Ensuring the quality of pedagogy through games in Dental Technology at a selected University of Technology.

Submitted in fulfilment of requirements of the degree of Doctor of Technology: Operations and Quality Management in the Faculty of Management Sciences at the Durban University of Technology.

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Abstract

The need for alternative teaching practices in the face of poor retention and student throughput rates has changed the context of higher education in South Africa. This study interrogates one alternative teaching practice: the use of a board game and a multimedia game. Arguments for the potential benefits of games in higher education have generated a growing body of literature, but the general focus of these studies has been empirical with little theorisation about the associated pedagogy. Using a mixed methods sequential explanatory research design, this thesis aimed to determine the quality of pedagogy through games in providing epistemological access to the subjects Tooth Morphology and Oral Anatomy in a Dental Technology Diploma at a selected University of Technology. The thesis also developed a framework for the design of games to enable quality teaching and learning of vocational subjects.

Preliminary and pilot studies were conducted. The preliminary study was conducted over a five-year period from 2003 to 2006. The total sample size for the Tooth Morphology board game was n=128 and for Oral Anatomy multimedia game was n=30. Academic experts validated the study by reviewing the contents of the game. The findings suggested that games assisted students to actively learn.

The pilot study was conducted in 2007 and 2008. The total sample size for the Tooth Morphology board game was n=62 and for the Oral Anatomy multimedia game was n=22. Dental technology experts validated the contents of the game. Cronbach's alpha index was used to assess the reliability of the study and was α=0.45 and α=0.757 for the Tooth Morphology board game and the Oral Anatomy multimedia game, respectively. The low alpha score obtained for the Tooth Morphology board game prompted improvements to be made to the survey for the main study.

The main study was conducted in 2009, 2010 and 2011. The total population size for the Tooth Morphology board game was n=83 and for the Oral Anatomy multimedia game was n=82. Surveys and pre- and post-tests were analysed using descriptive statistics, t-tests, factor analysis and cross tabulations. Content validity ensured that the survey focused on concepts and constructs that emerged from the review of

literature on games. Cronbach's alpha index was used to assess the reliability of the surveys and was α=0.794 and α=0.868 for the Tooth Morphology board game and Oral Anatomy multimedia game, respectively. Qualitative analyses entailed focus groups with students who used the games. The data generated was analysed using the conceptual frameworks of Bernstein's knowledge codes and Maton's Legitimation Code Theory of Specialisation. Trustworthiness of the data was achieved using methodological triangulation, data triangulation and peer debriefing.

Quantitative results revealed that an integrated game design with an appropriate mix of instructional content and applicable game features and mechanisms facilitates the provision of epistemological access to Tooth Morphology and Oral Anatomy. By placing a sociological lens on knowledge in the games, a major finding in the qualitative analyses was that epistemological access using games provided access to particular knowledge-knower structures of the target subjects or disciplines. An LCT (Specialisation) analysis revealed that the games in this study represented a knowledge code as specialist knowledge and skills were valued over the possession of personal attributes and dispositions. This knowledge code was in turn aligned to the knowledge code of the target programme.

In synthesising the results there were three recurring issues that emerged from the data as being key, namely: (1) access to knowledge; (2) instructional design of the games; and (3) technical design of the games. The thesis concluded by proposing the KITE framework, a guideline for lecturers to consider when designing games for higher education.

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Declaration

I, Anisa Vahed, hereby declare that this thesis is wholly my own work, and that all the references to the best of my knowledge, are accurately reported. This work has not been submitted for a degree at any other university, and that its only prior publication was in the form of conference paper as listed below.

> Vahed, A. 2008. The Tooth Morphology Board Game: An innovative strategy in tutoring Dental Technology learners in combating Rote Learning. Paper presented at the *2nd European Conference on Games Based Learning (ECGBL).* Hotel Silken Diagonal, University of Catalunya, Barcelona, Spain, 16 & 17 October.

_____ _____

Signature Date

This study is dedicated to the greatest power,
Through which all things are made possible, my creator,
ALLAH 'TAALA *(اللّٰہ/ GOD)*

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Gratitude is not the greatest virtue, but the parent of all the others.
Cicero (106-43 B.C.)

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Abbreviations and Terminology

Within this thesis various higher education and dental technology abbreviations and social sciences terminologies as outlined below are used.

