NFI	>9	.854

CFI: *Comparative fit index. Compares the covariances of the hypothesized model and the null-hypothesis model*

TLI*: Tucker Lewis index. Compares the* χ^2 *of the hypothesized model and the null-hypothesis model independent of sample size*

****NFI:*** *Normed-fit index. Compares the* χ^2 *of the hypothesized model and the null-hypothesis model*

The mannequin-head simulator

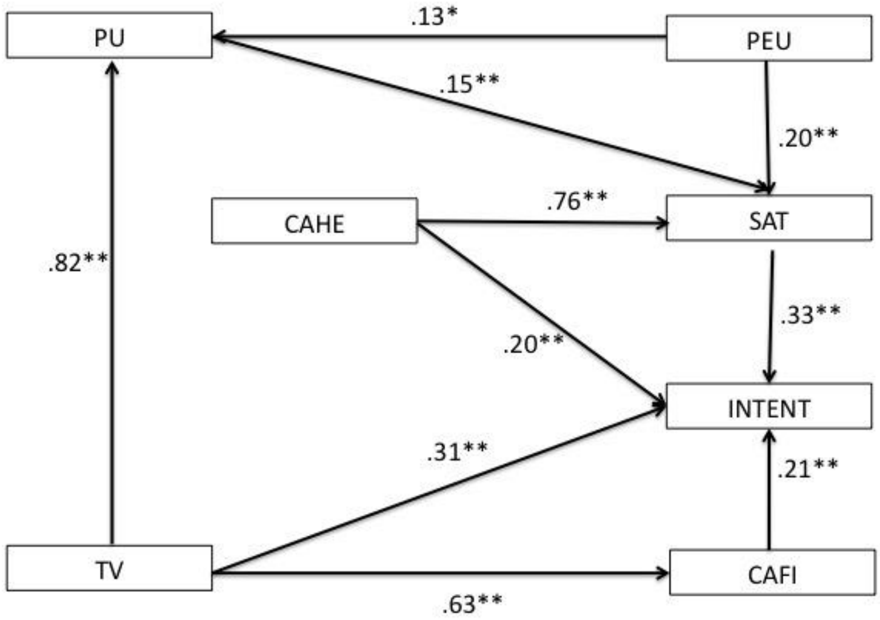
For the mannequin-head simulator Post-Usage Questionnaire the variables Task Value, Perceived Usefulness, Cognitive Absorption Focused Immersion, Cognitive Absorption Heightened Enjoyment and Perceived Ease of Use in the structural equation model along with the predicted variables Satisfaction and Intention.

Measurement model

The final model for the mannequin-head simulator Post-Usage Questionnaire included 21 items underlying the 7 variables from the Post-Usage Questionnaire (Task Value, Perceived Usefulness, Cognitive Absorption Focused Immersion, Cognitive Absorption Heightened Enjoyment, Perceived Ease of Use, Satisfaction and Intention). All the items loaded onto the underlying latent variable at the recommended level of .7 apart from the item Task Value 3 which loaded slightly below the recommended level at .640.

Structural model

The final structural model for the mannequin simulator Post-Usage Questionnaire is shown in Figure 4.4.



Key
TV: Task Value, PU: Perceived Usefulness, PEU: Perceived Ease of Use, CAFI: Cognitive Absorption Focused Immersion, CAHE: Cognitive Absorption Heightened Enjoyment, SAT: Satisfaction, INTENT: Intention

FIGURE 4-4 STRUCTURAL EQUATION MODEL FOR THE MANNEQUIN-HEAD SIMULATOR (n=196)

All the paths in the structural equation model were found to be highly significant (apart from the path between Perceived Usefulness and Perceived Ease of Use, which was found to be .005. The variables found to impact directly on Intention were Task Value at .63**, Cognitive Absorption Heightened Enjoyment at .20**, Cognitive Absorption Focused Immersion at .21** and Satisfaction at .33**. The variables found to impact directly on Satisfaction were

Perceived Ease of Use at .20**, Perceived Usefulness at .15** and Cognitive Absorption Heightened Enjoyment at .76**. Perceived Ease of Use was found to impact directly on Perceived Usefulness at .13* and Task Value was found to impact directly on Perceived Usefulness and Cognitive Absorption Focused Immersion at .82** and 63** respectively.

Table 4.30 shows the model fit indices for the mannequin-head simulator Pre-Usage Questionnaire. All the model fit indices were at acceptable levels apart from the NFI value and the TLI value, which were slightly below the recommended value of .9 and above at .874 and .885 respectively.

Table 4-30 Structural equation modeling fit indices for the mannequin-head simulator post-usage questionnaire (n=196)

Model fit indices	Recommended value	Value for Model
χ^2/df	≤5	3.980
CFI	>9	.902
TLI	>9	.885
NFI	>9	.874

CFI: *Comparative fit index. Compares the covariances of the hypothesized model and the null-hypothesis model*
TLI*: Tucker Lewis index. Compares the* χ^2 *of the hypothesized model and the null-hypothesis model independent of sample size*
****NFI:*** *Normed-fit index. Compares the* χ^2 *of the hypothesized model and the null-hypothesis model*

4.4 The effect of gender on Satisfaction with and Intention to use the hapTEL simulator and the mannequin-head simulator

This section addresses the issue of whether gender was a moderator of either Satisfaction with or Intention to use the hapTEL simulator and the mannequin-head simulator. See Chapter 2, Section 2.7.2 for a discussion on gender and simulators.

4.4.1 Independent t-test comparing overall mean scores for male and female students for the pre-usage questionnaire

This stage of the analysis involved carrying out an independent t-test to see if there was any significant difference between male students and female students mean scores for the variables included on the Pre-Usage Questionnaire.

- Tables 4.31 shows the results of the independent t-test for the hapTEL simulator
- Table 4.32 shows the results of the independent t-test for the mannequin-head simulator.

Table 4-31 Results from the independent t-test comparing the overall mean scores of the variables on the hapTEL simulator pre-usage questionnaire for male and female students (n=250)

	Variable	Mean Difference	Significance
Sig. higher score for female students	**Attitude** **Perceived Behavioural Control** **Satisfaction**	**-.848** **-.713** **-1.240**	**.030*** **.033*** **.002***
Sig higher score for male students	**Self-Efficacy Technology**	**.904**	**.030***
No sig. difference in score	Mastery Goals Perceived Usefulness Task Value Subjective Norms Self-Efficacy Task Perceived Ease of Use Cognitive Absorption Temporal Displacement Cognitive Absorption Focused Immersion	.258 -.352 -.205 -.164 .634 .623 .016 .167	.487 .391 .578 .715 .098 .081 .969 .677
	System Quality Interest Cognitive Absorption Heightened Enjoyment Emotion Intention	-.565 -.036 -.611 .0173 -.178	.152 .930 .126 .966 .681

* Significant at the .05 level

Note: A positive score for the mean difference indicates that male students had a higher overall mean score for that variable. A negative score for the mean difference indicates that female students had a higher overall score for that variable.

For the hapTEL simulator Pre-Usage Questionnaire, the overall mean score for the variables Attitude, Perceived Behavioural Control and Self-Efficacy Technology showed a significant difference between male and female students. Female students had a significantly higher overall mean score for the variables of Attitude (md .848, .030), Perceived Behavioural Control (md .713, .033) and anticipated Satisfaction (md 1.240, .002). Male students had a significantly higher overall mean for the variable Self-Efficacy Technology (md .904, .030). All the other variables showed no significant difference between the overall mean scores for male and female students.

Table 4.32: Results from the independent t – test comparing the overall mean scores of the variables on the mannequin-head simulator pre-usage questionnaire for male and female students (n=250)

Variable	Mean difference	Significance
Attitude	-.558	.216
Perceived Usefulness	-.440	.297
Task Value	-.402	.303
Subjective Norms	-.422	.369
Perceived Behavioural Control	-.481	.204
Self-Efficacy Task	.352	.374
Perceived Ease of Use	.380	.331
Self-Efficacy Technology	.786	.064
Cognitive Absorption Temporal Displacement	-.378	.356
Cognitive absorption focused immersion	-.014	.973
System Quality	-.223	.559
Interest	-.258	.563
Cognitive Absorption Heightened Enjoyment	-.532	.221
Emotion	-.089	.836
Satisfaction	-.419	.283
Intention	-.299	.492

Note: A positive score for the mean difference indicates that male students had a higher overall mean score for that variable. A negative score for the mean difference indicates that female students had a higher overall score for that variable

For the mannequin-head simulator, there were no significant differences in the overall mean scores for the variables for male and female students. However, male students had higher overall mean scores for the variables Self-Efficacy Task, Perceived Ease of Use and Self-Efficacy Technology. Female students had higher overall mean scores for the remaining thirteen variables.

4.4.2 Independent t-test comparing overall mean scores for male and female students for the post-usage questionnaire

This stage of the analysis involved carrying out an independent t-test to see if there was any significant difference between male students and female students mean scores for the variables included on the post-usage questionnaire.

- Tables 4.33 shows the result of the independent t-test for the hapTEL simulator

- Table 4.34 shows the results of the independent t-test for the mannequin-head simulator.

Table 4.33: Results from the independent t – test comparing the overall mean scores of the variables on the hapTEL simulator Post-Usage Questionnaire for male and female students (n=165)

	Variable	Mean difference	Significance
Sig. higher score for female students	**Perceived Behavioural Control**	**-1.978**	**.000****
Sig higher score for male students	**Self-Efficacy Task**	**1.617**	**.008***
	Perceived Ease of Use	**2.682**	**.000****
	Self-Efficacy Technology	**1.427**	**.014***
No sig. difference in score	Mastery Goals	-.041	.930
	Attitude	-.821	.228
	Perceived Usefulness	-.631	.378
	Task Value	-.363	.586
	Subjective Norms	-.851	.107
	Cognitive Absorption Temporal Displacement	.210	.773
	Cognitive absorption focused immersion	-.720	.325
	System Quality	.825	.230
	Interest	.923	.251
	Cognitive Absorption Heightened Enjoyment	.103	.889
	Emotion	.937	.169
	Satisfaction	.196	.790
	Intention	.445	.557

****Significant at the .01 level**
***Significant at the .05 level**
Note: A positive score for the mean difference indicates that male students had a higher overall mean score for that variable. A negative score for the mean difference indicates that female students had a higher overall score for that variable

The overall mean score for the variables Perceived Behavioural Control, Self-Efficacy Task, Perceived Ease of Use and Self-Efficacy Technology showed a significant difference between male and female students.

Female students had a significantly higher overall mean score for the variable Perceived Behavioural Control (md 1.978, .000). Male students had a significantly higher overall mean score for the variables Self-Efficacy Task (md 1.618, .008), Perceived Ease of Use (md 2.682, .000) and Self-Efficacy

Technology (md 1.427, .014). All the other variables showed no significant difference between the overall mean scores for male and female students.

Table 4.34: Results from the independent t – test comparing the overall mean scores of the variables on the mannequin-head simulator Post-Usage questionnaire for male and female students (n=196)

	Variable	Mean difference	Significance
Sig. higher score for female students	**Cognitive absorption focused immersion**	**-1.19865**	**.012***
	Interest	**-.95658**	**.044***
No sig. difference in score	Attitude	-.40562	.435
	Perceived Usefulness	-.05274	.916
	Task Value	-.42150	.401
	Subjective Norms	-.59076	.259
	Perceived Behavioural Control	-.08139	.869
	Self-Efficacy Task	-.07428	.866
	Perceived Ease of Use	.10637	.816
	Self-Efficacy Technology	-.45536	.313
	Cognitive Absorption Temporal Displacement	-.91817	.092
	System Quality	-.54042	.276
	Cognitive Absorption Heightened Enjoyment	-.73629	.109
	Emotion	-.05618	.904
	Satisfaction	-.78681	.124
	Intention	-.85843	.081

*Significant at the .05 level

Note: A positive score for the mean difference indicates that male students had a higher overall mean score for that variable. A negative score for the mean difference indicates that female students had a higher overall score for that variable

Female students had a significantly higher overall mean score for the variables Cognitive Absorption Focused Immersion (md 1.120, .012) and Interest (md .957, .044). All the other variables showed no significant difference between the overall mean scores for male and female students (however female students did have higher overall mean scores for all of the remaining variables).

In summary;

- Before using either simulator male and female students had similar initial perceptions in terms of Mastery Goals, Perceived Usefulness, Task Value, Subjective Norms, Self-Efficacy Task, Perceived Ease of Use, Cognitive Absorption Temporal Displacement, Cognitive Absorption Focused Immersion, System Quality, Interest, Cognitive Absorption Heightened Enjoyment, Emotion and initial Intention.
- For the hapTEL Pre-Usage Questionnaire, male students had a significantly higher overall mean score for Self-Efficacy Technology for the hapTEL simulator compared to female students, indicating that male students have a greater sense of confidence in their ability to use the hapTEL simulator before they have first-hand experience with the simulator. Female students had a significantly higher overall mean score for Attitude, Perceived Behavioural Control and anticipated Satisfaction for the hapTEL simulator compared to male students, indicating that female students have an initial higher, overall Attitude toward the hapTEL simulator.
- For the mannequin-head simulator Pre-Usage Questionnaire, there were no significant differences in overall mean scores between male and female students, however male students had a higher score for Self-Efficacy Technology that was close to being significant (.064).
- After using the simulators, male and female students had similar perceptions in terms of Mastery Goals, Attitude, Perceived Usefulness, Task Value, Subjective Norms, Cognitive Absorption Temporal

Displacement, System Quality, Interest, Cognitive Absorption Heightened Enjoyment, Emotion, Satisfaction and Intention.

- For the hapTEL Post-Usage Questionnaire female students had a significantly higher overall mean score for Perceived Behavioural Control compared to male students, indicating that female students believed they had more overall control of the hapTEL learning activity than the male students. Male students had a significantly higher overall mean score for Self-Efficacy Task, Perceived Ease of Use and Self-Efficacy Technology compared to female students, indicating that male students have a higher level of confidence in their ability to use and perform the tasks on the hapTEL simulator.
- For the mannequin-head simulator Post-Usage Questionnaire, female students had a significantly higher overall mean score for Cognitive Absorption Focused Immersion and Interest compared to male students, indicating that female students had a greater level of intrinsic motivation when using the mannequin-head simulator.

These results are discussed in detail in Chapter 6, Section 6.7.

4.5 The effect of computer experience on Satisfaction with and Intention to use the hapTEL simulator and the mannequin-head simulator

This section addresses the issue of whether computer experience was a moderator of either Satisfaction with or Intention to use the hapTEL simulator and the mannequin-head simulator. See Chapter 2, Section 2.7.1 for a discussion on computer experience.

Computer experience was measured by asking respondents which technological devices they owned, how often they used certain computer applications and programs, how skilled they felt in using those applications and programs and how confident they felt using new technologies. See Chapter 3, Section 3.5.3 for more information on how computer experience was measured.

A score for computer experience was calculated for each individual. This was done by summing the responses given by the individuals for each question. For example, the computer ownership sub-scale was calculated by assigning a score of 1 for each item the individual owned, for the computer usage and the skills and confidence sub-scales the individual was given a score corresponding to the Likert scale response category they used (for example, if an individual rated a particular question as five, then they would received a score of five for that question.) The scores for computer experience could therefore range from zero to 107.

The mean computer experience score for all the students in Study 1 and Study 2 was 64.

The mean computer score for all male students was 61 and the mean score for all female students was 58. Table 4.28 shows the mean and standard deviations for computer experience for the pre-usage questionnaire. Table 4.29 shows the mean and standard deviations for computer experience for the post-usage questionnaire. The scores are broken down into all students from Study 1 and Study 2, all students from Study 1 and all students from Study 2.

Table 4-32 Mean and standard deviations for the computer experience scores on the pre-usage questionnaire (n=250)

Study	Mean	Standard Deviation
All Students Study 1 and Study 2	59.45	11.17
All Students Study 1	58.13	10.17
All Students Study 2	60.79	11.98

The mean computer experience score for all students in Study 1 and Study 2 was 59.45, with a standard deviation of 11.17. The mean computer experience score for Study 1 was 58.13, with a standard deviation of 10.17. The mean computer score for Study 2 was 60.79, with a standard deviation of 11.98.

Table 4-33 Mean and standard deviations for the computer experience scores on the post-usage questionnaire (n=238)

Study	Mean	Standard Deviation
All Students Study 1 and Study 2	62.07	12.49
All Students Study 1	60.70	11.80
All Students Study 2	63.45	13.05

The mean computer experience score for all students in Study 1 and Study 2 was 62.07, with a standard deviation of 12.49. The mean computer experience score for Study 1 was 60.70, with a standard deviation of 11.80. The mean computer score for Study 2 was 63.45, with a standard deviation of 13.05.

An independent t-test was carried out to compare the mean computer experience scores for Study 1 and Study 2. The mean difference in computer scores for Study 1 and Study 2 was 2.658. The difference between the mean scores however was not significant, ($t = -1.871$ $p>.05$). As there was no significant difference between the mean scores then the data for computer experience for Study 1 and Study 2 could be analysed together.

The next stage in the analysis involved running a correlation between computer experience and the variables included on the pre-usage and post-usage questionnaire. The purpose of this test is to see if a relationship exists between computer experience and students' perceptions of and Intention to use the hapTEL simulator and the mannequin-head simulator. This information will help to determine if computer experience is a moderator of students Satisfaction with or Intention to use dental simulators.

Table 4-34 Correlation of computer experience scores with the variables included on the pre-usage questionnaire (n=250)

Variable	hapTEL Simulator	Mannequin-head Simulator
Mastery Goals	.08	
Attitude	.13	.11
Perceived Usefulness	.07	.06
Task Value	.11	.09
Subjective Norms	.10	.11
Perceived Behavioural Control	.02	.03
Self-Efficacy Task	**.18****	**.05**
Perceived Ease of Use	**.22****	**.12**
Self-Efficacy Technology	**.13***	**.18****
Cognitive Absorption Temporal Displacement	.10	.08
Cognitive Absorption Focused Immersion	-.02	.02
System Quality	**.02**	**.16***
Interest	.02	.09
Cognitive Absorption Heightened Enjoyment	-.04	.05
Emotion	.05	.09
Satisfaction	**-.03**	**.14***
Intention	.02	.14

For the hapTEL simulator there was:

- Weak, highly significant correlations between computer experience and the variables Self-Efficacy Task (.181**) and Perceived Ease of Use (.224**).
- Very weak, significant correlation between computer experience and Self-Efficacy Technology (.127*).

- No significant correlations between computer experience and the other variables included on the questionnaire.

For the mannequin-head simulator there was;

- A weak, highly significant correlation between computer experience and Self-Efficacy Technology (.182**).
- Very weak, significant correlations between computer experience and the variables System Quality (.155*) and Anticipated Satisfaction (.144*).