Abbreviation

CHE	Council of Higher Education
DENTASA	Dental Technology Association of South Africa
DoE	Department of Education
DUT	Durban University of Technology
ECP	Extended Curriculum Programme
HELTASA	Higher Education Teaching and Learning Association of Southern Africa
UoTs	University of Technology/Universities of Technology
SADTC	South African Dental Technology Council
SASSE	South African Survey of Student Engagement
SPSS	Statistical Package for Social Sciences

Terminology

1. Epistemology is a branch of philosophy that deals with "what counts as knowledge, with 'knowledge' defined as…. the justification around the questions of what is true, what can we know, and how we can know whether we in fact know it?" (Collins and O'Brien 2003: 126).

2. Ontology is "the study of being, an attempt to accurately and systematically explain what there is and what there is not" (Collins and O'Brien 2003: 250)

3. Pedagogy is the art and profession of teaching in terms of how a teacher teaches, the methodology one uses as a teacher, the style of teaching a teacher chooses (Collins and O'Brien 2003: 260). According to The New London Group (2000: 9), pedagogy is a teaching and learning relationship that creates the potential for building and learning conditions leading to full and equitable social participation.

4. Graduation rate is the number of graduates as a percentage of head count enrolments in a given year (Council on Higher Education 2013: 39).

5. Completion rate is the percentage of a given student intake, or cohort, that graduates (a longitudinal measure) (Council on Higher Education 2013: 5).

Table of Contents

List of Figures

List of Tables

List of Graphs

Chapter One – Introduction

1.1 Background and Context of the study

The Dental Technology diploma programme trains students to become dental technicians who fabricate removable intra-oral dental appliances in a dental laboratory (Figure 1-1). Dental technicians are skilled professionals who possess the precision, patience and dexterity to produce and repair dental appliances such as dentures, inlays, bridges, crowns, and orthodontic braces, according to dentists' written instructions (Christensen 2009: 475). Furthermore, the open and accurate communication of prescriptions between dentists and dental technicians is critical to the intra-oral success of the dental appliance (Juszczyk, Clark and Radford 2009; Evans, Henderson and Johnson 2010). Generally, such communication may include drawing the morphological features of teeth or other areas that are related to the design of the dental case (Christensen 2009). This implies that a distinctive characteristic of Dental Technology is that it has both theoretical and practical knowledge. It is the presence of two types of knowledge that appears to affect the throughput rate of students.

Figure 1-1: Various dental appliances

Internationally, an accepted indicator of efficiency is the throughput rate of students, which measures the proportion of enrolments to graduation in a given year (Department of Education 1996). While the throughput rate is not a representative indicator of quality in higher education, poor throughputs have implications regarding the credibility of qualifications offered in higher education institutions. Generally, low throughput rates indicate high student dropout and/or failure rates. In some instances, only 30% of students graduated with a three-year qualification, and this included those

who took up to five years to complete the qualification (Scott, Yeld and Hendry 2007: 12-14). Low throughput rates in the National Diploma: Dental Technology at the Durban University of Technology (DUT) were attributed to a decline particularly in the subjects Tooth Morphology and Oral Anatomy as reported by the head of department, Bass in an e-mail on 28 November 2002. He further reported that from a Faculty of Health perspective, the deterioration in student results has become an area of concern for the sustainability of the Dental Sciences Department at DUT. Equally important, concerns were raised by members of the Health Sciences executive committee as to whether the teaching and assessment practices used were effectively facilitating student learning. This prompted the department to investigate the quality, content, delivery and assessment of the aforementioned subjects. During lectures and through informal classroom feedback, students articulated their difficulties with the subjects Tooth Morphology and Oral Anatomy. These concerns were especially acute for those who do not enter the Dental Technology programme via the mainstream entrance requirements, but were part of the Extended Curriculum Programme[1] (ECP).

Essentially these subjects, Tooth Morphology and Oral Anatomy, provide the underpinning conceptual knowledge needed to produce and repair various dental appliances such as crowns, bridges, dentures and orthodontic braces (Figure 1-1). Students expressed that they had difficulties in understanding and remembering morphological and anatomical terminology, and its related concepts. Drawing exercises are typically used in practical sessions as a means of preparing students to carve morphologically correct teeth. Assessments of students during these sessions showed that they were unable to recall the requisite knowledge of the morphology of a tooth as was discussed in lectures, and that they were unable to apply it to their drawing exercises and practical carving exercises. Consequently, it was assumed that students were unable to make connections between their theoretical classes and their practical sessions.