Table 4-35 Correlation of computer experience scores with the variables included on the post-usage questionnaire (n=238)

Variable	hapTEL Simulator	Mannequin-head Simulator
Mastery Goals	-.04	
Attitude	-.03	-.03
Perceived Usefulness	.01	-.01
Task Value	-.01	-.05
Subjective Norms	-.07	.03
Perceived Behavioural Control	**-.14***	**-.02**
Self-Efficacy Task	.08	.04
Perceived Ease of Use	**.15***	**.06**
Self-Efficacy Technology	.06	-.01
Cognitive Absorption Temporal Displacement	-.02	-.08
Cognitive Absorption Focused Immersion	-.07	-.04
System Quality	.04	.01
Interest	-.02	-.01
Cognitive Absorption Heightened Enjoyment	-.06	-.01
Emotion	-.06	.07
Satisfaction	-.049	-.01
Intention	-.03	-.04

For the hapTEL simulator there was;

- Weak, significant correlations between computer experience and the variables Perceived Behavioural Control (-.136*) and Perceived Ease of Use (.152*).

- No significant correlations between computer experience and the other variables included on the post-usage questionnaire.

For the mannequin-head simulator there was:

- No significant correlations between computer experience and the variables included on the post-usage questionnaire.

Overall, the weak correlations between computer experience and the variables on the pre-usage and post-usage questionnaire suggests that the students' levels of computer experience are not a moderator of their Satisfaction with or Intention to use the hapTEL simulator or the mannequin-head simulator. This will be discussed in more detail in Chapter 6, Section 6.8.

This chapter presented the findings and the statistical analysis from the quantitative data that was collected via the questionnaire in Study 1 and Study 2. Chapter 5 presents the results from the qualitative data that was collected via student completed worksheets (Study 1) and the questionnaire (Study 2).

5 Results from the Qualitative Analysis for Study 1 and Study 2-Questionnaire and Worksheets

5.1 Introduction

This chapter presents the results from the qualitative data conducted in Study 1 and Study 2 for the hapTEL simulator and the mannequin-head simulator. The qualitative data in Study 1 was collected via worksheets completed during the sessions where students used either the hapTEL simulator or the mannequin-head simulator. Three worksheets were completed in total with one question included on each worksheet. The qualitative data in Study 2 was collected on the post-usage questionnaire completed by the students after they had used both the hapTEL simulator and the mannequin-head simulator. (For a detailed breakdown of Study 1 and Study 2 refer back to Chapter 3, Section 3.1). The final response rate for the qualitative data from Study 1 and Study 2 is shown in Table 5.1.

Table 5-1 Response rate for the qualitative data collected in Study 1 and Study 2

Simulator	Study 1			Study 2
	Worksheet 1	Worksheet 2	Worksheet 3	Post-usage questionnaire
hapTEL	41	45	42	79
Mannequin-head	84	83	84	35

The qualitative data was analysed using a thematic analysis approach. The variables included on the questionnaire were used as initial themes for the analysis. A colour-coding scheme was used to indicate comments that contained references to any of the variables (for an example see appendix 5A). Comments that did not contain references to any of the variables included on the questionnaire were then anyalsed again to identify any common themes among them. The qualitative data in Study 1 was collected on worksheets that the students completed during each session they had using their assigned simulator. (See Chapter 3, Section 3.6 for more information).

The following questions were asked:

1. *Describe your initial experience of using the (mannequin-head/hapTEL) simulator*

2. *Compare your experience of using the (mannequin-head/hapTEL) simulator in this session with your experience last session*

3. *Describe your overall experience of using the (mannequin-head/hapTEL) simulator*

In total, there were 41, 45 and 42 responses for the hapTEL simulator session one, two and three worksheets and 84, 83 and 84 responses for the mannequin-head simulator session one, two and three worksheets. The qualitative data in Study 2 was collected via the post-usage questionnaire that students completed at the end of the first term, after they had used both the hapTEL simulator and the mannequin-head simulator (see Chapter 3, Section 3.6 for more detail).

Two open-ended questions were asked on the questionnaire.

1) *Describe your overall experience of using the mannequin-head simulator*

2) *Describe your overall experience of using the hapTEL simulator*

The questions were optional for the students. In total, 79 responses were provided for the hapTEL simulator and 43 responses were provided for the mannequin-head simulator.

In terms of the analysis, some comments were easier to classify as they included a direct reference to one particular variable, e.g. *the simulator was easy to use* (Perceived Ease of Use). However, due to the nature of some of the variables and the fact that there are often overlaps between certain variables some discretion was taken when classifying particular comments that may fall into more than variable, for example, *it was appropriate* could be classified as Attitude as it is making an overall judgment on the simulator's suitability but it could also fall under Perceived Usefulness. For all variables the accepted definition of the term in attitudinal research was used to guide classification and to ensure consistency throughout the analysis. Table 5.2 shows the number of times that references were made to the variables included on the questionnaire for both Study 1 and Study 2.

Table 5-2 Number of times the variables are mentioned in the qualitative data for Study 1 and Study 2

	hapTEL Simulator Study 1			Mannequin-head Simulator Study 1			hapTEL Simulator Study 2	Mannequin-head Simulator Study 2
Variable	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*post-questionnaire*	*post-questionnaire*
Mastery Goals	0	0	0	0	0	2	0	0
Attitude	18	15	10	37	38	35	12	8
Perceived Usefulness	13	14	12	36	30	25	20	9
Task Value	1	0	4	1	0	1	19	3
Subjective Norms	0	0	0	0	1	0	0	0
Perceived Behavioural Control	1	5	6	0	6	11	0	0
Self-Efficacy Task	2	3	2	4	3	7	1	0
Perceived Ease of Use	5	3	2	3	1	1	10	2
Self-Efficacy Technology	4	5	0	6	5	5	1	0
Cognitive Absorption Temporal Displacement	0	0	0	0	0	0	0	0
Cognitive Absorption Focused Immersion	3	4	4	5	7	4	3	4
System Quality	7	1	3	1	2	0	1	0
Interest	11	15	6	36	32	21	2	0
Cognitive Absorption Heightened Enjoyment	10	5	5	30	33	32	11	10
Emotion	3	3	12	24	19	15	14	2
Satisfaction	1	2	0	1	0	0	2	0
Intention	9	8	9	41	34	25	1	0

The variables of Mastery Goals, Subjective Norms, Cognitive Absorption Temporal Displacement and Satisfaction were mentioned in the students' comments either not at all or a very small number of times. For Mastery Goals and Cognitive Absorption Temporal Displacement this may link with the fact that those variables had a low impact on behavioural Intention in the quantitative data (see Chapter 4, Section 4.2.4 and 4.3.4). If these variables are not playing a part in shaping student Intention then it is likely that the students would not mention them when asked about their experience of using the simulator. For Subjective Norms and Satisfaction however, both of these variables were found to be significant determinants of Intention in the quantitative data analysis. Subjective Norms was found to impact significantly on behavioural Intention at .045, .000 for the hapTEL simulator post-usage questionnaire, and Satisfaction was found to impact significantly on Intention for the hapTEL simulator post-usage questionnaire at .160, .012, and for the mannequin-head simulator at .33, .000. It is possible though that when describing their experience with using the simulator the students are thinking more about the session they had just experienced rather than their wider motivation for the simulator. Their thoughts about the opinions of the others may not have played a role whilst they were actually using the simulator during the session therefore they would not have reflected upon this when writing about their experience. For Satisfaction, it is possible that the students were thinking more about whether they would want to use the simulator and therefore expressed their Intention to use more often than their sense of Satisfaction.

The variables that were mentioned most often in the qualitative data were Attitude, Perceived Usefulness, System Quality, Interest, Cognitive Absorption Heightened Enjoyment and Intention. All of these variables were also found to be significant predictors in the structural equation modeling. Their presence in the qualitative data could lend support to these variables being important in shaping behavioural Intentions for using simulators. It could be however that the students find these variables easier to make judgments on and are therefore more likely to use that information when forming opinions of simulators.

The results for Study 1 and Study 2 were similar in terms of the variables that were mentioned often or not at all. There were however a few differences, for example: Task Value was referred to more often for the hapTEL simulator in Study 2, Perceived Behavioural Control and Interest were not mentioned or hardly mentioned in Study 2 compared to Study 1, and emotion was only mentioned a couple of times for the mannequin-head simulator in Study 2 compared to Study 1. The results from this section will be discussed in Chapter 6, Section 6.6.

5.2 Additional themes found in the qualitative data

The comments and parts of comments that did not contain any reference to the variables included in the questionnaire were reanalysed in order to identify any common themes among them. The following themes were identified.

- Realism
- Reliability

These themes will now be discussed and the relevant data presented.

5.2.1 Realism

Several comments were made regarding the perceived levels of realism for both the hapTEL simulator and the mannequin-head simulator. In total there were 31 responses referring to the realism of the hapTEL simulator and 1 response referring to the realism of the mannequin-head simulator. This was; *'Its just more real'.* Table 5.2 shows the results for the hapTEL simulator. Overall, the comments suggest that the students perceived the mannequin-head simulator to be more realistic than the hapTEL simulator.

Table 5-3 References to realism for the hapTEL simulator

Study 1-Worksheets		Study 2-Questionnaire
Session 1	Was very realistic	needs some work in terms of accuracy and real life simulation
	It was a very realistic virtual experience	the realistic feel of the 'touch' of the handpiece falls apart..... I was not satisfied with the realism of the program
	Was very realistic	nothing like the real thing
Session 2	More realistic than before	doesn't reflect the real mouth
	this system was more realistic	'real' clinical setting is more fruitful
	More realistic	before it feels as useful and realistic as using a real drill
	More realistic to a real life clinical situation	diverging away from reality
	this week was unrealistic	is different to real teeth
Session 3	more realistic	It doesn't seem that realistic
	was more realistic	I do not feel it is similar enough to the experience on a plastic/real tooth
	but not realistic	not entirely realistic.
	In terms of how realistic it is I think there are some improvements that could be made	does not feel real
	Have found it to be very realistic	does not seem to simulate the real cavity preparation experience
	Sometimes I feel the experience is unrealistic	it isn't an accurate representation of a real-life situation

	Does not feel real enough	The feel of the drill is very similar to the real life needs some work in terms of accuracy and real life simulation

The students in Study 1 had a more positive perception of the levels of realism for the hapTEL simulator than the students in Study 2, though the comments contained more negative references as the worksheets progressed from session one to three. The comments from the students in Study 2 were also more likely to contain more detailed references to realism than the comments from Study 1 for example "*I do not feel it is similar enough to the experience on a plastic/real tooth".*

The majority of the comments refer to the overall level of realism of the simulator as perceived by the students. Some comments though do make reference to specific aspects of realism e.g. "***The feel of the drill is very similar to the real life".*** The high proportion of comments making reference to realism show that this aspect of the simulator is important to the students but also that the students feel able to judge the simulator on this aspect. The majority of the students at this stage of the course would not have yet experienced real-life drilling situations or the use of real dental equipment. However, when examining the data from Study 1, for the hapTEL simulator there were only 3 comments about realism in the first session, all of which were positive. As the weeks progressed the number of comments about realism increased but the number of positive comments decreased and the number of negative comments increased. In session 3 for example, there were 4 negative comments about the realism of the hapTEL simulator and 3 positive comments about the realism of the hapTEL simulator. It is possible that as students gained more experience with the simulator they felt more able to judge this particular aspect. There is also a possibility that the students are referring to the emotional realism of the task rather than the haptic realism of the task. In that situation students would not need to have an accurate knowledge of the real-life procedure and how it physically feels whilst carrying out the procedure. Instead, they may be able to imagine how they would feel if they were carrying out the procedure on a real-life patient. Realism will be discussed in more detail in Chapter 7, Section 7.4.2.

5.2.2 Reliability

Another identified theme in the data was the reliability of the two simulators. This was typically expressed in terms of how often the simulator broke down or needed some form of troubleshooting. In total there were 14 responses regarding the reliability of the hapTEL simulator and there were 2 responses regarding the reliability of the mannequin-head simulator, though one response was referring to the reliability of the mannequin-head simulator in a positive manner. Table 5.4 shows the results for the hapTEL simulator. Overall, the comments suggest that the students found the hapTEL simulator to be unreliable. Table 5.5 shows the results for the mannequin-head simulator. Overall, the comments suggest that the students found the mannequin-head simulator to be of an acceptable level of reliability.

Table 5-4 References to reliability for the hapTEL simulator

Study 1 Worksheets	Study 2 Questionnaire	
When there were no technical difficulties it was Interesting to use	There is always a problem	Has crashed a couple of times
IT FAILED A LOT	There are software and hardware problems	Seems to break down regularly
A lot of shaking in the tooth and equipment	Constant crashing	Always crashes
It crashed on a few occasions	Repeatedly crashed on me	Frequently breaks down
The system had to be reloaded	had to change systems 4 times	The system is always crashing
Technical difficulties were troublesome	System/program crashes	The system seemed to crash quite a lot
Worked much better than last time	The reliability of the hapTEL system needs work	Its broken down
The system worked better this time	Often breaks	There are some glitches
There were some glitches in the system	The software is buggy	It fails to work
Still needs to iron out some bugs	Most practice time used troubleshooting	It didn't work a lot of the time
The device kept locking up	It is not very reliable	It stops working
Became frustrated when the handpiece became stuck	Less crashes of the software would improve the experience	Still malfunctions
Find the glitches problematic	There was a point where something didn't work	Hardly ever works
The dental mirror didn't work very well	Lots of technical problems	It crashed
Had to recalibrate it vey often	Still plenty of kinks and bugs	Often crashes
Have had a lot of problems with the hapTEL device as the system would keep on locking up	Too many bugs	The system does crash
System was not working as well as it usually does	Rarely seemed to work	Most of the time in the hapTEL lab has been spent fixing glitches
The program sometimes freezes	It is not very reliable	When the system fails in the middle of working on a tooth
	Would be better if there weren't so many software problems	On most occasions the computer crashed
	The ability of the system to crash is frustrating	Kept crashing

	Most of the time it did not work	Technology often crashes
	Constantly breaking	Machines are also very temperamental
	The constant problems with the system	Frustrating when the system kept crashing
	If it worked all the time I think I would be more positive towards it	The software often stopped working
	It is really easy to get it to not work	System often crashes
	The system often crashes	There are too many problems with the program
	It always has a problem every time	

Table 5-5 References to reliability for the mannequin-head simulator

Worksheet 1	Worksheet 2	Worksheet 3	Study 2
Our screen kept going on and off	**No references made**	**No references made**	It's more real and can never go wrong

The majority of the reliability issues for the hapTEL simulator were related to the software that ran the hapTEL program rather than the actual hardware of the simulator. This was not an issue for the mannequin-head simulator as it did not require any form of computer software. There was however, a computer monitor attached to the mannequin-head simulator that was used to project the lecture before the practical session and could also be used be the students to access the Internet. The students who commented on the computer screen may have considered this computer monitor to be part of the mannequin-head simulator even though it did not play a role in the actual simulator itself. Alongside the issues of software reliability was the time needed to fix any problems. In the hapTEL sessions the students often had to rely on technical support from project staff in order to overcome software problems. This could often lead to students having to wait for long periods of time whilst someone became available to help them and for the issue to be resolved. This highlights the importance of having good technical support available when using virtual-reality based simulators as problems with the software can be difficult for non-specialists to fix. Reliability will be discussed in more detail in Chapter 7, Section 7.4.3.

The very high number of responses regarding the reliability of the hapTEL simulator shows that this is an important consideration for the students when they are judging the simulator. The majority of the comments for the hapTEL simulator regarding reliability are negative, however it may be that students are more likely to be vocal about an issue when it is perceived as negative, i.e. had the reliability of the hapTEL simulator been high than the students may not have commented on this issue as much, even in a positive manner. It is possible that some variables have more power to influence student perceptions of simulators when they are negative rather than positive.

5.2.3 Comparisons between the simulators in Study 1

Another common occurrence amongst the responses was the presence of direct or indirect comparisons between the two simulators. In the open-ended questionnaire for the hapTEL simulator in Study 2 there were 3 responses that included a direct reference to the mannequin-head simulator and four responses that could be considered to be using an indirect reference to the mannequin-head simulator. In the open-ended question for the mannequin-head simulator in Study 2 there were 10 responses that included a direct reference to the hapTEL simulator and four responses could be considered to be using an indirect reference to the hapTEL simulator.

Although the indirect responses do not include the other simulator by name, the phrasing suggests that a comparison is being made to something. For example, words such as '***easier***', '***more realistic***', '***will be better***' imply that a point of reference is being used when making these statements.

Table 5-6 Responses that contained comparisons between the two simulators

Extract from Response
would take me literally seconds with the mannequin
before using the mannequin-head
effectively as the mannequin-head
…and hapTEL should be scrapped
Mannequin-head more useful than hapTEL
It is more realistic than the hapTEL system
better than the hapTEL technology
It is just more 'real'
I prefer using this to hapTEL
…easier to use than the hapTEL system
much better than hapTEL
…more beneficial than the hapTEL
gave a better feel for the handpieces than hapTEL
The mannequin will be better to use
…better feel for the handpieces than the hapTEL
I prefer using this to hapTEL
Fun, enjoyable and easier to use
The advantage of the head is the sensation is more realistic
It is more realistic
The mannequin head will be better to use
Compared to normal systems it crashed a lot and was unrealistic
Preferred the phantom head
I think using the phantom head would be more beneficial
I found the really drilling much more useful
'Real' clinical setting is more fruitful
Simulator is not as smooth as using plastic teeth
no further benefit using the hapTEL machine after using the phantom heads
I enjoyed the hapTEL experience until I was exposed to the plastic tooth, which I enjoyed more.
It doesn't seem that realistic to me as say a plastic tooth
It is not similar enough to the experience on a plastic/real tooth in clinical lab
does not seem to simulate the real cavity preparation experience as well as the mannequin-head
Practicing on plastic teeth is much easier
the experience is very different to when using the drills on plastic teeth
The plastic teeth are much better to work with

5.3 Conclusion

The most common variables that were found in the student responses were Perceived Usefulness, Task Value, System Quality, Interest, Cognitive Absorption Heightened Enjoyment, emotion and Intention. As well as the variables included on the questionnaire two additional themes were found in the qualitative data. These were realism and reliability. The mannequin-head simulator was generally found to be more realistic and reliable than the hapTEL simulator. The students appeared to engage comparative behaviour when evaluating the simulators in Study 2, probably due to the fact that they had used both of the simulators before completing the qualitative data unlike the students in Study 1 who had only used one simulator before completing the qualitative data.

6 Discussion and Conclusions

6.1 Introduction

This chapter discusses the results from Study 1 and Study 2 and answers the original research questions. This chapter is set out by the original questions which are presented below.

Q1) What are the dental students initial perceptions of the hapTEL simulator and the mannequin-head simulator before they have had first-hand experience using them?

Q2) How are the dental students' initial perceptions of the simulators related to the students' levels of anticipated Satisfaction and initial Intention to use?

Q3) What are the dental students perceptions of the hapTEL simulator and the mannequin-head simulator after they have had first-hand experience using them?

Q4) How are the dental students' perceptions related to their levels of Satisfaction and Intention to use?

Q5) Is gender a moderator of student perceptions of the hapTEL simulator and the mannequin-head simulator?

Q6) Is computer experience a moderator of student perceptions of the hapTEL simulator and the mannequin-head simulator?

6.2 What are the dental students initial perceptions of the hapTEL simulator and the mannequin-head simulator before they have had first-hand experience using them?

The students in Study 1 and Study 2 completed a pre-usage questionnaire at the beginning of the academic term before they had first-hand experience using either the hapTEL simulator or the mannequin-head simulator. The purpose of the pre-usage questionnaire was to gauge the students' initial perceptions about the two simulators and whether these perceptions would affect their initial levels of anticipated Satisfaction and Intention to use. Davis, creator of the Technology Acceptance Model, claimed that it was both possible and desirable to measure acceptance of a device before users have first-hand experience using the device (Davis 1985). In his study in which he developed the Technology Acceptance Model he successfully substituted hands-on experience with video-tape demonstrations of a device and found that it was still possible to measure acceptance of the device (See Chapter 2, Section 2.6.2).

In this study there were fifteen predictor variables along with the dependent variables of Satisfaction and Intention. These variables were measured using a seven-point Likert scale. For the pre-usage questionnaire there were positive overall mean scores for all the variables on the hapTEL simulator questionnaire and the mannequin-head simulator questionnaire (see Table 4.3 and Table 4.4 in Chapter 4). This implies that before students had any experience with using either simulator they had an initial positive impression towards both of them. The variable with the highest overall mean score for both the hapTEL simulator and the mannequin-head simulator was Mastery Goals, at 19.10 respectively (as

Mastery Goals was measured once.) The variables with the lowest overall mean score for both the hapTEL simulator and the mannequin-head simulator was Perceived Ease of Use, at 13.03 and 13.52 respectively. The overall mean scores for all the variables related to the ease of using the simulators were generally the lowest for both of the simulators. However, even though the variables Perceived Ease of Use had the lowest overall mean score out of all the variables for both the simulators the score itself was not negative but instead fell close to the neutral or ambivalent category. If students selected the mid-point (number 4) on the Likert scale for each item measuring that variable, then their overall score for that variable would be twelve. A score close to thirteen could indicate that students did not feel they were able to make a judgment about this aspect of the simulator before they had first-hand experience using the simulators.

This idea is supported by Davis (1986) who found that Perceived Ease of Use was difficult to measure in a pre-usage situation (see Chapter 2, Section 2.6.1). This idea is further supported by the fact that the variable Self-Efficacy Technology had the second lowest overall mean score for both the hapTEL simulator (at 13.58) and the mannequin-head simulator (at 14.10.) Both of these scores are close to the neutral/ambivalent mark, which could be expected as the variable of Self-Efficacy Technology measures individuals' beliefs that they possess the skills needed to use the technology successfully. If an individual feels they cannot judge how difficult or easy a technology is to use (Perceived Ease of Use), than they may also find it difficult to judge whether or not they have the skills to use that technology. For the variables Self-Efficacy Task, which measures how confident an individual feels carrying out a task, in this case performing a basic cavity preparation, the students may have felt more capable of making a judgment on this variable as it relies on their own knowledge and skill set as well as the simulator. This can be seen in its higher overall mean score of 16.03 for both the simulators.

The variables measuring intrinsic motivation: Interest, Cognitive Absorption Heightened Enjoyment and emotion, were generally high for both the hapTEL simulator and the mannequin-head simulator, with mean overall scores falling between 16 and 18. It is possible that individuals find it easier to judge these variables at a pre-usage stage due to the fact that they are more intrinsically linked to the individual themselves rather than the specific technology in question. Individuals may, for example, feel able to gauge how Interested they are in something before they have used it as opposed to gauging more object specific features such as how useful it will be for a particular task or how easy it will be to use.

For the variables that related to the overall usefulness of the simulator: Attitude, Perceived Usefulness, Task Value and System Quality, the overall mean scores fell in the top and mid-range for both simulators. Attitude and Perceived Usefulness were rated highly for both the hapTEL system, at 17.87 and 16.41, and the mannequin-head simulator, at 17.41 and 16.88. The overall mean score for Task Value fell in the mid-range at 15.26 for the hapTEl simulator and 15.97 for the mannequin-head simulator. System Quality was also in the mid-range at 14.82 and 14.84 for the hapTEL and mannequin-head simulator respectively. The students may have felt positive towards the variables of Attitude and Perceived Ease of Use as they were presented with the simulators as part of their course and would be using them to learn basic cavity preparation. The students may have felt that they were unlikely to be using simulators in their course that were not valuable to their learning. However, as discussed previously for the variables relating to ease of use, Task Value and System Quality may have to be judged by an individual after they have first-hand experience of using the simulator. Although some research suggests that individuals can form opinions of quality based on superficial aspects such as appearance (Thuring and Mahlke 2008), this may not be enough to form a concrete opinion regarding the quality of a technology. Task Value also requires an element of comparative judgment with regards to how valuable your time is being spent carrying out certain activities. Without any appropriate comparative base it may be difficult to judge this aspect of the simulator.

The variables relating to external factors, Subjective Norms and Perceived Behavioural Control, were in the mid-range at 15.45 and 14.30 for the hapTEL simulator and 15.62 and 14.64 for the mannequin-head simulator. For Subjective Norms, the students were likely to believe that the tutors on the course would approve of the simulators. They were also likely to value what the tutors on the course thought. However they may have find it more difficult to judge what their fellow students thought about the simulators at the pre-usage stage. Similarly for Perceived Behavioural Control the students may not have felt able to gauge the external factors that would make using the simulators difficult.

The initial overall positive perception of the simulators may also have been influenced by factors other than the simulators themselves, For example, the students were at the start of their new degree program for which they were probably excited about and eager to begin. This positive Attitude may therefore have influenced their more general perceptions towards aspects of the course such as the different types of learning activities they would be engaging in.

Although there were some similarities between the students' initial perceptions of the hapTEL simulator and the mannequin-head simulator, the paired-t test carried out to compare the overall mean scores for the variables showed that there were also some differences. The variables Attitude, Interest and Cognitive Absorption Heightened Enjoyment had significantly higher overall mean scores for the hapTEL simulator compared to the mannequin-head simulator. The variables Perceived Usefulness, Task Value, Perceived Behavioural Control, Perceived Ease of Use, Self-Efficacy Technology, anticipated Satisfaction and initial Intention had significantly higher overall mean scores for the mannequin-head simulator compared to the hapTEL simulator (see Table 4.6). All the other variables showed no significant difference in their overall mean scores. These results indicate that whilst students may have felt that the mannequin-head simulator was slightly easier to use (though the scores for Perceived Ease of Use and Self-Efficacy Technology were still close the neutral/ambivalent point) and potentially more useful, the students still felt a greater sense of Interest and potential enjoyment for the hapTEL simulator. This may have been caused by the 'novelty' factor of the hapTEL simulator and the fact that it was likely to be more unfamiliar to them than the mannequin-head simulator.

The students did have a higher level of anticipated Satisfaction and initial Intention to use the mannequin-head simulator compared to the hapTEL simulator. The reason behind this could be explained by examining both the results from the paired t-test and the results from the correlation analysis between the variables on the questionnaire. For example the variables of Perceived Usefulness and Task Value, which were higher for the mannequin-head simulator, had stronger correlations with anticipated Satisfaction and initial Intention to use than the variables of Attitude and Interest, therefore even though Attitude and Interest were higher for the hapTEL simulator the students were not necessarily basing their anticipated Satisfaction and initial Intention on these variables. The following section addresses these issues by looking at the relationship between the variables and anticipated Satisfaction and initial Intention.

In summary, the students' initial perceptions of both simulators were positive, with a reasonably high degree of both anticipated Satisfaction and initial Intention, the students' did have significantly higher levels of anticipated Satisfaction and initial Intention to use the mannequin-head simulator as well as perceiving it to be more useful and easier to use than the hapTEL simulator. The students had higher levels of intrinsic motivation toward the hapTEL simulator, possibly perceiving it as more Interesting and fun to use than the mannequin-head simulator. Aspects relating to the ease of use of the simulators may have proved difficult for the students to judge without having had any first-hand experience of using the simulators.

6.3 How are the students' initial perceptions of the simulators related to the students' levels of anticipated Satisfaction and initial Intention to use?

This section considers the relationships of the variables on the pre-usage questionnaire with the variables anticipated Satisfaction and initial Intention to use the hapTEL simulator and the mannequin-head simulator in order to determine which variables contribute to an individual's levels of anticipated Satisfaction and initial Intention at the pre-usage stage.

When the correlations between the variables and anticipated Satisfaction and initial Intention were examined it was found that anticipated Satisfaction correlated most strongly with the variables System Quality, Interest and Cognitive Absorption Heightened Enjoyment for the hapTEL simulator and Attitude, Perceived Usefulness and Task Value for the mannequin-head simulator. Initial Intention was found to correlate most strongly with the variables Cognitive Absorption Heightened Enjoyment, Interest and Perceived Usefulness for the hapTEL simulator and Perceived Usefulness, Attitude and Task Value for the mannequin-head simulator. It is possible that correlations exist between these six variables and either anticipated Satisfaction and initial Intention simply because students are able to make judgments about these variables.

The six variables of Perceived Usefulness, Attitude, Task Value, System Quality, Interest and Cognitive Absorption Heightened Enjoyment had overall means scores that were in the mid or high end of the variable scores (see previous section), meaning that the students were able to make a judgment about these variables and therefore the students may only have been able to base their levels of anticipated Satisfaction and initial Intention on these variables. However some other variables also had high positive overall mean scores, for example emotion, which was 16.36 for the hapTEL simulator and 16.53 for the mannequin-head simulator, but were not strongly correlated with anticipated Satisfaction and initial Intention, indicating that the students are not just relying on the variables that are able to make judgments about but are using specific variables to form their perceptions of anticipated Satisfaction and initial Intention at the pre-usage stage.

The importance of the variables Perceived Ease of Use and self-efficacy at the pre-usage stage can be seen in their relationship with the variables of anticipated Satisfaction and initial Intention. Perceived Ease of Use, Self-Efficacy Technology and Self-Efficacy Task all had low, insignificant correlations with both anticipated Satisfaction and initial Intention. However, both anticipated Satisfaction and initial Intention had scores above the neutral/ambivalent (hence the low correlation with Perceived Ease of Use, Self-Efficacy Technology and Self-Efficacy Task, which all had overall mean scores close to the neutral/ambivalent point), meaning that even though students could not at this stage adequately judge the variables of Perceived Ease of Use, Self-Efficacy Technology and Self-Efficacy Task, the students still felt able to make a judgment about their anticipated level of Satisfaction and their initial Intention to use the simulators and must therefore be using some other information or criteria upon which they are basing their judgments of the simulators. This does not necessarily mean though that the students would not have been influenced by the ease of use variables if they had been able to make a judgment about them.

The variables on the questionnaire were also regressed with anticipated Satisfaction and initial Intention in order to see which variables if any were able to predict anticipated Satisfaction or initial Intention. For the hapTEL simulator, the variables R^2 value for was .61 for anticipated Satisfaction and .62 for initial Intention. For the mannequin-head simulator the R^2 value was .61 for anticipated Satisfaction and .71 for initial Intention. These means that the variables explained between 61 and 71% of the variation in anticipated Satisfaction and initial Intention for the hapTEL simulator and mannequin-head simulator (See Chapter 4, Section 4.2.5).

For anticipated Satisfaction for the hapTEL simulator the variables Perceived Usefulness, Subjective Norms, Cognitive Absorption Focused Immersion and Cognitive Absorption Heightened Enjoyment were significant predictors of at the .05 level and System Quality was a significant predictor at the .01 level. All of the other variables were not significant predictors of anticipated Satisfaction. This shows that students' levels of anticipated Satisfaction are influenced by aspects of usefulness (Perceived Usefulness, System Quality), perceptions of usefulness by others (Subjective Norms) as well as some aspects of intrinsic motivation (cognitive absorption focused immersion, Cognitive Absorption Heightened Enjoyment). This highlights the importance of demonstrating to students the value of the simulator at the pre-usage stage as well as attempting to cultivate students' sense of intrinsic motivation to use the simulator.

For initial Intention for the hapTEL simulator the variables Perceived Usefulness and Self-Efficacy Task were found to be significant predictors at the .05 level and the variable anticipated Satisfaction was found to be a significant predictor of initial Intention at the .01 level. This again shows the importance of the variable Perceived Usefulness, which acts directly on initial Intention and indirectly on initial Intention through anticipated Satisfaction. The direct impact of Self-Efficacy Task on initial Intention shows the importance of fostering a high level of self-belief in students about their ability to carry out the learning tasks on the simulator.

For anticipated Satisfaction for the mannequin-head simulator the variables Perceived Usefulness, Self-Efficacy Task, Perceived Ease of Use, System Quality, and Cognitive Absorption Heightened Enjoyment were significant predictors at the .05 level. All of the other variables were not significant predictors of anticipated Satisfaction. As with the hapTEL simulator, this shows the importance of demonstrating the simulators' value at the pre-usage stage and developing students' intrinsic motivation. However, the presence of Perceived Ease of Use shows that for a non-virtual reality based simulator it may be possible for students to form an initial idea regarding how easy it will be to use, therefore demonstrating this aspect at the pre-usage stage would be important for traditional plastic-based simulators.

For initial Intention for the mannequin-head simulator the variables Attitude, Cognitive Absorption Temporal Displacement, and System Quality were found to be significant predictors at the .05 level and the variables emotion and anticipated Satisfaction were found to be a significant predictors at the .01 level. Again this highlights the importance of Perceived Usefulness variables in forming initial Intention however, unlike the hapTEL simulator, there is a greater impact from intrinsic motivational variables on Initial Intention to use the mannequin-head simulator.

All the variables that were found to be significant predictors in the regression analysis for either anticipated Satisfaction or Initial Intention also showed moderate to high significant correlations with either anticipated Satisfaction or Initial Intention. This suggests that there is a causal relationship between these variables and Anticipated Satisfaction or Initial Intention and that there is unlikely to be any confounding variables present. However, in order to strengthen the evidence of any causal relationship structural equation modeling was carried out on the variables that were found to be significant predictors of either Anticipated Satisfaction or Initial Intention for the hapTEL simulator and the mannequin-head simulator.

For the hapTEL simulator the variables Perceived Usefulness, Subjective Norms, cognitive absorption focused immersion, Cognitive Absorption Heightened Enjoyment, System Quality and Self-Efficacy Task were used in the structural equation modeling along with Anticipated Satisfaction and Initial Intention. For the hapTEL simulator, all the paths in the structural equation model were found to be highly significant apart from the path between Anticipated Satisfaction and Cognitive Absorption Focused Immersion, which was found to be .242. (See Chapter 4, Section 4.2.6).

Perceived Usefulness (.35**) impacted directly on Initial Intention. This is consistent with the Technology Acceptance Model (see Chapter 2, Section 2.3), which has Perceived Usefulness as a direct antecedent for Intention. However, in pre-usage settings, the way Perceived Usefulness is formed is likely to be different than in post-usage settings. For example, in the model for the hapTEL simulator Subjective Norms was found to act directly on Perceived Usefulness. This effect can be explained by considering the fact that Subjective Norms measures how the respondents think important others view the device. In this case, the students were considering the views of their tutors and the other students on their course. If they believe that these important others think they should use the hapTEL simulator, then this is likely to increase their perception of how useful the simulator is. At the pre-usage this may be an important determinate in shaping their perception of Perceived Usefulness as they have less information at this stage with which to make a judgment. This idea is supported by the work of Venkatesh and Davis (2000) who conducted longitudinal field studies using an extended Technology Acceptance Model. They found that at Time 1 and Time 2 Subjective Norms had a significant effect on Perceived Usefulness but by Time 3 this effect had weakened. They suggest this is due to the participants having more direct system experience, therefore gaining more direct, relevant knowledge of the system. This idea is supported by other authors including Hartwick and Barki (1994) and Agarwal and Prasad (1997) who both found that Subjective Norms was important in the initial stages of system use when the participants knowledge about the system is weak and they are having to rely on the opinions of others to guide them. However, after direct experience for themselves the strength of Subjective Norms on Perceived Usefulness fades. This effect of Subjective Norms on Perceived Usefulness has been found in other studies for example Schepers and Wetzels (2007).

System Quality also had a direct impact on Perceived Usefulness in the hapTEL simulator pre-usage model. This relationship has been found in other studies, for example Liaw (2008) found that System Quality was one of the biggest predictors of Perceived Usefulness in a study on students' perceptions of Blackboard and Mabed and Kohler (2012) found a positive link between System Quality and Perceived Usefulness in their study of learning management systems. The role of System Quality at the pre-usage stage however may be based on superficial aspects as suggested by Thuring (2008) such as the aesthetics of the system as the participants have not had any first-hand experience upon which to base their perception of the System Quality.

Cognitive Absorption Focused Immersion was not found to have a significant effect on anticipated Satisfaction. However there was a high level of covariance between Cognitive Absorption Focused Immersion and Cognitive Absorption Heightened Enjoyment (.56**), which may have led to the effect of Cognitive Absorption Focused Immersion being masked by Cognitive Absorption Heightened Enjoyment.

Anticipated Satisfaction was found to have a direct impact on Initial Intention. This is consistent with the work by Liaw (2008) which found Satisfaction and Perceived Usefulness to be positive affecters of Intention to use e-learning. This shows that anticipated Satisfaction is an important determinate of Intention to use even at the pre-usage stage. This is most probably related to the Expectancy Disconfirmation Theory whereby individuals base their initial choice of whether to use a device on their perception of how well the device will serve their needs (See Chapter 2, Section 2.6.1).

For the model itself, all fit indices were at acceptable levels ($\chi 2$/df, 2.568, CFI, .935 and TLI, .924) apart from the NFI value, which was slightly below the recommended value of .9 and above at .898 (See Chapter 4, Section 4.2.6). Overall these results suggest that the model has an acceptable fit and that the proposed relationships between the variables are valid.

For the mannequin-head simulator, all the paths in the structural equation model were found to be highly significant. The variables found to impact directly on initial Intention were System Quality at .42**, emotion at .28** and anticipated Satisfaction at 46**. Perceived Ease of Use (.18**), System Quality (.44**) and Perceived Usefulness (.37**) acted directly on anticipated Satisfaction and indirectly on initial Intention through anticipated Satisfaction.

As with the hapTEL simulator, System Quality acted on Perceived Usefulness and anticipated Satisfaction. Unlike the hapTEL simulator however Perceived Usefulness acted directly on anticipated Satisfaction rather than initial Intention. This is suggests that Perceived Usefulness is more important in determining Intention for the hapTEL simulator than the mannequin-head simulator. This may be because the students are less familiar with the hapTEL simulator technology and are therefore more concerned with how useful the simulator will be for them.