Through probing the student learning, teaching and assessment practices in lectures and in workshops for the Tooth Morphology and Oral Anatomy subjects, alternate

[1] There are two entry routes into the Dental Technology programme, namely through the mainstream programme and through the extended curriculum programme (ECP). The minimum time for completion of the National Diploma qualification is three years for mainstream students and four years for ECP, as their first year of study extends over two years.

teaching practices in the form of games were developed and introduced into the classroom. It was perceived that games would provide a means of delivery that was different from conventional methods, and would help students to make the morphological and anatomical abstractions more tangible to enable them to acquire the concepts of the subject matter. The morphological information from the Tooth Morphology subject was developed as a board game, while the anatomical content from the Oral Anatomy subject was developed as a digital multimedia game.

Pedagogically, this classroom-based practice was different from conventional ways of teaching and learning in Dental Technology. According to Oblinger (2004), da Rosa *et al*. (2006) and Wideman *et al.* (2007), games could potentially activate students in their learning, as well as encourage them to link their theoretical knowledge to practice. Such a pedagogical approach (discussed in more detail in Chapter 2) is viewed by Trigwell *et al.* (2005) and Lindblom-Ylanne *et al.* (2006) as being characteristic of a student-centered conception of teaching. Student centeredness is a goal for the teaching and learning practices of DUT.

1.2 The Problem Statement

Tooth Morphology and Oral Anatomy are pre-requisite subjects for progression to higher levels of study. Inevitably, low pass rates in these pre-requisite subjects adversely impact on the student throughput and graduation rates within the Dental Technology programme, and the Faculty overall. In an effort to improve student pass rates alternate classroom-based practices, in this case games, were developed. Arguments for the importance of focusing on games as a vehicle for change in education have generated an increasing volume of research (Ogershok and Cottrell 2004; Bogost *et al.* 2005; Zagal, Rick and Hsi 2006; Beylefeld and Struwig 2007). The general focus of these studies, which are discussed in Chapter Two, is based largely on empirically documented work with little theoretical interrogation on the quality of pedagogy through games. This study will move beyond the descriptive to provide a theorised account of the pedagogical use of games within the specific context of the Dental Technology diploma.

1.3 Aim of the Study and Research Objectives

The aim of the research is to develop a framework to ensure the quality of pedagogy through games in order to provide epistemological access to Tooth Morphology and Oral Anatomy.

Research Objectives:

1. To investigate the quality of teaching and learning in the subjects Tooth Morphology and Oral Anatomy using the board game and the digital multimedia game, through questionnaire surveys and interviews.
2. To evaluate the efficacy of the board game and the digital multimedia game by pre- and post-tests in assessing epistemological access in the subjects Tooth Morphology and Oral Anatomy in the Dental Technology programme.
3. To develop a framework to support the design of games for quality teaching and learning of vocational subjects.

1.4 Rationale of the Study

In his keynote address on curriculum transformation, the South African Minister of Higher Education and Training asserted that efforts need to be made to change '…the very content of the vehicle through which we teach and develop our young people' (Nzimande 2011: 2). Similarly, Scott, Yeld and Hendry (2007) recommended that a key investment for higher education is to provide conceptual and analytical tools that will enhance the quality of teaching and learning of non-traditional practices.

There is paucity in the literature on how learning occurs through games. Most of this classroom-based research relies on evaluations of interventions that generally focus upon the representational dimension of the game (Ballon and Silver 2004; da Rosa *et al.* 2006), or upon the practice of using games for motivation by integrating elements of play and factual knowledge (Eckert *et al.* 2004; O'Leary *et al.* 2005; Gareau and Guo 2009). In considering the advice given by Bogost *et al.* (2005: 60) that "…you must make games to study them, and you must study games to make them.", implies that the results of this study, specifically in view of the plea made by Nzimande (2011), will contribute to the urgent need for better pass rates in Tooth Morphology and Oral Anatomy.

1.5 Proposed theories on teaching and learning through games

Scholars of teaching with games (for example Gee 2003; de Freitas 2006; Buckingham and Burn 2007; Gee 2008b) suggest various concepts that need to be considered for effective teaching and learning to occur through games. Some of these concepts include game literacy, epistemological access and the knowledge structure of vocational programmes. Brief outlines of these concepts follow below. A detailed discussion of the concepts will ensue in Chapter two and their contributions to the development of the framework in this study will be duly considered.

1.5.1 Game Literacy

Research on video games used by Gee (2003; 2007) and Squire (2006; 2008), as well as games in general, posited that teaching and learning through games is an acceptable literacy practice. This study will consider two forms of games as a new literacy genre, namely a digital multimedia game and board game. Underlying Gee (2003; 2007) and Squire's (2006; 2008) work is a concept that literacy has shifted as games are developed on the assumptions unlike those of traditional print cultures. For example, Squire (2008: 658) points out that text within a game is interactive as its meaning emerges in response to an action. This suggests that literacy as a technology, does not exist free of human contexts but through their involvement with social networks.

According to Street (1995: 29) literacy is a social practice and is characterised as the 'ideological' as it offers a social and culturally conscious view of becoming literate. His work illustrates how literacy and learning are embedded in social contexts that steer a form of social action that has social purposes and consequences. This view contradicts the everyday understanding of being cognitively skilled, or that literacy can be taught and studied independently of its social context. It can be gleaned that games are representations of the written medium that can be used as a means for university lecturers to develop students' social relations in the classroom. This point has been mooted by Buckingham and Burn (2007).

Buckingham and Burn (2007: 328) state that in understanding game literacy, the social background of player/s in conjunction with the formal attributes of the game should be

considered. This understanding is consistent with literacy being underpinned by social accounts as expressed in the New Literacy Studies (NLS) (Lea and Street 1998; Brandt and Clinton 2002; Street 2003). The NLS posits a rethinking of what university lecturers might do with new literacy genres like games, to engage students from diverse backgrounds and understandings of the world. Similarly, Wilson *et al.* (2009) report that high levels of reading, communicative and psychomotor skills are needed to understand and play educational games. Inevitably, this could help to draw attention to aspects of games that need to be addressed more carefully. It can be postulated that if games enable students to acquire the skills mentioned above, then understanding the educational value of games could help them to gain access to subject-specific discipline knowledge. This access to subject-specific discipline knowledge is regarded by Morrow (1993) as epistemological access.

1.5.2 Epistemological Access

Epistemology is derived from the word 'episteme', a branch of philosophy that deals with the theory of knowledge (Collins and O'Brien 2003: 126). Recent research studies clearly show that epistemological access is concerned with how students get access to acquire the knowledge offered within the university (Bozalek, Garraway and McKenna 2011; Winberg *et al.* 2013). Epistemological access was coined by Morrow (1993) and has a particular relevance in South Africa in terms of the high student drop-out rates. Although there is increased physical access, Morrow and others argue that teaching needs to contribute to students' learning by showing them to how become successful participants in their relevant academic practice (see, for example, Clerehan 2003; Boughey 2005; Scott, Yeld and Hendry 2007). Regardless of the efforts made by various scholars, insufficient attention has been given to epistemological access in higher education. Ensuring greater equity in getting students into the university needs to be met with greater equity in granting students access to the knowledge within the university. In particular, universities like DUT that offer vocationally orientated training needs to provide students with epistemological access to both disciplinary and situated knowledge, in ways that support the provision of professional knowledge (Winberg *et al.* 2013). The games in this study are considered to be a pedagogical approach that can enhance epistemological access.

While advocates of educational games (Henderson 2005; Gee 2008b; Squire and Giovanetto 2008; Rupp *et al.* 2010) acknowledge the growing debate on the pedagogical potential of games in providing access to scholarly content, some have also raised concerns on the usefulness of teaching and learning through games (Shaffer 2005; Shaffer and Gee 2005; de Freitas and Oliver 2006). For example, in the Madison 2200 digital game Shaffer (2005) mentioned how teaching and learning through this game made his students develop ways of reading, thinking and understanding the subject matter that are distinctive of their discipline. This game enabled his students to have enriching experiences as urban planners. Hence it can be gleaned that by creating experiences that mimic the professional practice, games can situate players in their professional roles. From the findings of Shaffer (2005), games are perceived to induct students into the professional practice. Understanding the way knowledge or curricula is structured, in this case Dental Technology, could offer a comprehensive and systematic understanding of pedagogy through games.

1.5.3 Knowledge Structure

There are opinions that games can support the teaching and learning of vocationally orientated programmes. Advocates of games such as de Freitas (2006) and de Freitas and Oliver (2006) suggest that there should be an association between the subject material and the understanding of the person designing the game, as success of the game depends upon the designer's knowledge of the curriculum. This is consistent with the findings of Sandford *et al.* (2006), who reported that the teacher's knowledge of the curriculum/subject area is central to achieving effective learning objectives through games. The underlying assumption is that the teacher's knowledge, together with the value and relevance of what is taught, is significantly important to enable students to advance through their subjects from introductory to higher levels. This suggests that understanding the way knowledge is structured could be central to evaluating teaching and learning of vocational subjects such as Tooth Morphology and Oral Anatomy.