Perceived Ease of Use was found to have a direct impact on anticipated Satisfaction for the mannequin-head simulator model. This may have been because students felt it was slightly easier to gauge the Perceived Ease of Use of the mannequin-head simulator compared to the hapTEL simulator, as they may have been more familiar with it. This can be seen in the t-test comparing the overall mean scores for the variables on the questionnaire which showed that Perceived Ease of Use was significantly higher for the mannequin-head simulator compared to the hapTEL simulator (though the value itself was still low at 13.52). However the path between Perceived Ease of Use and Anticipated Satisfaction was at the lower end with Perceived Ease of Use explaining 18% of the variation in Anticipated Satisfaction.

Emotion also appeared in the mannequin-head model, showing a direct impact on initial Intention. The mannequin-head simulator did score higher than the hapTEL simulator for emotion on the pre-usage questionnaire but the difference was not significant. The impact of emotion was at the lower end with emotion explaining 28% of the variation in initial Intention. Subjective Norms was not in the mannequin-head simulator model. This may have been because students felt more familiar with the mannequin-head simulator or they had some previous knowledge or experience with it therefore they did not feel they had to rely so much on the opinions of others to guide them.

In terms of the model, all fit indices were at acceptable levels ($\chi 2$/df, 2.687, CFI, .917 and TLI, .901) apart from the NFI value, which was slightly below the recommended value of .9 and above at .875. (See Chapter 4, Section 4.2.6). Overall these results suggest that the model has an acceptable fit and that the proposed relationships between the variables are valid.

In summary, the variables related to Perceived Usefulness and intrinsic motivation are the ones most significantly related to Anticipated Satisfaction and

Initial Intention for both the simulators. Both structural equation models showed acceptable levels of fit for the data. The results were different for the hapTEL simulator and the mannequin-head simulator suggesting that the students use different factors to judge the two different types of simulator.

6.4 What are the dental students' perceptions of the hapTEL simulator and the mannequin-head simulator after they have had first-hand experience using them?

The students in Study 1 and Study 2 completed a post-usage questionnaire at the end of the academic term after they had first-hand experience using either the hapTEL simulator or the mannequin-head simulator (Study 1) or both the hapTEL simulator and mannequin-head simulator (Study 2). The purpose of the post-usage questionnaire was to gauge the students' perceptions about the two simulators after they had used them and whether these perceptions would affect their levels of Satisfaction with the simulators and their Intention to use the simulators.

For the post-usage questionnaire there were positive overall mean scores for all the variables on the mannequin-head simulator questionnaire (See Chapter 4, Section 4.3.2). These results show that after having had first hand experience with the mannequin-head simulator the students were generally positive towards most aspects of the simulator and had high levels of Satisfaction and Intention to use. This can be seen in the overall mean scores for the variables Satisfaction and Intention, which were 17.73 and 18.25 respectively.

For the hapTEL simulator the variables Mastery Goals, Attitude, Subjective Norms, Perceived Behavioural Control, Perceived Ease of Use, Self-Efficacy Task and Cognitive Absorption Focused Immersion had positive overall mean scores. All the other variables for the hapTEL simulator had negative overall mean scores (Chapter 4, Section 4.3.2). These results show that after having had first hand experience with the hapTEL simulator the students were negative towards some aspects of the simulator and had low levels of Satisfaction and Intention to use. This can be seen in the overall mean scores for the variables Satisfaction and Intention, which were 10.10 and 9.29 respectively. These values were significantly lower than the values obtained for the mannequin-head simulator, and suggests that out of the two simulators the students had a more favourable perception of the mannequin-head simulator and would be more likely to use the mannequin-head simulator. This can also be seen in the t-test run to compare the overall mean scores on the post-usage questionnaire for the hapTEL simulator and the mannequin-head simulator. All of the variables, apart from Perceived Behavioural Control, were significantly higher for the mannequin-head simulator compared to the hapTEL simulator (Perceived Behavioural Control was higher for the mannequin-head simulator but not significantly).

The results also indicate that after using the hapTEL simulator the students felt less positive towards it then before they had first-hand experience using it. This can be seen when examining the t-test conducted between the pre-and post-usage questionnaires for the hapTEL simulator. Even though some variables remained positive for the hapTEL simulator on the post-usage questionnaire, the mean scores for all of the variables, apart from Self-Efficacy Technology and Cognitive Absorption Heightened Enjoyment, had decreased from the pre-usage questionnaire compared to the post-usage questionnaire. This decrease in the overall mean scores for the variables may explain the low scores for Satisfaction and Intention to use the hapTEL simulator due to the Expectancy Disconfirmation Theory. As discussed in Chapter 2, Section 2.6.1, the Expectancy Disconfirmation Theory suggests that individuals base their evaluations of products on the extent to which the product matched their initial perception. For example, if an individual perceives that a product will be satisfactory but, after using the product, found that it did not in fact meet their expectations, then the product has disconfirmed their high expectations and the individual will then have a lower opinion of that product. On the other hand if an individual has low expectations of a product that they then find performs well disconfirmed their low expectations and the individual will then have a higher opinion of that product.

As the students in this study had an initial positive perception of the hapTEL simulator, if they found that the simulator did not live up to their initial expectations, they may have become more negative towards the simulator than if they had had a lower initial perception of the simulator. Conversely, with the mannequin-head simulator the students had an initial positive perception, and after they had used the simulator, they found their initial perception was confirmed. This may have caused them to become even more positive towards the mannequin-head simulator, as seen by the high overall mean score for Satisfaction and Intention for the mannequin-head simulator.

As was found in the pre-usage questionnaire, the variables with the highest overall mean score for both the hapTEL simulator and the mannequin-head simulator was Mastery Goals, at 19.18 respectively (as Mastery Goals was measured once.) As students have now had experience with using both simulators (unlike the pre-usage questionnaire) this high score may be due to how Mastery Goals is measured (see Chapter 7, Section 7.4.7) and the fact that the students are likely to have high Intention to achieve well on their course. The variables with the lowest overall mean score was Intention, at 9.29, for the hapTEL simulator and Perceived Behavioural Control, at 12.55, for the mannequin-head simulator. This indicates that the students had very low levels of Intention towards using the hapTEL simulator and also that the variables that did have higher overall scores for the hapTEL simulator, e.g. Cognitive Absorption Focused Immersion at 14.41, were unlikely to be impacting the students' levels of Intention to use the hapTEL simulator. For the mannequin-head simulator the results show that the students were neutral or ambivalent towards the Perceived Behavioural Control of the simulator, meaning that this variable is unlikely to impact on their Intention to use the simulator.

For the mannequin-head simulator the variables of Perceived Ease of Use, Self-Efficacy Technology and Self-Efficacy Task had a significantly higher overall mean score on the post-usage questionnaire compared to the pre-usage questionnaire. As was discussed previously, the students would most likely have found it difficult to judge these variables before using the simulator, hence the fact that on the pre-usage questionnaire these variables fell close to the neutral/ambivalent point. By the time the students have had first-hand experience using the simulators they are able to make a more accurate judgment for these variables. For the mannequin-head simulators the students judged the simulator as being reasonably easy to use, with scores of 15.80, 16.47 and 17.26 for the three variables.

For the hapTEL simulator the overall mean score only increased for Self-Efficacy Technology on the post-usage questionnaire. The variables Perceived Ease of Use and Self-Efficacy Task were lower on the post-usage questionnaire compared to the pre-usage questionnaire, though only Self-Efficacy Task was significantly lower on the post-usage questionnaire. The scores themselves were low at 14.05 (Self-Efficacy Task), 12.59 (Perceived Ease of Use) and 13.46 (Self-Efficacy Technology). These lower values are no longer caused by the students not having enough knowledge to base their perception on as they have now had first-hand experience using the simulator. Instead, these results show that the students find the hapTEL simulator more difficult to use compared to the mannequin-head simulator. This can also be seen when examining the paired t-test for the hapTEL simulator and mannequin-head simulator post-usage questionnaire. All the variables (apart from Perceived Behavioural Control) had a significantly higher overall mean score for the mannequin-head simulator compared to the hapTEL simulator.

The variables measuring intrinsic motivation, Interest, Cognitive Absorption Heightened Enjoyment and emotion, were generally much higher for the mannequin-head simulator compared to the hapTEL simulator. For the mannequin-head simulator the scores fell between 16 and 18, indicating a high level of intrinsic motivation toward using the mannequin-head simulator. For the hapTEL simulator the overall mean scores fell between 10 and 11, indicating a low level of intrinsic motivation toward using the hapTEL simulator. As mentioned previously, the scores for all the variables on the mannequin-head simulator were higher for the post-usage questionnaire compared to the pre-usage questionnaire. This shows that not only was the intrinsic motivation high for the mannequin-head simulator but it had increased after use of the simulator. The opposite was the case for the hapTEL simulator where the overall mean scores decreased apart from Cognitive Absorption Heightened Enjoyment where it increased slightly.

For the variables that related to the overall usefulness of the simulator, Attitude, Perceived Usefulness, Task Value and System Quality, the overall mean scores fell in the top range for the mannequin-head simulator and were in the bottom range for the hapTEL simulator. These variables were rated highly for the mannequin-head simulator with overall mean scores between 16 and 18, indicating a high level of Perceived Usefulness for the mannequin-head simulator. For the hapTEL simulator the scores were very low, with overall mean scores between 9 and 12. The variable Task Value had the lowest overall mean score of the four (and second lowest at out of all the variables) at 9.62. As discussed previously, Task Value has an element of comparative judgment with regards to how valuable your time is being spent carrying out certain activities. The students may have been comparing the two simulators when responding to this variable and, as they perceived the mannequin-head simulator as being very useful, this may have resulted in the low score for Task Value.

In summary, the students' perception of the hapTEL system after using it was negative overall, though some aspects of the simulator were rated positively. The students generally had low levels of Satisfaction and Intention to use the hapTEL simulator. The students' perception of the mannequin-head simulator after using it was very positive with high levels of Satisfaction and Intention to use. The mannequin scored higher than the hapTEL simulator for all the variables on the questionnaire.

6.5 How are the dental students' perceptions of the simulators related to their levels of Satisfaction and Intention to use?

This section considers the relationship of the variables on the post-usage questionnaire with the variables Satisfaction and Intention to use the hapTEL simulator and the mannequin-head simulator in order to determine which variables contribute to an individual's levels of Satisfaction and Intention at the post-usage stage.

When the correlations between the variables and Satisfaction and Intention were examined it was found that Satisfaction correlated most strongly with the variables emotion, Interest, and Cognitive Absorption Heightened Enjoyment for the hapTEL simulator and Cognitive Absorption Heightened Enjoyment, cognitive absorption focused immersion, and Interest for the mannequin-head simulator. Intention was found to correlate most strongly with the variables emotion, Task Value and Cognitive Absorption Heightened Enjoyment for the hapTEL simulator and Cognitive Absorption Heightened Enjoyment Interest and Task Value for the mannequin-head simulator. These results show that at the post-usage the variables related to intrinsic motivation are most strongly associated with Satisfaction and Intention for the both the hapTEL simulator and the mannequin-head simulator along with the variable of Task Value. Unlike the pre-usage questionnaire, the students' should have found it easier to make judgments regarding the ease of use variables as they now had first-hand experience using the simulator. However, even though the students could make judgments for these variables they were not strongly correlated with Satisfaction or Intention for either simulator.

The variables on the post-usage questionnaire were then regressed with Satisfaction and Intention in order to see which variables if any were able to predict Satisfaction or Intention. For the hapTEL simulator, the R^2 value was .65 for Satisfaction and .80 for Intention. For the mannequin-head simulator the R^2 value was .76 for anticipated Satisfaction and .82 for initial Intention. This means that the variables explained between 65 and 82% of the variation in Satisfaction and Intention for the hapTEL simulator and mannequin-head simulator.

For Satisfaction for the hapTEL simulator the variables Perceived Usefulness, Self-Efficacy Technology and System Quality were significant predictors of at the .05 level. All of the other variables were not significant predictors of Satisfaction. This shows that at the post-usage stage the students' levels of Satisfaction are mostly influenced by aspects of usefulness (which was also found in the pre-usage questionnaire), and their belief in their ability to use the simulator (Self-Efficacy Technology). Unlike the pre-usage questionnaire however, the variables measuring aspects of intrinsic motivation were not found to predict Satisfaction. This shows that at the post-usage stage the Perceived Usefulness of the simulator remains an important determinate of Satisfaction with the simulator whereas intrinsic motivation is important at the pre-usage stage but becomes less important as students gain experience with the simulator.

For Intention for the hapTEL simulator the variables Perceived Behavioural Control, cognitive absorption focused immersion, emotion and Satisfaction were found to be significant predictors at the .05 level and the variables Subjective Norms and Interest were found to be significant predictors of at the .01 level. This is in contrast to the pre-usage questionnaire, where Perceived Usefulness and self-efficacy were found to predict Intention (for the post usage questionnaire these variables now predict Satisfaction). Instead, motivational variables are now more important in shaping the students Intention to use the simulator along with external factors such as Subjective Norms and Perceived Behavioural Control.

For Satisfaction for the mannequin-head simulator the variables Attitude, Perceived Usefulness, Perceived Ease of Use were significant predictors at the .05 level. The variable Cognitive Absorption Heightened Enjoyment was found to be a significant predictor at the .01 level. This is similar to the hapTEL simulator in that aspects of usefulness and the ease of use (though for the mannequin this is Perceived Ease of Use rather than self-efficacy) of the simulator are important in shaping the students' Satisfaction with the mannequin-head simulator. Unlike the hapTEL simulator however there is still an element of intrinsic motivation affecting Satisfaction in the form of Cognitive Absorption Heightened Enjoyment.

For Intention for the mannequin-head simulator the variable Cognitive Absorption Heightened Enjoyment was found to be a significant predictor at the .05 level and the variables Task Value and Satisfaction were found to be significant predictors at the .01 level. This shows that at the post-usage stage

Intention to use the mannequin-head simulator is formed by aspects of intrinsic motivation and perceptions of usefulness along with Satisfaction itself.

As was the case in the pre-usage questionnaire, all the variables that were found to be significant predictors in the regression analysis for either Satisfaction or Intention also showed moderate to high significant correlations with either Satisfaction or Intention suggesting that there is a causal relationship between these variables and Satisfaction or Intention and that there is unlikely to be any confounding variables present. In order to strengthen the evidence of any causal relationship structural equation modeling was carried out on the variables that were found to be significant predictors of either Satisfaction or Intention for the hapTEL simulator and the mannequin-head simulator.

For the hapTEL simulator the variables Perceived Usefulness, Subjective Norms, System Quality, Self-Efficacy Technology, Perceived Behavioural Control, Interest, Cognitive Absorption Focused Immersion and emotion were used in the structural equation modeling along with Satisfaction and Intention. For the hapTEL simulator, all the paths in the structural equation model were found to be highly significant.

Perceived Usefulness (.42), System Quality (.50) and Self-Efficacy Technology (.40) impacted directly on Satisfaction. Emotion (.56), Perceived Behavioural Control (.17), Subjective Norms (.62) and Satisfaction (.16) impacted directly on Intention.

As was found in the pre-usage questionnaire, Satisfaction had a direct impact on Intention, Subjective Norms had a direct impact on Perceived Usefulness and

Satisfaction and Perceived Usefulness had a direct impact on Intention. Unlike the pre-usage questionnaire Perceived Usefulness did not act directly on Intention but indirectly through Satisfaction. This may be due to the increased importance if intrinsic motivational variables at the post-usage stage (see previous section).

Both Perceived Behavioural Control and Subjective Norms had a direct impact on Intention showing the importance of these external variables at the post-usage stage. This is consistent with Ajzens' Theory of Planned Behaviour, which has both Perceived Behavioural Control and Subjective Norms as direct predictors of behavioural Intention. (See Chapter 2, Section 2.2).

System Quality was also found to act directly on emotion. This effect could be due to individuals' perceptions of the quality of the system they are using causing a negative or positive affective state in the individual whilst they are using the simulator. Interest also had a direct impact on emotion. As emotion and Interest are both intrinsic motivational variables there is likely to be a relationship between the two of them. Also, as Interest is considered by some researchers to consist of both affective and cognitive elements (Hidi 2006) it is possible that the cognitive elements involved in sustaining a level of Interest (or disinterest) can lead to additional affective (emotional) states in individuals. This may explain why emotion was found to impact directly on Intention as both System Quality and Interest are acting through emotion.

For the model itself, all fit indices were at acceptable levels ($\chi 2$/df, 2.264, CFI, .904) apart from the TLI and NFI Value, which were slightly below the recommended value of .9 and above at .892. and .842 respectively. Overall these results suggest that the model has an acceptable fit and that the proposed relationships between the variables are valid.

For the mannequin-head simulator, all the paths in the structural equation model were found to be highly significant. The variables found to impact directly on Intention were Task Value at .31**, Cognitive Absorption Focused Immersion at .21**, Cognitive Absorption Heightened Enjoyment at .21* and Satisfaction at 33**. The variables found to impact directly on Satisfaction were Perceived Ease of Use at .20**, Cognitive Absorption Heightened Enjoyment at .44** and Perceived Usefulness at 33**.

As was found in the pre-usage questionnaire Perceived Ease of Use had a direct impact on Satisfaction for the mannequin-head simulator model. The hapTEL simulator however had Self-Efficacy Technology impacting on Satisfaction in the post-usage questionnaire. This may have been because students found the mannequin-head simulator easier to use, therefore self-efficacy was not as important in determining Satisfaction. Additionally, as the hapTEL simulator is a virtual-reality based simulator the students may have felt less familiar with it and were unsure of their own skills levels in using it.

Subjective Norms was not in the mannequin-head simulator model. As with the pre-usage questionnaire this may have been because students felt more familiar with the mannequin-head simulator so they did not feel they had to rely so much on the opinions of others to guide them.

Task Value had a direct impact on both Perceived Usefulness and cognitive absorption focused immersion. Perceived Usefulness is likely to be affected Task Value as the overall usefulness of the simulator will be partly determined by the usefulness of the tasks undertaken on the simulator. Cognitive Absorption Focused Immersion is concerned with how immersed an individual feels in an activity. If a task is deemed to be useful, it can be supposed that the students will engage with the task and will not become distracted or unfocused. Therefore having a greater sense of Task Value could lead to high levels of cognitive absorption focused immersion.

Cognitive Absorption Heightened Enjoyment and Cognitive Absorption Focused Immersion both impacted directly on Intention to use the mannequin-head simulator. This is similar to the hapTEL simulator in that intrinsic motivational variables are shaping Intention however the exact variables involved are different (with hapTEL affected by emotion and Interest). This shows that intrinsic motivational variables are important determinants of Intention to use a simulator but are likely to differ depending on the type of simulator. The traditional, plastic based simulator may be more reliable and less likely to experience technical problems, meaning that students are more able to focus on the task and become cognitively absorbed whilst using the simulator. Virtual reality simulators may initially stimulate more Interest due to their novelty factor but may lead to more affective arousal if technical problems arise, leading to emotion playing a greater role in shaping Intention. (This can be also be seen in the qualitative data collected in this study).

In terms of the model, all fit indices were at acceptable levels ($\chi 2$/df, 2.687, CFI, .917 and TLI, .901) apart from the NFI value, which was slightly below the recommended value of .9 and above at .875. Overall these results suggest that the model has an acceptable fit and that the proposed relationships between the variables are valid.

In summary, the variables related to Perceived Usefulness, intrinsic motivation and Subjective Norms are the ones most significantly related to anticipated Satisfaction and Initial Intention for both the simulators. Both structural equation models showed acceptable levels fit for the data. The results were different for the hapTEL simulator and the mannequin-head simulator suggesting that the students use different factors to judge the two different types of simulator.

6.6 The qualitative data collected in Study 1 and Study 2

The purpose of the qualitative data collected in Study 1 and Study 2 was to illuminate the quantitative data and to provide insights into any other factors that may influence students' Satisfaction with and Intention to use the simulators that were not included in the questionnaire. The data was analysed using a thematic approach using the variables from the questionnaire. The data was also analysed to see whether any additional themes occurred.

The most common variables from the questionnaire that were found in the qualitative data were Perceived Usefulness, Task Value, System Quality, Interest, Cognitive Absorption Heightened Enjoyment, emotion and Intention. All of these variables were also found to be significant predictors in the quantitative data analysis, providing additional support for the results drawn from the statistical analysis. As well as these variables, two additional themes were also found in the qualitative data. These were realism and reliability.

In terms of realism, the hapTEL simulator was in general found to be less realistic than the mannequin-head simulator (see Chapter 5, Section 5.2.1). Most of the comments about the realism for the hapTEL simulator were referring to its overall level of realism, e.g. *its just not very real*. The high number of comments about the hapTEL simulators level of realism and the fact that the number of negative comments for realism were much higher for the hapTEL simulator compared to the mannequin-head simulator suggest that this is a potentially important factor for determining students' Intentions to use the hapTEL simulator.

Some comments do make reference to specific aspects of realism e.g. "***The feel of the drill is very similar to the real life".*** The high proportion of comments making reference to realism show that this aspect of the simulator is important to the students but also that the students feel able to judge the simulator on this aspect. The majority of the students at this stage of the course would not have yet experienced real-life drilling situations or the use of real dental equipment. However, when examining the data from Study 1 for the hapTEL simulator there were only 3 comments about realism, all of which were positive. As the weeks progressed the number of comments about realism increased but the number of positive comments decreased and the number of negative comments increased. It is possible that as students gained more experience with the simulator they felt more able to judge this particular aspect. There is also a possibility that the students are referring to the emotional realism of the task rather than the haptic realism of the task. In that situation students would not need to have an accurate knowledge of the real-life procedure and how it physically feels whilst carrying out the procedure. Instead, they may be able to imagine how they would feel if they were carrying out the procedure on a real-life patient.

Although the students perceived the hapTEL simulator as being ‘less realistic’ than the mannequin-head simulator, this does not necessarily mean that the hapTEL simulator is consequently less useful or valuable as a simulator. In fact, simulators with a lower level of ‘realism’ are often used with students who are beginning to learn a particular skill or procedure before they progress onto more realistic simulations (Brydges, Carnahan et al. 2010).

This level of realism is usually referred to as fidelity in the literature, with simulators often categorized as having either low, medium or high fidelity depending on how well they are able to recreate the physical and emotional experience of the simulated procedure (see Chapter 1, Section 1.2.1 for more information). Simulators with higher levels of fidelity do not necessarily produce better results in terms of student performance. For example the study by Hoadley (2008) compared the experiences of two groups of nursing students who used either a low-fidelity mannequin or a high fidelity mannequin in order to learn resuscitation skills. Hoadley found that there was no significant difference between the two groups in terms of their performance on a subsequent resuscitation task or their levels of Satisfaction with the simulator and their perceived confidence in completing the task.

Although the actual levels of fidelity (realism) of the hapTEL simulator and the mannequin-head simulator is not necessarily indicative of their value as an educational device for teaching cavity preparation, the **perceived** levels of realism by the students may still be an important consideration. This research is concerned with the perceptions that students hold towards the two simulators and their subsequent Intention regarding whether they wish to use the simulator. It is possible that they may be inaccurate when judging the levels of realism of the simulator, particularly if they have limited experience with the real-life procedure. However, the same could be said of other variables. For example Perceived Usefulness is measuring how useful respondents **think** a particular device is, not how useful the device **actually** is.

Indeed, certain aspects of the hapTEL simulator were deliberately designed to be unrealistic due to the potential educational benefits they afforded, for example, being able to replay the procedure they had just carried out and the ability to know the precise amount of dental decay they had removed from the tooth. These features could be seen as adding to the unrealistic nature of the task, however the benefits to the students and to the tutors on the course could be argued to be more important than the effect they have on the 'realism' of the simulator.

In terms of reliability, the hapTEL simulator was found to be less reliable than the mannequin-head simulator. This result was likely to be expected as the hapTEL simulator was in a prototype phase during the course of the studies whereas the mannequin-head style simulators have been in existent and in use in dental schools since the 1980s (Jasinevicius, Landers et al. 2004). The reliability of the hapTEL simulator at this stage may have negatively influenced the students by impacting not only on Satisfaction and Intention directly but also through other variables that impacted on Satisfaction and Intention. For example, the issues with the reliability of the hapTEL simulator may have contributed to the students' negative levels of emotion whilst using the hapTEL simulator.

6.7 Is gender a moderator of student perceptions of the hapTEL simulator and the mannequin-head simulator?

Another aim of this research was to ascertain whether gender was a moderator of the dental students' Satisfaction and Intention with the simulators. It is possible that male and female students may view the two simulators differently. Additionally, the factors which shape the levels of Satisfaction and Intention may be different for male and female students.

An independent t-test was run in order compare the overall mean scores of the variables for male and female students for both the pre-usage and the post-usage questionnaire (See Chapter 4, Section 4.4). For the hapTEL simulator pre-usage questionnaire, female students had a significantly higher overall mean score for the variables Attitude (mean difference (md)= .848, .030*) Perceived Behavioural Control (md= .71328, .033*) and anticipated Satisfaction (md = 1.240, .002*). Male students had a significantly higher overall mean score for the variable Self-Efficacy Technology (md= .904, .030*). This indicates that initially, female students had a more positive overall perception of the hapTEL simulator and anticipated levels of Satisfaction but had a lower belief in their ability to use the hapTEL simulator than their male counterparts. This is consistent with previous research which has found that female students have lower levels of self-efficacy when using technological devices for example, Liu and Chang (2010).

As well as finding that female students had lower levels of self-efficacy, other research has also found that some variables differ in how they shape female and male students' Satisfaction with and Intention to use technology. Chorng-Shyong and Jung-Lu's (2006) investigation into the determinants of e-learning acceptance among male and female students found that female students were more influenced by their perceived levels of computer self-efficacy than their male counterparts. For female students, computer self-efficacy was more strongly correlated with Perceived Ease of Use and Perceived Usefulness (PEU, .72**, PU, .47** respectively) than for male students (PEU, .56**, PU .14). However, the difference in the relationship between Perceived Ease of Use and behavioural Intention for male and female students was non-significant. This may be because the variables of Perceived Ease of Use and self-efficacy do not act directly through behavioural Intention but instead act through perceived levels of Satisfaction (as was found with the hapTEL post-usage questionnaire). Therefore any difference in the strength of the relationship may only be seen through the link between Perceived Ease of Use and Satisfaction.

For the mannequin-head simulator pre-usage questionnaire there were no significant differences in the overall mean scores of the variables between male and female students. This may be because the mannequin-head simulator is viewed less as a ‘technology’ by the students, therefore reducing any differences in the self-efficacy variable between male and female students. However, unlike the hapTEL simulator there was also no significant difference in the anticipated Satisfaction variable, indicating that the initial perceived levels of anticipated Satisfaction were the same for both male and female students.

For the hapTEL simulator post-usage questionnaire, female students had a significantly higher overall mean score for the variable Perceived Behavioural Control (md = 1.998, .000) compared to male students. This means that female students had a greater sense of external control than the male students. The male students had a significantly higher overall mean score for the variables Self-Efficacy Task, Perceived Ease of Use and Self-Efficacy Technology. As with the pre-usage questionnaire, this indicates that male students have a greater level of confidence in their ability to use and complete the tasks on the hapTEL simulator as well believing that the hapTEL simulator is easier to use compared to the female students perceptions. This difference may have emerged at the post-usage stage because at the pre-usage stage the students were unable to accurately rate the ease of using the simulator and the ease of completing the tasks on the simulator.

For the mannequin-head simulator post-usage questionnaire, female students had a significantly higher overall mean score for the variables cognitive absorption focuses immersion (md= 1.199, .012) and Interest (md= .957, .044). This could be interpreted as female students having a greater intrinsic motivation for using the mannequin-head simulator than male students. Other studies have found that not only are intrinsic motivational variables higher for female students compared to male students but that these intrinsic variables are also more influential for female students. Nysveen, Pedersen and Thorbjornsen (1984) looked at the antecedents of using mobile chat services and found that females were more motivated by intrinsic motivational factors such as enjoyment as opposed to males who were motivated by extrinsic factors such as Perceived Usefulness. The study by Padilla-Melendez, Aguila-Obra and Garrido-Moreno (Padilla-Melendez, Aguila-Obra et al. 2013) into the effect of perceived playfulness on the Technology Acceptance Model found that the relationship between perceived playfulness and Attitude was significant for females but not for males. In a study on student Attitudes towards a blended learning setting (Padilla-Melendez, Aguila-Obra et al. 2012) using an enhanced technology acceptance model, perceived playfulness was found to directly influence Attitude toward the system in females whereas in males perceived playfulness acted through Perceived Usefulness (which in turn acted on Attitude toward the system).

In summary, although there were some significant differences in the overall mean scores for male and female students, gender does not appear to be a significant moderator of Satisfaction and Intention in this study. Female students did have significantly lower levels of self-efficacy regarding the hapTEL simulator and this is consistent with research that has found female students often have lower levels of self-efficacy with technological devices. However, as self-efficacy was found to act directly on Satisfaction rather than Intention for the hapTEL simulator this variable is unlikely to have a large effect on Intention and only contributes to a similar amount of the variation in Satisfaction as the other variables in the model (System Quality and Perceived Usefulness).

6.8 Is computer experience a moderator of student perceptions of the hapTEL simulator and the mannequin-head simulator?

A further goal of this research was to investigate whether previous computer experience acted as a moderator of students' Satisfaction with or Intention to use the hapTEL simulator or mannequin-head simulator. To do this a computer experience score was calculated for each student. This score was then correlated with all of the variables included on the pre and post-usage questionnaires. (See Chapter 4, Section 4.5).

It was hypothesised that there would be no direct relationship between computer experience and either Satisfaction with or Intention to use the hapTEL simulator. Instead it was hypothesized that previous computer experience would be significantly correlated with Self-Efficacy Technology for the hapTEL simulator It was also hypothesized that computer experience would not be significantly correlated with either Satisfaction with or Intention to use the mannequin-head simulator or any of the predictor variables for the mannequin-head simulator.

For the pre-usage questionnaire there were very weak, highly significant correlations between computer experience and Self-Efficacy Technology for both the hapTEL simulator (.13**) and the mannequin-head simulator (.18**). The weakness of the relationship may be due to the fact that Self-Efficacy Technology was difficult for the students to judge at the pre-usage stage. If this were the case then the correlation between computer experience and Self-Efficacy Technology would improve in the post-usage questionnaire. However, in the post-usage questionnaire there was no significant correlation between computer experience and Self-Efficacy Technology for either the hapTEL simulator or the mannequin-head simulator. Therefore the hypothesis that computer experience would be significantly correlated with Self-Efficacy Technology for the hapTEL simulator was not supported. However the hypothesis that computer experience would not be significantly correlated with Self-Efficacy Technology for the mannequin-head simulator was supported. The hypothesis that computer experience would not be significantly correlated with Satisfaction or Intention for both the hapTEL simulator and the mannequin-head simulator were both supported. Therefore it can be concluded that computer experience is not a moderator of Satisfaction and Intention in this study.

6.9 The Theory of Planned Behaviour, Technology Acceptance Model and additional variables

The Theory of Planned Behaviour was one model that was used in this study (see Chapter 2, Section 2.2 for a discussion of the Theory of Planned Behaviour) in order to measure dental students' perceptions of the two different dental simulators. In terms of the models for the hapTEL simulator and the mannequin-head simulator, the variables in the Theory of Planned Behaviour (attitude, subjective norms and perceived behavioural control), did not appear consistently in the structural equation models. The variable Subjective Norms was found to be significant in the model for the hapTEL simulator pre-usage and for the hapTEL simulator post-usage and the variable Perceived Behavioural

Control was found to be significant in the model for the hapTEL simulator post-usage questionnaire. No variables from the Theory of Planned Behaviour featured in the models for the mannequin-head simulator. This suggests that the Theory of Planned Behaviour in context was not a useful measure for the mannequin-head simulator. In terms of the hapTEL simulator, two variables from the Theory of Planned Behaviour were found within the models suggesting that it was useful for the hapTEL simulator. Subjective norms impacted directly on Anticipated Satisfaction in the pre-usage model and directly on Intention in the post-usage questionnaire. Perceived Behavioural Control impacted directly on Intention in the post-usage questionnaire. The fact that these variables are acting directly on Anticipated Satisfaction and Intention suggest that they are important variables in shaping student perceptions of a virtual-reality based simulator. However, the variable of Attitude was not found to be significant in any of the models for the hapTEL simulator. This may be because the hapTEL simulator was viewed as more of a 'technology' by the students, meaning that the variables from the Technology Acceptance Model were more important for determining levels of Satisfaction and Intention. Davis (1985) found when he created the Technology Acceptance Model that Attitude was not a significant predictor of intention to use a technology. This may have also been the case with the hapTEL simulator.

In terms of the Technology Acceptance Model, (see Chapter 2, Section 2.3 for a discussion of the Technology Acceptance Model) the variables (Perceived Usefulness and Perceived Ease of Use) were more consistently significant in the structural equation models than the variables from the Theory of Planned

Behaviour. Perceived Usefulness was found to be significant in all of the models for the hapTEL simulator and the mannequin-head simulator. The variable Perceived Ease of Use was found to be significant in the mannequin-head simulator pre-usage and post-usage model. However, Self-Efficacy Technology was found to be significant in the hapTEL simulator post-usage model. Self-Efficacy is a variable that is often added to the Technology Acceptance Model and has been found to have a direct impact itself on Perceived Ease of Use (Roca, Chiu et al. 2006). These results suggest that The Technology Acceptance Model was the most useful model in the context of this study, for both the hapTEL simulator and the mannequin-head simulator. This means that the model is useful for both haptic-based and traditional plastic-based simulators.

As well as the Theory of Planned Behaviour and the Technology Acceptance Model additional variables were also used in this research. These included Mastery Goals, Self-Efficacy Task, Self-Efficacy Technology, Task Value, Cognitive Absorption Temporal Displacement, Cognitive Absorption Focused Immersion, System Quality, Emotion, Interest and Cognitive Absorption Heightened Enjoyment. The variables Cognitive Absorption Focused Immersion, Cognitive Absorption Heightened Enjoyment and System Quality were featured in the hapTEL pre-usage model. The variables Emotion, Interest and System Quality were featured in the hapTEL post-usage model. The variables System Quality and Emotion were featured in the mannequin-head simulator pre-usage model and the variables Task Value, Cognitive Absorption Heightened Enjoyment and Cognitive Absorption Focused Immersion were found in the mannequin-head simulator post-usage model. Of these variables, System Quality appears to be the most significant as it appears in 3 out of the 4 models, suggesting that this is a variable that can be used with both haptic-based and traditional plastic-based simulators.

The variables Emotion, Cognitive Absorption Heightened Enjoyment and Cognitive Absorption Focused Immersion appeared in models for both the hapTEL and mannequin-head simulator, but at different time stages. This again suggests that these variables can be used with both haptic-based and traditional plastic-based simulators but more research could be done to see whether these variables can be used at both a pre-usage and post-usage stage for both types of simulators. The variables of Task Value and Interest only appeared in one model each (hapTEL post and mannequin-head post) suggesting that there is not enough evidence that these variables are important factors for determining student perceptions of both haptic-based and traditional plastic-based simulators. The variables Mastery Goals, Self-Efficacy Task and Cognitive Absorption Temporal Displacement did not feature in any of the models for the hapTEL simulator or the mannequin-head simulator. This suggests that these variables are not useful in the context of measuring student perceptions of haptic-based and traditional plastic-based simulators. Overall, although motivational variables appeared in all of the models, suggesting that they are a useful addition to Theory of Planned behaviour, there was no one variable that was found to be useful in all of the models at both the pre-usage and post-usage stage. Table 6.1 shows a summery of the variables that were found in the SEM models.

Table 6.1 Summary of the variables found in the SEM models

Variables	hapTEL Pre-usage Model	hapTEL Post-usage Model	Mannequin-head Pre-usage model	Mannequin-head Post-usage model
Theory of Planned Behaviour	Subjective Norms	Subjective Norms Perceived Behavioural Control	n/a	n/a
Technology Acceptance Model	Perceived Usefulness	Perceived Usefulness	Perceived Usefulness Perceived Ease of Use	Perceived Usefulness Perceived Ease of Use
Motivational Models	Cognitive Absorption Heightened Enjoyment Cognitive Absorption Focused Immersion System Quality	Self-Efficacy Technology Emotion Interest System Quality	Emotion System Quality	Task Value Cognitive Absorption Heightened Enjoyment Cognitive Absorption Focused Immersion

6.10 The use of Structural Equation Modeling in this research

Structural equation modeling (SEM) was used in this research in order to help develop and test a model for student acceptance of two different dental simulators. A model was produced for the hapTEL simulator and the mannequin-head simulator at the pre and post usage stage. The use of SEM is beneficial as it allows causal relationships between different variables to be tested (Byrne 2010). In the case of this research this enabled the relationship between variables and Satisfaction and Intention to be tested. By showing a causal relationship between these variables it is possible to see what variables are directly having an effect on a students' level of Satisfaction with and Intention to use a dental simulator. SEM is also helpful in cases where there are high levels of collinearity between variables in the models (Garson 2012). This occurred in the hapTEL pre-usage model where Cognitive Absorption Focused Immersion and Cognitive Absorption Heightened Enjoyment had a high level of collinearity (see Figure 4.1, Chapter 4). The use of SEM also allowed for post-hoc model specification, where variables that were not found to be significant in the model were removed and the resulting model was re-tested and compared to the original model. The resulting models were found to have acceptable model fit, suggesting that SEM is an appropriate method for further research in this area.

A limitation for the use of SEM in this research was the lack of a test group with which the final models could be 're-tested' in order to confirm the results. This is discussed in more detail in Chapter 7, Section 7.3.1.