Game Literacy, Epistemological Access and Knowledge Structures are key concepts that will form the conceptual framework in the final chapter of this thesis.

1.6 Hypothesis

Teaching and learning through games facilitates epistemological access to Tooth Morphology and Oral Anatomy.

H_1: Students will acquire epistemological access to Tooth Morphology and Oral Anatomy through the board game and digital multimedia game, respectively.

H_0: Students will not acquire epistemological access to Tooth Morphology and Oral Anatomy through the board game and digital multimedia game, respectively.

1.7 Assumptions

The assumptions made in this research are:

- All student participants will respond honestly, and will make a sincere effort to complete the assigned tutorial activities.
- Pairing mainstream and ECP students will encourage teamwork and student communication.
- Student teams choosing their opponents will introduce competition during game play.
- The integration of realistic morphological and anatomical representation in discipline-specific games suggests that Dental Technology concepts are situated in their meanings. The games will therefore not only facilitate the contextual embedding of formal knowledge but in the process will possibly enable students to behave and express themselves (embodied knowledge) in the context of Dental Technology.
- The teaching and learning through games will positively impact on student learning experiences. It is therefore envisaged that students from the years 2009, 2010 and 2011 will recall their game experiences.

1.8 Delimitations

- Only students who are registered for the ‘first time’ in the subjects Tooth Morphology and Oral Anatomy at the time of data collection will be considered.

- As [the researcher is] an insider in the department, the use of semi-structured interviews will minimise any obtrusion and influence on students.
- Although the findings of the study may have application, the study will not evaluate psychosocial behaviour of students.
- In this study, and as per the Council on Higher Education in South Africa (2004a), Quality will explicitly focus on the concepts of Quality as 'fitness for purpose' and Quality as 'transformation'.

- Given the time that elapsed between the students' first engagement (2009-2011) and focus group (2012), it is difficult to determine the credibility and ability of the students' to recall their past experiences with the games. Hence, to support the findings of the focus groups, triangulation of the responses with other forms of data, for example the digital images, field notes and video recordings at the time in which the games were played, helped to strengthen the reliability of the data.

1.9 Structure of the Thesis

This thesis comprises six chapters. This chapter provided a background of the study by detailing the reasons for using alternate classroom-based practices such as games. This steered the chapter towards the aim and research objectives. Consequently, the concepts of student-centered teaching and learning, game literacy, epistemological access and knowledge structures emerged.

Chapter 2 presents a review of the literature by initially outlining student learning problems in Dental Technology, followed by an overview of approaches to, and conceptions of, teaching and learning in higher education. This chapter then makes explicit the association to game literacy and provides the pedagogical rationale for the use of games in higher education, while highlighting the links between teaching, learning and assessment (TLA). This chapter also includes an integrated perspective of literacy, epistemological access and knowledge structures to explain the pedagogical potential of, and epistemological access to, Tooth Morphology and Oral Anatomy through games. As illustrated in Figure 1-2, and in order to explicitly position this study, there are four inter-related parts to Chapter 2.

Part 1 of Chapter Two highlights the student learning problems in Dental Technology, particularly in the context of low throughput and students' transition from school into university. The conceptions of teaching and learning namely, teacher-centered and student-centered approaches in higher education, will assist in strengthening this section of the literature review. The chapter then turns to the work of Epistemological Access (part 2) and will detail the links to the epistemological structure of disciplines. The seminal work of Morrow (1993; 2007; 2009), together with research conducted by higher education advocates of epistemological access, underpins this section in an effort to develop richer understandings of the pedagogical potential of the Dental Technology games. Part 3 of Chapter Two describes literacies linked to games and epistemological access. Subsequently, Part 4 adopts a sociological perspective to discuss the knowledge structure of Dental Technology at DUT. The work of Bernstein (1999; 2000) and other theorists provides a platform to understand the conceptual knowledge and the contextual knowledge of Dental Technology. This description is considered to be valuable in theorising the teaching and learning of Tooth Morphology and Oral Anatomy through games.