6.11 Summary of key findings

- At the pre-usage stage the students were positive towards using both simulators.
- At the post-usage stage the students were positive towards using the mannequin-head simulator but had become negative towards using the hapTEL simulator.
- For the hapTEL simulator pre-usage questionnaire the variables System Quality, Subjective Norms, Cognitive Absorption Focused Immersion and Cognitive Absorption Heightened Enjoyment impacted directly on anticipated Satisfaction and Perceived Usefulness and anticipated Satisfaction impacted directly on initial Intention.

- For the mannequin-head simulator pre-usage questionnaire the variables Perceived Ease of Use, Perceived Usefulness and System Quality impacted directly on anticipated Satisfaction and emotion, System Quality and anticipated Satisfaction impacted directly on initial Intention.
- For the hapTEL simulator post-usage questionnaire the variables System Quality, Self-Efficacy Technology and Perceived Usefulness impacted directly on Satisfaction and emotion, Subjective Norms, Perceived Behavioural Control and Satisfaction impacted directly on Intention.
- For the mannequin-head simulator post-usage questionnaire the variables Perceived Usefulness, Perceived Ease of Use and Cognitive Absorption Heightened Enjoyment impacted directly on Satisfaction and Task Value, Cognitive Absorption Focused Immersion and Cognitive Absorption Heightened Enjoyment impacted directly on Intention.
- The qualitative data showed two additional variables that may affect the students' perceptions of the simulators: realism of the simulator and reliability of the simulator.
- All of the structural equation models showed an acceptable level of fit for the data.
- Gender and previous computer experience were not found to be moderators of either Satisfaction or Intention for both of the simulators.

7 Implications, Limitations, and Future Research

7.1 Introduction

This chapter discusses the implications and limitations of this research along with potential areas for future research. The main implications of this research are on areas concerning the use of dental simulators by dental students, the wider use of simulators by health-care students, the development of simulators for health-care students and the use of models for measuring student acceptance of technologies. The limitations of this research are mostly connected with methodological issues connected to this research whilst the areas of future research include the development of additional scales for measuring realism and reliability and the testing of additional student populations.

7.2 Implications of this research

This section will address the implications of this research in the context of the use of dental simulators by dental students, the wider context of using simulators with health-care students and the implications for attitudinal research.

7.2.1 Implications for the selection, introduction and development of dental simulators

The results from this research highlight the factors that influence students' perceptions of dental simulators and how these perceptions influence their desire to use a dental simulator. This information can be used by tutors and course organisers to ensure that they emphasise the variables that impact most on student Satisfaction and Intention when introducing simulators to students. For example, this research found that Subjective Norms was particularly important in shaping Intention to use the hapTEL simulator, therefore when using a virtual reality dental simulator, particularly if the students are not familiar with it, it is important for tutors to actively show a positive Attitude towards using the simulator.

This research has also highlighted some key some issues regarding the method of introducing simulators to students. It does appear possible that students can be introduced to a simulator and an Initial Intention to wish to use it formed without having to have first-hand experience using it. Substitutes such as video-demonstrations, oral demonstrations and written information can be used instead. This could prove useful if introducing all students to a particular simulator at one time is not logistically feasible. If students have free choice over whether to use the simulator, this introduction can be enough to spark Initial Intention to use the simulator. However, at this initial stage the students may be basing their Intention to use the simulator on factors such as Emotion and Cognitive Absorption as well as usability factors such as Perceived Usefulness. This can be seen in the structural equation models for the pre-usage questionnaire for both the hapTEL simulator and the mannequin-head simulator where Cognitive Absorption Heightened Enjoyment and Cognitive Absorption Focused Immersion appear in the hapTEL model and Emotion appears in the mannequin-head simulator model (see Chapter 4, Figures 4.1 and 4.2.). This means that introductory sessions could focus on stimulating these aspects within students as well. Factors such as Perceived Ease of Use and self-efficacy are less likely to play a part in shaping students' Initial Intention to use a device as they have little reference material with which to form an opinion.

The setting in which a simulator is placed was also found to be a potentially important consideration. Students may prefer to use a simulator in what they perceive as a suitable clinical environment for the simulator. For example, in the qualitative data collected one student remarked that 'the real clinical setting is more fruitful' (Table 5.3, Chapter 5.). This situation however may not always be possible due to issues such as space and resources. It may therefore be desirable to introduce some elements of the clinical environment into the simulator's setting even if it cannot be placed in a wholly clinical setting. For example, in this research the hapTEL simulator was located in a standard computer-lab. However, aspects of the traditional dental clinical lab were incorporated into the setting for example: relevant health and safety posters were placed in the lab, the students were required to wear appropriate personal protective equipment and clinical waste bins were provided.

The results from this research could also be of benefit when it comes to the actual development of simulators. By considering the factors that contribute to students' perceptions of simulators at the developmental stage, it is possible to develop simulators that are more likely to be positively viewed by students when they come to use them. The development of a simulator can often be a lengthy and costly process, so increasingly the likelihood the simulators being accepted by the target students is desirable.

7.2.2 Implications for the measurement of students' perceptions of simulators

The results from this research can also impact on the measurement of students' perceptions of simulators, both dental simulators and other health-based simulators. Firstly, the questionnaire that was developed in this research was found to have satisfactory levels of validity and reliability, and was developed from well-established models and scales. This questionnaire is therefore a useful starting point for other researchers investigating student perceptions of simulators.

The research also demonstrated the potential use of the Theory of Planned Behaviour and the Technology Acceptance Model for measuring students' perceptions of simulators. For the Technology Acceptance Model, the variable Perceived Usefulness was found to be significant in all of the structural equation models and Perceived Ease of Use was found to be significant in the structural equation models for the mannequin-head simulator (Self-Efficacy Technology, a variable closely related to Perceived Ease of Use, was found to be significant in the post-usage questionnaire for the hapTEL simulator). This suggests that the Technology Acceptance Model is a useful model for measuring student perceptions of simulators (see Chapter 6, Section 6.9 for a discussion of the variables).

For the Theory of Planned Behaviour, the variable Subjective Norms was found to be significant for the models for the hapTEL simulator and Perceived Behavioural Control was found to be significant for the model for the hapTEL simulator post-usage questionnaire. This suggests that the variable of Subjective Norms is useful for measuring student perceptions of simulators that are less familiar to students but that the rest of the variables from the Theory of Planned Behaviour (Attitude and Perceived Behavioural Control) are less useful in measuring student perceptions of simulators (see Chapter 6, Section 6.9 for a discussion of the variables).

Although the target population in this research was dental students using dental simulators it is possible for the instrument to be used with other student populations, for example, medical students and nursing students, with the respective simulators on their courses. It is possible that the variables that contribute towards a student's perception of a simulator will remain stable over these student populations, however the relationship between the variables may change.

Certain student populations may value different aspects of simulators more highly than others, for instance Perceived Usefulness may be more of a greater contribution toward Satisfaction for one student population whereas emotion may be a greater contributor for another student population. So far, there is little research in this area as the development of measures for student acceptance of simulators is still in its infancy (see Chapter 1, Section 1.3.3). However, with the development of the instrument in this research it would be possible to measure different student populations to see if the variables that contribute towards the perception of simulators remain stable over the different populations or if there is variation amongst the different student groups. This information would then help to inform the design and introduction of simulators for different health-based students.

7.3 Limitations of this research

This section will address the limitations of this research in terms of: the lack of a test group for the structural equation modeling, the order the students used the simulators, the use of paper-based and online questionnaires, the order of items on the questionnaire, the use of Likert scales and the non-random sampling method.

7.3.1 Lack of test group for the structural equation model

One limitation of this research was the lack of a test group for the structural equation modeling. Although a large number of structural equation modeling studies will construct and test their model using one sample population, it is recommended to re-test a structural equation model with a subsequent group of participants. This would have made the results from the structural equation modeling analysis in this study stronger. A potential solution would be to use the method adopted by some researchers where the sample for the study is divided into two groups. The first group is used to develop and test the model. The second group is then used to test the model derived from the first structural equation modeling analysis. However, in this study the sample size was not large enough to be able to divide it into two groups that would remain large enough for the structural equation modeling to be carried out.

7.3.2 Order effect for the use of the simulators

A further potential limitation in this study is the order effect. Order effect refers to the order in which individuals are exposed to a particular intervention; in this case the hapTEL simulator and the mannequin-head simulator. It is possible that the first simulator the students were exposed to became a 'reference point' for them from which they subsequently judged and evaluated the second simulator they were exposed to. This may have produced inflated positive or negative responses to the second simulator, depending on how they viewed the first simulator.

Some evidence for this can be found in the qualitative data collected in Study 2. Students often referred to both simulators or compared the two simulators when responding to the open-ended question for the hapTEL simulator and the mannequin-head simulator (See Chapter 5, Section 5.2.3). This effect has been seen in other studies. For example in the study conducted by Hoadley (2008) comparing high-fidelity and low-fidelity simulators for training nursing students, it was found that there was no significant difference in levels of Satisfaction with the learning experience between the two different groups. However, in the case of Hoadley's study the students were only ever exposed to either the high-fidelity simulator or the low-fidelity simulator during the course of the study and, as Hoadley states, the low-fidelity group "did not know what they were missing" p.165. Had the students not been exposed to both the hapTEL simulator and the mannequin-head simulator in this study, or had the order of exposure been different, then the results may have varied from what was found. For example, had the students only used the hapTEL simulator and not the mannequin-head simulator their perceptions of the hapTEL simulator may have been more positive. As in the case of Hoadley's (2008) study, the students would not have had a more sophisticated simulator to compare with the hapTEL simulator and therefore would not be judging the hapTEL simulator based on their knowledge of the mannequin-head simulator. This effect can be seen in the qualitative data collected from the two different studies. In Study 1, the students are generally more positive in their responses for the qualitative data, though there are negative comments present also. In Study 2 however the comments for the hapTEL simulator contain many more negative references to the hapTEL simulator. The students in Study 1 completed the qualitative data each week as they used the hapTEL simulator, without having direct experience of using the mannequin-head simulator. In Study 2 however the students completed the qualitative data after having used both simulators. This may have led to the students in Study 2 being able to make more comparisons between the simulators and therefore leading to more negative comments regarding the hapTEL simulator.

7.3.3 Use of paper and web-based questionnaire formats

For Study 2, a paper-based and a web-based version of the questionnaire was used for the pre-usage questionnaire. This was done due to the limited availability of computers in the room that the questionnaire was administered in (see Chapter 3, Section 3.7 for more information). Although some statistical testing was conducted to see if there was any significant difference between the mean responses of the students who used the online version of the questionnaire compared to the students who used the paper-based version, it was beyond the scope of this research to conduct any further statistical analysis on this factor. Further tests that could have been carried out include comparisons of reliability and Cochran's Q test to investigate the potential differences between the responses to the paper-based questionnaire and the web-based questionnaire.

7.3.4 The potential order effect of items on the questionnaire

This research did not consider the potential effect of the order that the items appeared on the questionnaire. For all the questionnaires in this research the items from each variable were grouped together. The reason for this was to reduce the cognitive load of participants by grouping similar items together. (See Chapter 3, Section 3.5.2 for an explanation). However this can have the effect of increasing automatic response to items, including mis-resposne to reverse worded items. By conducting a further study using a questionnaire with randomly sorted items it would be possible to see whether the order of the items had any effect on the student responses.

7.3.5 General issues regarding self-reported behaviour

A further limitation with this research was the use of self-reported behaviour in the form of Likert scales. Likert scales involve asking individuals to respond to items regarding their beliefs or behaviours. It is hoped that by doing this an accurate reflection can be made of what this individual thinks and/or does. If the individual responds to the Likert scale in a way that corresponds to how they think or act, then this will be the case. However, it cannot be guaranteed that this will occur. Individuals may unconsciously answer in a way that does not match their true feelings or behaviour or they may simply not tell the truth (Cohen, Manion et al. 2000). These concerns exist for all forms of self-reported behaviour however and are not limited to Likert scales.

With Likert scales there is also the issue of scale interpretation. This is mainly concerned with the idea of equal intervals between categories on the scale. Although Likert scales are linear some researchers argue that it cannot be assumed that the distance between response categories on a Likert scale represent identical cognitive distances. For example, it is not possible to infer that point twelve on a Likert scale indicates twice as much feeling as point six nor is it possible to assume that the strength of feeling between point two and point three is the same as the strength of feeling between point three and point four (Cummins and Gullone 2000).

This issue of equal intervals between categories has important consequences for the analysis of data derived from Likert scales. If it is assumed that the points on a Likert scale are equally distributed, then the data arising from the scale can be considered interval data. If however it is deemed that the points on a Likert scale are not equal, then the data it produces must be considered as ordinal data. Interval data is a type of continuous variable where an individual can have a score anywhere along the measurement scale being used. Ordinal data on the other type is a type of categorical variable where the data tells us the order in which it occurred. Whether data is interval or ordinal has implications for statistical analysis. There are two main categories of statistical tests, parametric and non-parametric. Only interval and ratio data can be analysed using parametric tests. For other data types, including ordinal data, non-parametric tests are generally considered to be the appropriate mode of analysis. The problem with this however is that non-parametric tests have considerably less predictive power compared to parametric tests (Field 2009).

Some authors have suggested that Likert scale data can be considered interval data but only when it is at the scale level (Carifio and Perla 2007). This means that individual items should not be considered to be providing interval data and should therefore not be analysed using parametric tests. However, when responses from more than one item are combined in order to produce an overall score for a particular scale (e.g. Attitude), then this can be thought of as interval data. Behavioural-predication models are usually broken down into a number of smaller sub-scales or variables (for example Attitude, Perceived Ease of Use etc). This data can then be treated as interval data. The analysis in this research did use parametric testing for the Likert scale data, however it only used data at the variable (scale) level.

7.3.6 Non-random sampling method

As discussed in the Chapter 3, this study used a nonequivalent control group design. This meant that naturally occurring groups were used for an experimental group and a non-experimental group. The naturally occurring groups in this study were the dental students applied dental skills group to which they were assigned at the beginning of the year. This means that the groups were not sorted pre-experimentally in any form. As dental students were the target population for this research the sample was valid for this study however the non-random sampling could pose a treat to the study's external validity.

7.4 Areas for future research

This section will consider potential areas for future research based on the results of this study and the limitations within this study. These include: the measurement of other student populations perceptions of simulators, development of a realism scale, development of a reliability scale, student perceptions of full scale simulation, the effect of student perceptions on learning, factors external to the simulators and improvement of the Mastery Goals variable.

7.4.1 Measuring the perceptions of other health-based, student populations with task-trainer simulators

This research measured the perceptions dental students had of two different task-trainer simulators. However, as discussed in Chapter 1, Section 1.3.3 dental students are only one type of health-based professionals. The opinions of other groups of health-based students towards simulators may be different to those of dental students. It would be possible for future research to measure the perceptions that other health-based students have with task-trainer simulators from their respective fields. The results of such research would show whether the factors that affect student perceptions of simulators holds steady across the different populations or if certain groups place a stronger emphasis on certain factors when evaluating a simulator. This research could also be extended to the tutors on health-based courses to see whether tutors use the same criteria to evaluate simulators as students.

By measuring the perceptions of other student populations and tutors with simulators it may be possible to develop a universal model of students' perceptions of simulators. Although the variables which contribute to different student groups' perceptions of simulators may vary, it is possible that a core set of variables will be present for each student group. This striped –down model would provide less explanatory power when used with a particular student group (See Chapter 2, Section 2.3 for an explanation) but it would provide a more generalisable measurement which could be used with many different student groups or where a simulator is used by more than one student group, e.g. nursing and medical students.

7.4.2 Development of a realism scale

A potential area for future research is the development of a realism scale. A common theme throughout the qualitative data collected in Study 1 and Study 2 was the perceived level of realism of the two simulators. For example some comments made were:

- The tooth was in a more realistic environment
- Presence of a cheek provided more realistic problems
- More realistic to a real life clinical situation

It is possible that the perceived levels of realism impacted directly on Satisfaction and Intention and may have influenced other variables such as Perceived Usefulness. A future area for research could therefore be the development of a realism scale. By having a scale for realism it would be possible to see the exact relationships between realism and the other variables included in the model. It would also allow for the breakdown of realism into its potential subcomponents. Although it is theoretically possible that realism could be measured via a direct measurement, for example,

- ***The realism of the (insert name) simulator is high***

It is also possible that a more explanatory scale of realism could be developed by investigating the different types of realism shown by the simulator. For example, in the case of this research the tactile sensation of drilling the teeth was aspect of realism mentioned by the students whilst others commented on the realism of the environmental surroundings with others commenting on the realism of the situation. A scale of realism could be developed that breaks down the variable of realism into sub-categories of realism. These sub-categories could then provide an overall indication of the realism of the simulator whilst also demonstrating which aspects of realism are 1) most important to students when it comes to evaluating a simulator and 2) how the different types of realism relate to other variables, for example, a category of realism that related to the tactile feel produced by the simulator may impact upon Perceived Usefulness whereas a category of realism related to the reality of the situation may impact upon the emotional experience of the student.

7.4.3 Development of a reliability scale

Another regular theme found in the qualitative data collected in Study 2 was the reliability of the hapTEL simulator and the mannequin-head simulator. The high volume of responses that referred to some aspect of reliability indicates that this variable could potentially have a high impact on Satisfaction and Intention.

The reliability of a simulator could be broken down into different sub-components. In the qualitative data, the most common sub-themes within the overall theme of reliability were;

- Overall, general reliability of the simulator
- ‘Crashing’ of the system
- Presence of ‘bugs’ or ‘glitches’
- Time spent having to trouble shoot

A scale for reliability of simulators could be developed using these sub-themes. For example;

1. The simulator is reliable
2. The simulator does not crash
3. The simulator is free from software bugs and glitches
4. I spend little time troubleshooting the simulator

Similar to realism, these sub-categories could then provide an overall indication of the reliability of the simulator whilst also demonstrating which aspects of reliability of impact most on students' perceptions of a simulator and how these aspects of reliability affect other variables.

7.4.4 Students' perceptions of full scale-simulation

As discussed in Chapter 1, Section 1.2.1 this research concentrated on student perceptions of two different types of task-trainer simulators. A task-trainer simulator is one in which students gain, develop and practice a particular skill or set of skills needed for a specific procedure. Full-scale simulation on the other hand involves replicating an entire scenario of a procedure or several procedures and often include team-based, complex scenarios. It is, however, theoretically possible to measure student perceptions of full-scale simulators, however the resulting levels of Satisfaction and Intention are more likely to be influenced by factors external to the 'simulator' itself than is the case for task-trainer simulators, though this may not necessarily be a negative consequence. As full-scale simulation purposefully includes additional elements such as simulated scenarios, teamwork, feedback etc, measuring students' perceptions of these elements would provide an accurate view of their experience with the simulation exercise as a whole.

7.4.5 Effect on student learning and perceived learning

Further research might seek to investigate any link between student perceptions of simulators and their subsequent learning and/or perceived learning using that simulator. Some studies have looked at measures of student learning with a simulator along with general measures of student Satisfaction. For example, Hoadley (2009) compared the effectiveness of low and high fidelity simulators on nurses learning cardiac life support, using the Student Satisfaction and Self-Confidence in Learning Scale (discussed in Chapter 1, Section 1.3.3) to measure students overall Satisfaction with the simulator experience and the students' self-confidence in resuscitating a patient after practicing with the simulator. The results showed that the majority of the students were both satisfied with the simulation experience and were confident in their learning (in both the low-fidelity simulator group and the high-fidelity simulator group). This could be seen as an indicator that high levels of Satisfaction with a simulator are associated with high levels of perceived learning when using that simulator. However in the case of the Hoadley study, more precise investigations of the relationship between student Satisfaction and perceived learning are not possible due to the lack of variation in Satisfaction and perceived learning scores.

Indeed, this has been found in other educational contexts for example, asynchronous online courses (Eom, Wen et al. 2006). However, perceived learning cannot always be counted on as an accurate measure of the actual learning of students. There is also no definite causal link between high levels of Satisfaction and student learning. It is possible that students who perceive that they have learnt a lot will feel more satisfied with the learning device than students who feel they have not learnt as much.

7.4.6 Factors external to the simulators

The aim of this research was to measure dental students perceptions of two different task-trainer dental simulators. It was decided that the measures used to investigate this should focus on the simulators themselves rather than any external factors such as for example instruction method or tutor interaction. See Chapter 1, Section 1.3.1 for more explanation. Although this method allows for detailed understanding of the students perceptions of the simulators themselves, it does mean that factors that are external to the simulators have not been considered. Future research could consider the role that external factors have on students' Satisfaction with and Intention to use a simulator. These factors could include (but are not limited to) the following factors.

- **The setting for the simulator**

The same simulator used in different environmental surroundings may produce different levels of Satisfaction in students. This potential effect can be seen in the qualitative data produced from study two, where (two) comments were made regarding the environment that the simulators were used in. A more 'clinical' environment may be favoured by students, as this has the potential to increase the level of realism or fidelity they experience whilst using the simulator. It may also contribute to the emotional experience felt by the students whilst using the simulator. The clinical setting will vary according to the type of simulator being used and can also very in terms of its fidelity. For example, some virtual-reality dental simulators have been installed in labs alongside traditional, mannequin-head simulators

This issue of the simulator setting has potential implications for the use of simulators in training health-allied students. It may not always be feasible for example to install simulators in full-scale, clinical settings. This could be due to constraints regarding space, resources, staffing, costs etc. If it is found that the setting in which simulators are located has little effect on the levels of Satisfaction students derive from them, then this is unlikely to be a problem. However, if it is found that the setting used for the simulator impacts the levels of Satisfaction, then this may necessitate adjustments being to the setting. This could include for example requiring students to wear appropriate personal protective equipment for the clinical task they will be carrying out (as was the case with students in this students in this research)

- **The tutors and instruction on the course**

Another factor that could influence students' perceptions of a simulator is the role played by the tutor and/or instructor (if a tutor or instructor is present). If students perceive that the tutor or instructor is not enthusiastic about the use of the simulator or appears to have difficulties using it or lacks confidence when teaching with it, then students may pick up on these feelings and subsequently develop negative feelings towards the simulator itself.

Additionally, it is possible that student perceptions of a simulator can also be affected by the instruction and feedback they have received whilst using the simulator. Although these perceptions by the students are not accurate reflections of the simulator itself, they could act as potential moderator effects. The learning activities the students engage in could be an important variable in determining their level of Satisfaction and Intention. Students may feel that a simulator is well designed for teaching a particular skill, but if the learning activities do not allow for sufficient development skill, or the activities are too easy or too difficult for students then they may judge that their instruction has not been satisfactory. Although this would really be an evaluation of the wider learning experience they have had with the simulator, it may be difficult for students to separate the wider learning experience from the simulator itself. Similarly, if the feedback received after they have used the simulator is thought to be inadequate, inaccurate or unhelpful by students then this may also negativity impact their thoughts regarding the simulator.

7.4.7 Improving the measure of the Mastery Goals variable

In this research the variable of Mastery Goals produced an overall mean score of 19.10 for the pre-usage questionnaire and 19.18 for the post-usage questionnaire, with a very high level of positive kurtosis and negative skew. This indicates that students were most often selecting the extreme positive end of the Likert scale (number 7) for all of their response to the Mastery Goals items. This response could be expected as students are likely to have high levels of Mastery Goals on a dental course. This does however mean that there is little to no variation in the responses to the Mastery Goals variable, making it difficult to examine how much of a role this variable may be playing in shaping student perceptions of simulators.

One way to increase differentiation within items that are likely to be ranked as positive by most individuals is to use a Likert scale that ranges across positive values only. For example, instead of using a scale that has disagree and agree as the end points, a positive only scale may have agree and strongly agree as end-points. This would enable the participant to indicate their level of positive agreement on a finer scale. For example:

1	2	3	4	5	6	7
Agree						Strongly Agree

This would allow respondents to indicate their level of positive agreement with a greater level of detail. The disadvantage with using this method in this study is the increased cognitive load it would generate for participants if more than one type of scale was used within the same questionnaire. Another alternative could be to use a different measure of Mastery Goals. Focusing on Mastery Goals that measure how much a student wants to master the material in a course may not in fact be the best way to gauge student. Instead, the focus could be placed on how much effort the student is willing to exert in order to master the material presented on the course.

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9 Appendices

9.1 Appendix 1A

Date: Your Name:

Undergraduate course name: Year:

Please enter the course year, and your name in the designated spaces above. Your name is needed for follow-up surveys and to ensure that all students who will be using the haptic devices have responded to this survey. However, all responses to this survey are **completely** confidential. All identifying information will be removed from this questionnaire and destroyed as soon as all data has been collected.

ICT for personal and dental education use: Opinion Survey

As you know, The Dental Institute, in collaboration with Reading and Birmingham City Universities is working on a large Dental Education project from 2007-2011 to produce and evaluate new technologies (Haptics) for teaching clinical skills. Haptics is the sense of touch and is explained in the PHANTOM leaflet. As part of this study we need to find out specific things about your experiences and Attitudes towards using ICT:e.g. what kind of ICT (computer) skills you have; how important ICT is for your personal and educational use and what your opinions are about using them for personal and university workin general and haptics specifically.

Please enter the course year, and your name in the designated spaces above.

Your name is needed for follow-up surveys and to ensure that all students who will be using the haptic devices have responded to this survey. However, all responses to this survey are **completely** confidential. All identifying information will be removed from this questionnaire and destroyed as soon as all data has been collected. Please be assured that the information you provide in this study will have **no effect on your grade but will help us in improving this questionnaire which will later be used in a revised form at the beginning and end of next academic year with Year 2 studentsour research.**

Thank you very much for your participation in this study.

Instructions

Many questions in this survey make use of rating scales with 7 places; please circle the number

that best describes your opinion. For example, if you were asked to rate "The Weather in London" on such a scale, the 7 places should be interpreted as follows:

The Weather in London is:

	____1___	_2__	3	_4_	__5_	_6_	7	
good	extremely	quite _	slightly___ _	neither __	slightly	quite ___	extremely ___	**bad**

If you think the weather in London is extremely good, then you would circle the *number 1*. If you think the weather in London is quite bad, then you would circle the *number 6* and so on.

In making your ratings, please remember the following points:

* Be sure to answer all items – do not omit any.

* Never circle more than one number on a single scale.

ICT (new technologies) in Education Survey

Please answer each of the following questions by circling the number that best describes your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues.

Please read each question carefully.

[Outcome Evaluations]

1. For me, to gain a better understanding of Dentistry is:

extremely important :__1__:__2__:__3__:__4__:__5__:__6__:__7__: extremely unimportant

2. For me to do well and get a high grade in this course is:

extremely important :__1__:__2__:__3__:__4__:__5__:__6__:__7__: extremely unimportant

3. For me to have an opportunity to use ICT to improve my learning is:

extremely important :__1__:__2__:__3__:__4__:__5__:__6__:__7__: extremely unimportant

4. For me to use ICT regularly is

extremely important :__1_:__2_:__3_:__4_:__5_:__6_:__7_: extremely unimportant

5. For me to be able to develop new ICT skills is

extremely important :__1_:__2_:__3_:__4_:__5_:__6_:__7_: extremely unimportant

6. For me to use haptic devices which simulate clinical skills on my course would be

extremely important :__1_:__2_:__3_:__4_:__5_:__6_:__7_: extremely unimportant

7. For me, being involved in new ICT uses in my course is:

extremely important :__1_:__2_:__3_:__4_:__5_:__6_:__7_: extremely unimportant

8. Becoming good at clinical skills is

extremely important :__1_:__2_:__3_:__4_:__5_:__6_:__7_: extremely unimportant

9. Being a competent user of new technologies in my life is

extremely important :__1_:__2_:__3_:__4_:__5_:__6_:__7_: extremely unimportant

10. Having access to the latest technologies in my studies is

extremely important :__1_:__2_:__3_:__4_:__5_:__6_:__7_: extremely unimportant

[Past Behavior: Self-Report]

11. During the past 4 weeks, what percentage of each day have you used ICT to support your studies?

During the past 4 weeks, I have used ICT about ___ % of each day on average.

12. During the past 4 weeks I have used the following ICT resources

ICT resource	Every day	Several time a week	Once a week	Once
Word processing				
Email				
Spreadsheets				
Databases				
Internet searches				
Blogs,chat-rooms				
WebCT				
PDAs				

[Direct Measures of Perceived Behavioral Control, Subjective Norm, Attitude, and Intention]

13. For me to get regular access to ICT

extremely difficult :___1__:___2__:___3__:___4__:___5__:___6__:___7__: extremely easy

14. Most people who are important to me think that

I should :___1__:___2__:___3__:___4__:___5__:___6__:___7__: I should not be using ICT for my Dental education studies

15. It is expected of me that I should use ICT to improve my learning

definitely true :___1__:___2__:___3__:___4__:___5__:___6__:___7__: definitely false

16. The people in my life whose opinions I value would approve of me using ICT on my

course

definitely true :___1__:___2__:___3__:___4__:___5__:___6__:___7__: definitely false

17. Most people who are important to me use ICT on a regular basis

definitely true :___1__:___2__:___3__:___4__:___5__:___6__:___7__: definitely false

18. Most of the students in my year with whom I am acquainted use ICT on a regular basis

definitely true :___1__:___2__:___3__:___4__:___5__:___6__:___7__: definitely false

19. For me to use ICT for my studies is

extremely valuable :___1__:___2__:___3__:___4__:___5__:___6__:___7__: extremely worthless

20. I am confident that if I wanted to I could use ICT more frequently on a regular basis

definitely true :___1__:___2__:___3__:___4__:___5__:___6__:___7__: definitely false

21. I will make an effort to use ICT on a regular basis

I definitely will :___1__:___2__:___3__:___4__:___5__:___6__:___7__: I definitely will not

22. For me to use ICT on a regular basis is

impossible :___1__:___2__:___3__:___4__:___5__:___6__:___7__: possible

too difficult :___1__:___2__:___3__:___4__:___5__:___6__:___7__: easy

Interesting :___1__:___2__:___3__:___4__:___5__:___6__:___7__: boring

[Motivation to Comply]

23. Generally speaking, how much do you care what the tutor of this course thinks you should do?

not at all :___1__:___2__:___3__:___4__:___5__:___6__:___7__: very much

24. Generally speaking, how much do you care what your parents think you should do?

not at all :___1__:___2__:___3__:___4__:___5__:___6__:___7__: very much

25. Generally speaking, how much do you care what your close friends think you should do?

not at all :___1__:___2__:___3__:___4__:___5__:___6__:___7__: very much

26. Generally speaking, how much do you care what your fellow students think you should do?

not at all :___1__:___2__:___3__:___4__:___5__:___6__:___7__: very much

[Behavioral Beliefs]

27. Using ICT in my courses on a regular basis will help me to gain a better understanding of

the subject matter.

extremely unlikely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: extremely likely

28. Trying to improve my ICT skills will help me improve my dental skills learning

extremely unlikely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: extremely likely

29. Using ICT in the dental undergraduate programme is beneficial to my studies

extremely unlikely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: extremely likely

30. Using ICT in the dental undergraduate programme makes my studies more pleasant

strongly disagree :___1__:___2__:___3__:___4__:___5__:___6__:___7__: strongly agree

31. Using ICT to help me learn is a very valuable use of my time

strongly disagree :___1__:___2__:___3__:___4__:___5__:___6__:___7__: strongly agree

32. Using ICT in the dental undergraduate programme will make my studies more effective

strongly disagree :___1__:___2__:___3__:___4__:___5__:___6__:___7__: strongly agree

33. Using haptic devices in the clinical laboratory will improve my clinical skills

extremely unlikely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: extremely likely

34. Using haptic devices in the clinical laboratory will make my learning more Interesting

extremely unlikely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: extremely likely

35. Using haptic devices in the clinical laboratory will make me learn faster

extremely unlikely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: extremely likely

[Control Beliefs]

36. How often do you encounter unanticipated events that place demands on your time?

very rarely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: very frequently

37. How often do you feel ill, tired or listless?

very rarely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: very frequently

38. How often do family obligations place unanticipated demands on your time?

very rarely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: very frequently

39. How often do specific aspects of your course place unanticipated demands on your time?

very rarely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: very frequently

40. How often do other courses place heavy demands on your time?

very rarely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: very frequently

41. How often do the computers you use go wrong

very rarely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: very frequently

42. How often is using ICT too difficult to bother

very rarely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: very frequently

[Power of Control Factors]

43. If I encountered unanticipated events that placed demands on my time, it would make it more difficult for me to use ICT regularly

strongly agree :___1__:___2__:___3__:___4__:___5__:___6__:___7__: strongly disagree

44. If I felt ill, tired, or listless, it would make it more difficult for me to use ICT for learning

strongly agree :___1__:___2__:___3__:___4__:___5__:___6__:___7__: strongly disagree

45. If I had to do more work to use ICT, it would be less likely for me to want to use it

strongly agree :___1__:___2__:___3__:___4__:___5__:___6__:___7__: strongly disagree

46. I would have to deal with other course demands first before developing my ICT skills

strongly agree :___1__:___2__:___3__:___4__:___5__:___6__:___7__: strongly disagree

47. If I am not very good at ICT I would be less likely to want to use it in the skills laboratory

strongly agree :___1__:___2__:___3__:___4__:___5__:___6__:___7__: strongly disagree

48. I don't have much time for using ICT for personal use

strongly agree :___1__:___2__:___3__:___4__:___5__:___6__:___7__: strongly disagree

49. I don't have much time for using ICT for my studies

strongly agree :___1__:___2__:___3__:___4__:___5__:___6__:___7__: strongly disagree

[Normative Beliefs]

50. The tutors of this course think that I should use the haptics devices in the laboratory

extremely likely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: extremely unlikely

51. My parents think that I should use ICT in my courses

extremely likely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: extremely unlikely

52. My close friends think that I should use ICT in my courses

extremely likely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: extremely unlikely

53. My fellow students think that I should use ICT in my courses

extremely likely :___1__:___2__:___3__:___4__:___5__:___6__:___7__: extremely unlikely

[Behavior: Observed]

Willingness and ease of use of the haptic devices in the laboratory

9.2 Appendix 1B

hapTEL ICT Opinion Survey

The Dental Institute, in collaboration with the University of Reading, is working on a large Dental Education project from 2007-2011 to examine the influences of two types of technologies (see figure 1 and 2, phantom-head mannequin and haptics,* respectively) for teaching clinical skills. As part of this study, we need to find out what kind of ICT (computer) skills you have and what your opinions are about using them for personal and university work. We also want to gather your opinion towards the use of the said two types of technologies.

Please enter the personal details required in the designated text fields below. Your name is needed for follow-up surveys and to ensure that all students who may sometime be using the haptic devices have responded to this survey. However, all responses to this survey are completely confidential. All identifying information will be removed from this questionnaire and destroyed as soon as all data have been collected.

Thank you very much for your participation in this study.

** We understand that you may not be familiar with and may not have used the two technologies given in this questionnaire. A phantom-head mannequin is a plastic dummy head with removable plastic teeth (see figure 1 below); whereas haptics system includes a computer input device that provides a virtual sense of touch or tactile feedback to the user. In completing this survey, we want you to imagine that you are familiar with these technologies.*

PERSONAL DETAILS

Date:

Your Name:

Undergraduate course name:

Year:

Male: Female:

Right handed: Left handed:

Please tick which of the following items you currently own:
Laptop:
Desk Top Computer:
PDA:
Touch Screen Mobile Device: *e.g. iPhone*
Stylus Assisted Mobile Device: *e.g.*
Computer Console: *e.g. Xbox*
Hand-held Computer Console : *e.g. Nintendo DS*
Digital Music Player: *e.g. iPod*

Please indicate how often you have used each of the following technological applications in the past **two months**

Word processing	Never	1234567	Every Day
Email	Never	1234567	Every Day
Spreadsheets	Never	1234567	Every Day
Databases	Never	1234567	Every Day
Web searches	Never	1234567	Every Day
Blogs/Chat rooms	Never	1234567	Every Day
Social Network Sites	Never	1234567	Every Day
Computing Programming	Never	1234567	Every Day
PDAs	Never	1234567	Every Day
Computer Gaming	Never	1234567	Every Day
Website design	Never	1234567	Every Day
Photo Editing	Never	1234567	Every Day
Music/Film Download	Never	1234567	Every Day

Please estimate how often you use the above technological applications overall:

Never 1 2 3 4 5 6 7 Every Day

Overall, how would you rate your current skills in using the above technological applications?
Very Low Skilled 1 2 3 4 5 6 7 Very Highly skilled

Generally, how confident do you feel using new technologies?
Not Confident 1 2 3 4 5 6 7 Very Confident

1. Using haptic devices will improve my ability to cut a tooth to the correct shape

Extremely Unlikely 1 2 3 4 5 6 7 Extremely Likely

2. Using haptic devices will improve my ability to cut a tooth to the correct depth

Extremely Unlikely 1 2 3 4 5 6 7 Extremely Likely

3. Using haptic devices will improve my ability to cut a tooth to the correct angle

Extremely Unlikely 1 2 3 4 5 6 7 Extremely Likely

4. Using haptic devices will improve my ability to recognise different densities of healthy and decayed teeth sections

Extremely Unlikely 1 2 3 4 5 6 7 Extremely Likely

5. Using haptic devices will improve my ability to determine the speed and loading a bur

Extremely Unlikely 1 2 3 4 5 6 7 Extremely Likely

6. Using haptic devices to practice pre-paring a cavity will take up more time than using a mannequin head

Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree

7. It will be hard for me to gain access to haptic devices in order to practice preparing a cavity

Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree

8. Haptic devices produce more realistic teeth than mannequin heads

Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree

9. Haptic devices are more difficult to use on my own than a mannequin head

Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree

10. Haptic devices are less reliable than mannequin heads to my practice preparing a cavity

Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree

11. Being able to cut a tooth to the correct shape is…

Extremely Unimportant 1 2 3 4 5 6 7 Extremely Important

12. Being able to cut a tooth to the correct depth is…
Extremely Unimportant 1 2 3 4 5 6 7 Extremely Important

13. Being able to cut a tooth to the correct angle is…
Extremely Unimportant 1 2 3 4 5 6 7 Extremely Important

14. Being able to recognise different densities of healthy and decayed teeth sections
Extremely Unimportant 1 2 3 4 5 6 7 Extremely Important