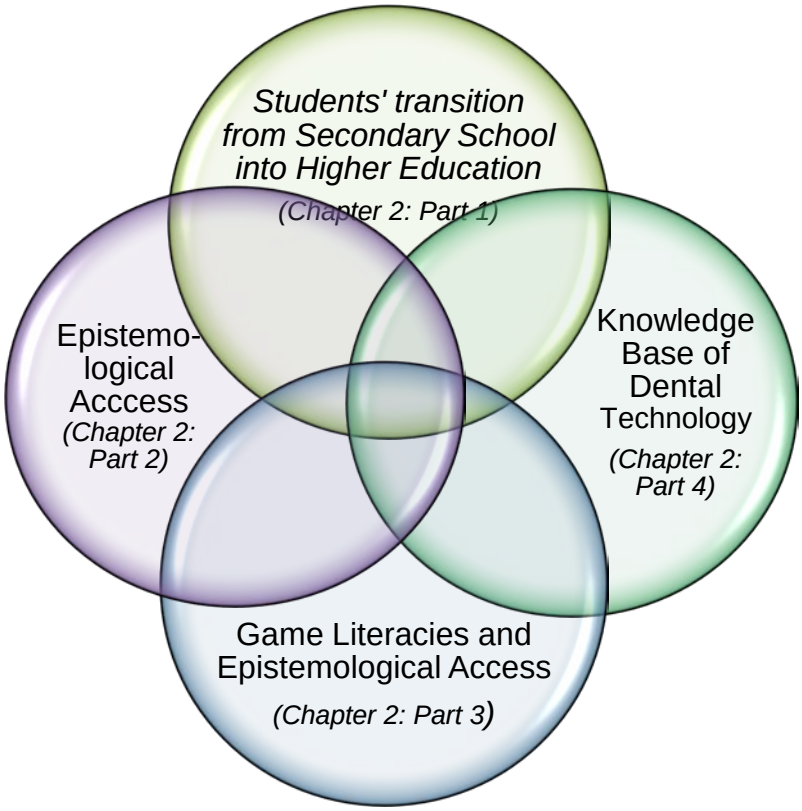


Figure 1-2: Schematic layout of Chapter Two

Chapter 3 details the philosophical stance of the research design and methodological rationale employed in this study. This will include a review of the preliminary and pilot[2] studies. This chapter will further introduce the theories of 'knowledge codes' to conceptually analyse quality pedagogy of games.

Chapter 4 reports on the findings and analysis of the Tooth Morphology board game and Oral Anatomy multimedia game through figures, graphs and tables (Research objectives one and two in Section 1.3). Specific attention will be given to various analytical features around the board game and multimedia game, such as pre- and post-tests, students' perceptions of the game through surveys, and debriefing sessions together with video recordings and digital images, to allow for triangulation of results. Overall, this chapter will assess the extent to which students acquire epistemological access to Tooth Morphology and Oral Anatomy.

Chapter 5 conceptually interrogates and fully theorises the extent to which students acquire epistemological access to Tooth Morphology and Oral Anatomy. The data presented is from the focus groups.

Chapter 6 forms the final chapter of this thesis. It will provide conclusions of the thesis by synthesising the findings presented in Chapters Four and Five, and interpreting these findings in light of the theories used. The developed framework (Research objective three in Section 1.3) to support the design of games for quality teaching and learning of vocational subjects will be presented in this chapter. This final chapter also identifies any limitations and considers future directions for this research.

[2] Extracts from Chapter Three have been published as 'The Tooth Morphology Board Game: An innovative strategy in tutoring Dental Technology learners in combating Rote Learning.' *2nd European Conference on Games Based Learning (ECGBL) Proceedings: 2008 pp 81-95.*

Chapter Two – Literature Review

2.1 Introduction

This chapter reviews literature related to the quality of pedagogy through the use of games. The literature review is structured into four sections. Section one outlines students' transition from secondary school into higher education followed by student learning problems in Dental Technology, particularly in view of low throughput. Section two examines epistemological access of students in relation to teaching and learning. It focuses specifically on the conceptions of teaching and learning, namely, teacher-centered and student-centered approaches in higher education. A discussion on the epistemological structure of the various disciplines follows, as it is perceived as an underpinning theory on the two types of teaching approaches used in higher education. Section three examines studies on game literacies. A discussion of the potential relationship between pedagogical games and epistemological access to discipline-specific learning material then ensues. It is perceived that the association between games and epistemological access will help the researcher to determine if the fundamental principles of teaching and learning through games, developed during this study, have been attended to. Section four examines the knowledge structure of Dental Technology, as the structure of the target knowledge is understood to be a key underpinning concept in the design of discipline-specific games. Understanding the association between games and knowledge structure could facilitate the pedagogical use of games to be more widely accepted as an alternate means of instructional offering in higher education. Therefore, it is envisaged that these four sections could yield a number of insights about the quality of pedagogy through games, and conceptually the areas of work that will be explored through the research in the chapters to follow.

Research conducted by the Council on Higher Education (2010a; 2010b) indicates that the increased use of alternate classroom-based practices has arisen from the growing awareness of the disjuncture between secondary school and higher education. It also suggests that there are problems and inefficiencies with conventional forms of teaching. Therefore, researchers are engaged in discussions on student access and their transition into higher education. There is consensus

among these researchers that due to the lack of sound foundations for higher education studies, students need to bridge the gap to higher education that is cognitively, linguistically, affectively and socially different from their secondary school and home experiences. In consideration of this gap, several aspects such as the socio-economic status of students (Boughey 2002; Clerehan 2003; Jones *et al.* 2008), enabling epistemological access (Morrow 2009; Bozalek, Garraway and McKenna 2011), the induction into appropriate academic literacy practices (Ballard and Clanchy 1988; Thesen and van Pletzen 2006; Boughey 2007; Blommaert, Street and Turner 2008), and the approaches to, and conception of, teaching and learning (Hattie, Biggs and Purdie 1996; Prosser and Trigwell 1999; Trigwell and Ashwin 2006; Biggs and Tang 2007), just to name a few, need to be taken into account.

2.2 The Secondary School - Higher Education transition

Clerehan (2003) posits that students experience difficulties in making a vertical shift from secondary school into university, and a lateral shift from one discipline field to the next. She proposes that to help ease students' transition into university study, academics should use teaching and learning practices that empower students to become successful participants in their academic practice. Similarly, Biggs and Tang (2007) caution that teaching is not only about conveying academic discipline knowledge orally or in writing to the students. Instead, teaching needs to help students understand how this knowledge functions, both within the university and in the work place. Essentially, the authors above advocate that academic discipline-specific knowledge needs to equip university students with knowledge that better prepares them for their professional practice, which they termed as functioning know-how. This is particularly pertinent in this study, as it is placed within a vocational qualification in a university of technology.

The functioning know-how knowledge aligns to Biggs' (1996; 2003) concept of constructing knowledge at an abstraction level, that is, training would-be professionals to seek new information in the field, how to apply it, and how to evaluate its importance. Newly-qualified professionals also need to learn how to solve novel and non-textbook professional problems. Therefore, he suggests that students need to make the shift from being passive recipients of recalled information and become active participants

in the learning process. It is worth noting that Biggs and Tang (2007) suggest that the reason students struggle to learn the know-how (subject-specific) knowledge may be attributed to the diversity, and increased number, of students currently entering university. They believe that this brings a range of needs and challenges in relation to students' higher education experience. Hence, their work prompts a closer examination of both the transition of students from secondary school to university, and on the kinds of obstacles students could experience when entering university.

Educational research reports on the problematic transition students experience when moving from secondary school into higher education (Boughey 2003; Northedge 2003b; Chisholm and Sujee 2006; Haggis 2006; Jones *et al.* 2008; Boughey 2012). Inequalities in the schooling system, general socio-economic conditions, and differences in the socio-cultural and language background, are predominantly the reasons why students struggle to articulate the gap between secondary school and higher education. It can therefore be gathered that problems of student transition into higher education can be viewed from two different perspectives, each of which has two related factors. The first two factors, which include school and socio-economic backgrounds, relates to the marked social changes of the post-apartheid political transition in South Africa. The other two factors, namely, socio-cultural differences and the university's medium of instruction, relates to the transition that students experience when they enter a new literacy practice. These different conceptions of transition can be understood through the earlier work of Thesen (1997).

Thesen (1997: 487-490) argues that an increase in access of black African[3], working-class students into historically white, English-medium, elite institutions, was concomitant with the increase in student problems related to their transition into the university. She also argues that these problems related to increased student diversity as university education becomes more widely accessible. This has been internationally felt, albeit with a particular edge in post-apartheid South Africa. Thesen (1997) elaborates that the unequal division of the state education system, namely, the

[3]This study uses the 'race' or 'population group' categories of Statistics South Africa, namely: Black African, Coloured, Indian or Asian, and White (Statistics South Africa. 2003. *Census 2001: Census in brief/Statistics South Africa*. Pretoria: Statistics South Africa. Available: http://www.statssa.gov.za/census01/html/CInBrief/CIB2001.pdf (Accessed 2 September 2010).

separate and unequally resourced education departments such as the Department of Education and Training (DET), ex-Natal Education Department (former White) and ex-House of Delegates (former Indian), created disparities between students. Notably, this occurred to such an extent that black African students from DET high schools, who are often English as an additional language learners (EAL), were expected to make a double linguistic shift. They are expected to learn in a language other than their own vernacular, and they are ascribed as being under-prepared to successfully access new university discourse practices.