15. Being able to determine the speed and loading of a bur
Extremely Unimportant 1 2 3 4 5 6 7 Extremely Important

16. I want to use haptic devices to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

17. Other students on my course think using haptic devices will improve their skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

18. The tutors on my course think using haptic devices will improve skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

19. Qualified dentists would approve of me using haptic devices to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

20. Max-facial surgeons would approve of me using haptic devices to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

21. My future patients will expect me to have used haptic devices to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

22. I intend to use haptic devices to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

23. People whose opinions I value believe I should use haptic devices to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

24. Whether I use haptic devices to improve my skills in preparing a cavity is entirely up to me
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

25. Using haptic devices to improve my skills in preparing a cavity is…

Difficult	1	2	3	4	5	6	7	Easy
Boring	1	2	3	4	5	6	7	Interesting
Worthless	1	2	3	4	5	6	7	Useful
Impossible	1	2	3	4	5	6	7	Possible
Harmful	1	2	3	4	5	6	7	Beneficial

26. I feel under pressure to use haptic devices to improve my skills in preparing a cavity

Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

27. Doing what the tutors on my course think I should do to improve my skills in preparing a cavity is important to me
Not at all 1 2 3 4 5 6 7 Extremely

28. Doing what my future patients think I should do to improve my skills in preparing a cavity is important to me
Not at all 1 2 3 4 5 6 7 Extremely

29. Doing what qualified dentists think I should do to improve my skills in preparing a cavity is important to me
Not at all 1 2 3 4 5 6 7 Extremely

30. Doing what maxi-facial surgeons think I should do to improve my skills in preparing a cavity is important to me
Not at all 1 2 3 4 5 6 7 Extremely

31. Doing what other students on my course do to improve their skills in preparing a cavity is important to me
Not at all 1 2 3 4 5 6 7 Extremely

32. I expect that I will use haptic devices to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

33. For me to use haptic devices to improve my skills in preparing a cavity is….
Extremely Difficult 1 2 3 4 5 6 7 Extremely Easy

34. I am less likely to use haptic devices if I find them unreliable
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

35. If using haptic devices to practice pre-paring a cavity takes up more time than using a mannequin head, I will be less likely to want to use them
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

36. I am more likely to use haptic devices if they produce realistic teeth
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

37. If haptic devices are difficult to use by myself, I will be less likely to want to use them
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

38. If it is hard to gain access to haptic devices, I will be less likely to want to use them
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

39. It is expected of me that I use haptic devices to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

40. I am confident that I could use haptic devices to improve my skills in preparing a cavity if I wanted to
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

41. Using a mannequin head will improve my ability to cut a tooth to the correct shape
Extremely Unlikely 1 2 3 4 5 6 7 Extremely Likely

42. Using a mannequin head will improve my ability to cut a tooth to the correct depth
Extremely Unlikely 1 2 3 4 5 6 7 Extremely Likely

43. Using a mannequin head will improve my ability to cut a tooth to the correct angle
Extremely Unlikely 1 2 3 4 5 6 7 Extremely Likely

44. Using a mannequin head will improve my ability to recognise different densities of healthy and decayed teeth sections
Extremely Unlikely 1 2 3 4 5 6 7 Extremely Likely

45. Using a mannequin head will improve my ability to determine the speed and loading a bur
Extremely Unlikely 1 2 3 4 5 6 7 Extremely Likely

46. Using a mannequin head to practice pre-paring a cavity will take up more time than using haptic devices
Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree

47. It will be hard for me to gain access to a mannequin head in order to practice preparing a cavity
Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree

48. A mannequin head produce more realistic teeth than haptic devices
Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree

49. A mannequin head is more difficult to use on my own than haptic devices
Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree

50. A mannequin head is less reliable than haptic devices to my practice preparing a cavity
Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree

51. I want to use a mannequin head to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

52. Other students on my course think using a mannequin head will improve their skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

53. The tutors on my course think using a mannequin head will improve skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

54. Qualified dentists would approve of me using a mannequin head to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

55. Max-facial surgeons would approve of me using a mannequin head to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

56. My future patients will expect me to have used a mannequin head to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

57. I intend to use a mannequin head to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

58. People whose opinions I value believe I should use a mannequin head to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

59. Whether I use a mannequin head to improve my skills in preparing a cavity is entirely up to me
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

60. Using a mannequin head to improve my skills in preparing a cavity is…

Difficult	1	2	3	4	5	6	7	Easy
Boring	1	2	3	4	5	6	7	Interesting
Worthless	1	2	3	4	5	6	7	Useful
Impossible	1	2	3	4	5	6	7	Possible
Harmful	1	2	3	4	5	6	7	Beneficial

61. I feel under pressure to use a mannequin head to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

62. I expect that I will use a mannequin head to improve my skills in preparing a cavity

Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

63. For me to use a mannequin head to improve my skills in preparing a cavity is….
Extremely Difficult 1 2 3 4 5 6 7 Extremely Easy

64. I am less likely to use a mannequin head if I find them unreliable
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

65. If using a mannequin head to practice pre-paring a cavity takes up more time than using a haptic devices, I will be less likely to want to use them
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

66. I am more likely to use a mannequin head if they produce realistic teeth
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

67. If a mannequin head are difficult to use by myself, I will be less likely to want to use them
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

68. If it is hard to gain access to a mannequin head, I will be less likely to want to use them
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

69. It is expected of me that I use a mannequin head to improve my skills in preparing a cavity
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

70. I am confident that I could use a mannequin head to improve my skills in preparing a cavity if I wanted to
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree

9.3 Appendix 3A

Elicitation Interview for development of ICT Opinion Questionnaire

Please write your answers in the spaces provided. Thank you for your participation in this study.

1) What do you think are the advantages of using haptics to improve your ability to control a mirror and hand-piece around the mouth?

2) What do you think are the disadvantages of using haptics to improve your ability to control a mirror and hand-piece around the mouth?

3) What do you think are the advantages of using a mannequin head to improve your ability to control a mirror and hand-piece around the mouth?

4) What do you think are the disadvantages of using a mannequin head to improve your ability to control a mirror and hand-piece around the mouth?

5) What do you think are the advantages of using haptics to improve your ability to control a hand-piece in order to drill a cavity?

6) What do you think are the disadvantages of using haptics to improve your ability to control a hand-piece in order drill a cavity?

7) What do you think are the advantages of using a mannequin head to improve your ability to control a hand-piece in order to drill a cavity?

8) What do you think are the advantages of using a mannequin head to improve your ability to control a hand-piece in order to drill a cavity?

9) Can you imagine any groups of people who might consider haptic training beneficial to your studies?

10) Can you imagine any groups of people who might not consider haptic training beneficial to your studies?

11) Can you imagine any groups of people who might consider using a mannequin head beneficial to your studies?

12) Can you imagine any groups of people who might not consider using a mannequin head beneficial to your studies?

13) What would make it easier to use haptic devices in your dental studies?

14) What would make it more difficult to use haptic devices in your dental studies?

15) What would make it easier to use a mannequin head in your dental studies?

16) What would make it more difficult to use a mannequin head in your dental studies?

9.4 Appendix 3B

INFORMATION SHEET 1 FOR PARTICIPANTS (Strand 2)

THIS INFORMATION SHEET IS FOR YOU TO KEEP AND TELLS YOU ABOUT THE PHANTOM PROJECT WHICH YOU CAN CONTRIBUTE TO IF YOU WISH

PHANTOM stands for: Personalised learning with Haptics when Teaching with Online Media: (PHANTOM)

We would like to invite you to participate in this research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important for you to understand why the research is being done and what your participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information.

This study is exploring the use of computer simulations on the learning of manual and 3-D perception skills amongst students studying dentistry. In particular we are Interested in whether the use of haptics improves learning. Haptics is the computer-based simulation of touch which means that the feel of doing a practical task visualised on a computer is similar to actually doing that task in real life.

The research we are carrying out is in three parts. The first part is purely technical and involves building the computer simulations. The second and third parts explore how introducing these technologies has an effect on learning. It is one of these parts that we are asking you to think about taking part in (Strand 2).

Using the haptic devices

In order to help us to design high quality simulators, Strand 2 of the research looks at what happens in current teaching contexts and also between teachers and students when haptic technologies are introduced as part of teaching and learning. Does the introduction of computer simulations change the way students and teachers interact and modify the learning process? In order to study this we shall be providing these devices for all students who want to use them in sub-groups so that everyone will be able to use them sometime during the clinical laboratory course this year.

We shall demonstrate how these devices can be used and go through an example activity with all students before you need to decide whether to participate or not. Each student in the sub-group will have a device to use with a computer screen providing an image of the tooth you might be working on and feedback as to how accurately you are working. It is a bit like working on a real tooth or set of teeth but with feedback to your hand of pressure, rigidity etc which can be monitored on the screen. It is up to you to decide whether or not to take part in using these devices. If you do decide to take part you will be asked to sign a consent form agreeing to using them.

The haptics devices will be used by about 20 students at a time and the total time you will have to use them will be about 3-4 sessions over the entire year's clinical laboratory course. Your turn may be near the beginning of the course or not until much later on depending upon when you are randomly selected within your laboratory group. This is called a cross-over trial and is explained in more detail in Strand 3 information sheet.

Anonymity and confidentiality

All records of each student will be given a number which is then used from then on instead of your name to protect your anonymity. Observational and interview data which is stored will be stored anonymously by number only. Any audio and video materials will be disconnected with named participants and where required faces and voices can also be disguised.

We shall provide a register for you sign in addition to the consent forms at the first clinical laboratory session so you can let us know if you would like to take part.

If you would like any further information please contact one of the following:

Project Director: Professor Margaret Cox, mj.cox@kcl.ac.uk, Tel: 020-7848-3126/01483-566949

Assistant Director and Strand 2 leader: Professor Patricia Reynolds, p.a.reynolds@kcl.ac.uk, Tel: 020 7848 1517

Senior research officer: Dr. Jonathan San-Diego, J.P.San_Diego@kcl.ac.uk, Tel: 020 7848 7013

In the event of you suffering any adverse effects as a consequence of your participation in this study, you will be compensated through King's College London's 'No-fault Compensation Scheme'

INFORMATION SHEET 2 FOR PARTICIPANTS – Students (Strand 3)

REC Protocol Number CREC/06/07.

THIS INFORMATION SHEET IS FOR YOU TO KEEP AND TELLS YOU ABOUT STRAND 3 of THE PHANTOM PROJECT WHICH YOU CAN CONTRIBUTE TO IF YOU WISH

PHANTOM stands for: Personalised learning with Haptics when Teaching with Online Media: (PHANTOM)

We would like to invite you to participate in this research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important for you to understand why the research is being done and what your participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information.

This study is exploring the use of computer simulations on the learning of manual and 3-D perception skills amongst students studying dentistry. In particular we are Interested in whether the use of haptics improves learning. Haptics is the computer-based simulation of touch which means that the feel of doing a practical task visualised on a computer is similar to actually doing that task in real life.

The research we are carrying out is in three parts. The first part is purely technical and involves building the computer simulations. The second and third parts explore how introducing these technologies has an effect on learning. It is one of these parts that we are asking you to think about taking part in (Strand 3).

Using PHANTOM Tools

The phantom haptics tools are explained in Information sheet 2 (pilot and Strand 2)

Strand 3 - Teaching Arrangements

Strand 3 of the project measures how well students learn when haptic technologies are introduced as part of their teaching. In order to study this we are going to conduct a cross over trial. This means that you will be taught in two ways as explained in Strand 2: the traditional way in the clinical labs and the clinics, which you are probably familiar with, and these traditional teaching approaches supplemented by the use of the haptic devices which we have developed. Strand 2 explains what the haptics devices are and you will be given a demonstration before making a decision as explained in Information Sheet 1. You will be assigned to a group which either has the traditional approach first followed by the haptic approach, OR a group which has the haptic devices first followed by the more traditional approach. The use of the haptics will be as explained in Sheet 1, for about 3-4 sessions over the length of the clinical skills course spread over the academic year. Everyone who agrees to participate will experience both forms of teaching. If you wish to take part in this form of teaching you will be asked to sign a consent form If you do not wish to take part in using the haptics you can be taught by the traditional methods only.

Observations

For the research we need to carry out observations and also make video and audio recordings of the teaching sessions both in the clinical laboratories and in the clinics. This will help us to measure how haptics devices could be used in dental education. These observations and recordings will then be analysed by experienced researchers who are familiar with studying the way that students and teachers interact. We will only use the recordings for research and teaching purposes. All uses for commercial or other non-research and teaching purposes are prohibited. We may present segments of the tape with accompanying transcriptions in the context of scholarly publications, academic conferences, university classes, and professional training activities. We will try to anonymise the data as much as possible and your name will not be used outside the clinic

If you do decide that you are happy to be observed using video and audio recordings either in the clinical labs. and/or in the clinics you will be asked to sign a second section on the consent form. If you decide to take part either just using the haptics and/or being observed you are still free to withdraw from being observed at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect the standard of teaching you receive. You will simply use the other methods currently used in the teaching of clinical skills.

You may ask for the recording to stop at any time and also withdraw your data from the project at any time.

We also hope to interview some students to find out more details of your experience, especially concerning your experience of learning to use dental instruments. These interviews would take about 45 minutes to an hour and are optional as well. It would be helpful to audio record the interviews to be as accurate as possible. The consent form will also include asking you if you would be willing to be interviewed and if you are happy for the interview to be recorded at a time convenient to yourself. Recordings of interviews will be kept in a secure location and will only be accessible to members of the project team

Strand 3 - Measuring the impact on learning

In order to assess the impact on your learning we will ask you to complete various questionnaire measures, including measures of your ability to think in three dimensions, measures of your Attitude towards technology enhanced learning, measures of the quality of your clinical work on models of teeth and your views about learning. We will ask you to complete these measures at the start of the study and at the end. Some of these will be part of your usual assessment by tutor observations. In addition, the other measures and the time taken to complete them will be as follows:

(i) A 3-dimensional paper based test: 35-40 minutes

(ii) Attitude paper-based or on-line test. This is a questionnaire consisting of boxes to select for about 50 questions and takes about 35-40 minutes to complete

(iii) Computer-based monitoring of your haptics work. This will occur while you are using them.

The paper based 3-D test will take place during one of the lab sessions.

You will be asked to return your questionnaires at the following session after having received them (about a week later)

(iv) If you consent to take part in this strand you will be invited to participate in interviews with the researchers towards the end of the project teaching sessions to provide more in-depth information about your own clinical skills experiences.

(v) We shall also be organising a series of focus group discussions (about 1-2 per year) to which you are invited to provide your own personal views about the research and the experiences you have had. More details will be circulated at the end of the first year. We hope you will wish to attend these but there is no obligation.

Anonymity and confidentiality

Information collected through the questionnaires and tests returned of each student will be given a number (code) which is then used from then on instead of your name to protect your anonymity. Focus group and interview data will be stored anonymously by number only.

We shall provide a register for you sign in addition to the consent forms at the first clinical laboratory session so you can let us know I you would like to take part.

If you would like any further information please contact one of the following:

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect the standard of teaching you receive.

If you decide not to take part in using the haptics, as explained in Information sheet 1, you will attend the teaching sessions as usual and follow the traditional methods of learning.

If you decide to use the haptics but do not want to be involved in the additional measurements on learning then you will not be given any questionnaires or Attitude tests to complete.

You may withdraw your data from the project at any time up until it is transcribed for use in the final report.

If you would like any further information please contact one of the following:

Project Director: Professor Margaret Cox, mj.cox@kcl.ac.uk, Tel: 020-7848-3126/01483-566949

Assistant Director and Strand leader: Professor Patricia Reynolds, p.a.reynolds@kcl.ac.uk, Tel: 20 7848 1517

Project quantitative research leader: Professor Tim Newton, tim.newton@kcl.ac.uk, Tel: 020 3299 3481

Qualitative research co-ordinator: Dr. Jon Hindmarsh, Jon.Hindmarsh@kcl.ac.uk, Tel: 020 7848 4194

Senior research officer: Dr. Jonathan San-Diego, J.P.San_Diego@kcl.ac.uk, Tel: 020 7848 7013

In the event of you suffering any adverse effects as a consequence of your participation in this study, you will be compensated through King's College London's 'No-fault Compensation Scheme'

9.5 Appendix 3C

CONSENT FORM FOR STUDENT PARTICIPANTS
IN HAPTEL RESEARCH STUDIES

Please complete this form after you have read the Information Sheets 1 and 2 and seen a demonstration and explanation about the research. Please return the signed form to the staff.

King's College Research Ethics Committee Ref:CREC/06/07-22

- *Thank you for considering to take part in this research. The person organising the research must explain the project to you before you agree to take part.*
- *If you have any questions arising from the Information Sheet or an explanation already given to you, please ask the researcher before you decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.*
- *I understand that if I decide at any other time during the research that I no longer wish to participate in this project, I can notify the researchers involved and be withdrawn from it immediately.*
- *I consent to the processing of my personal information for the purposes of this research study. I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.*

Participant's Statement:

I ____ Student Number: ___________________

agree that the research project named above has been explained to me to my Satisfaction and I agree to take part in the following aspects of the study:

Please delete any you do **NOT** wish to take part in.

(a) **Using the haptic devices**

(b) **Being recorded by audio and/or video (Strand 2)**

(c) **Completing the learning measures and interviews (Strand 3)**

I have read both the notes written above and the Information Sheets about the project, and understand what the research study involves.

Signed ______________________________________ **Date** ___________________

Investigator's Statement:

I ____

confirm that I have carefully explained the nature, demands and any foreseeable risks (where applicable) of the proposed research to the volunteer.

Signed ______________________________________ **Date** ____________________

9.6 Appendix 5A

	Response	MG	ATT	PU	TV	SN	PBC	SETA	PEU	SETE	CATD	CAFI	SQ	INT	CAHE	EMO	SAT	INTENT
1	I found the hand-eye co ordination difficult and strange at first but it became easier the longer I practiced																	
2	Very enjoyable, and extremely Interesting																	
3	It was difficult getting used to and the system in general needs tweaking however good introduction to using instruments and the feeling of the layers of the tooth.																	
4	It was very Interesting and definitely something that I feel I will be able to improve on during the course. My technique improved during the first session and by the end of it I felt more confident and comfortable holding the instruments and drilling the teeth																	
5	I found it very useful and enjoyable but quite difficult to get used to, I am excited about using it again.																	
6	This was very appropriate and extremely useful for learning, and required a lot of manual dexterity. I would use this again if the handling was smoother.																	