From an academic support perspective, Thesen (1997) notes that in attempting to initiate under-prepared students into university-based literacies, academics created additional academic development courses that were shaped by a particular culture that gave contradictory messages on how EAL's should participate with literacy practices. She points out that the educational differences in the schooling system (DET, Natal Education and House of Delegate), which followed a distinct socio-economic path, were not considered. Slonimsky and Shalem (2006: 36) concur with Thesen (1997) that students who are products of a poor schooling system are generally under-prepared for university study. They believe that such students are likely to have greater learning difficulties in acquiring the different forms of specialised university knowledge. The argument underpinning the work of Thesen (1997) and Slonimsky and Shalem (2006), is that the focus on deficiencies brought by black African students to higher education study are an inappropriate way of addressing students' shift from secondary school into higher education. Instead, they contend that higher education needs to examine their curricula and teaching and learning practices in order to consider the extent to which they facilitate or impede access to students, particularly those characterised as under-prepared.

Ten years later Thesen (1997) is supported by the work of Scott, Yeld and Hendry (2007), who report that the secondary school - higher education disjuncture is problematic across all ethnic groups, as evidenced by poor throughput rates, but is experienced most sharply by black African students who perform the worst across all qualification types and levels. More recently, a report by the Council on Higher Education (2013) on a 2006 cohort study that tracked first-time intake of students from entry to exit, revealed that only 42% of African contact students graduated within the

expected time of completing a qualification (regulation time). If UNISA, which provides educational opportunities for large numbers of African students, is included then the graduation rate drops significantly to 30%. Equally concerning is the substantial difference in the five-year completion rate (the percentage of a given student intake, or cohort, that graduates) between population groups. On average, the completion rate of the 2006 cohort of White students is 50% higher than African students. This is indicative of the prevailing differentials that exist amongst student population groups.

In addition, while schools generally do not directly prepare students for higher education (Geisler 1994; Slonimsky and Shalem 2006), it is highly probable that students coming from marginalised socio-economic communities and under-resourced schools have been exposed to a teaching and learning environment that is different from that which is required for preparation into higher education institutions (Thesen 2001; Haggis 2003; Nomdo 2006; Boughey 2010a). Similarly, scholars such as Jones *et al.* (2008), Letseka and Maile (2008), Morrow (2007) and van der Berg (2007) have indicated that the socio-economic disparities in the school systems, particularly in rural or under-developed urban areas, hinders the upward movement of students into higher education. Such students have not been exposed to the experiences, discourses and expectations associated with higher education (Nomdo 2006; Jones *et al.* 2008; Soudien 2010). It can therefore be gleaned that student transition problems, which are frequently understood as student deficiencies, are systemic. Notably, it could relate to disparity in terms of social class, schooling (with urban and rural, township and suburb featuring strongly as causal factors), as well as teaching and learning practices that hinder rather than enable students access into higher education.

Bawa (2011: 1), Vice-Chancellor and Principal of DUT where this study takes place, acknowledges that the university attracts a large number of students who come from marginalised socio-economic backgrounds. This suggests that students may come from families that do not have the educational capital or educational resources to support them in their academic studies. His observation is commensurate with the South African Survey of Student Engagement institutional report (2010) that shows 75% of DUT students are first-generation students. This finding indicates that DUT students, particularly the 80% black African students who participated in the survey

(South African Survey of Student Engagment 2010: 15), have not been widely exposed to the experiences, discourses and expectations associated with higher education. This result is significant, specifically when considering the experiences that students bring into higher education as a function of their first-generation academic status.

On a policy level, higher education endeavours to address the challenge of the secondary school to university transition through equity redress and the widening of formal access. This is evident in the publications by the Department of Education (1997) and by the Council on Higher Education (2004c; 2007; 2010a). Similarly, Soudien (2010) argues that equity redress and widening of formal access can be enhanced if the university builds direct links with schools. He points out that the National Benchmark Test (NBT), developed under the auspices of Higher Education South Africa (HESA), is an example of such an initiative. The NBTs, which test students in the domains of Academic Literacy, Quantitative Literacy and Cognitive Academic Mathematical Proficiency, aims to help institutions to identify the deficiencies in knowledge to support their students to succeed in their higher education studies. In spite of this, Soudien (2010) asserts that universities need to do more. He proposes that attention should be given to improve the quality of teaching and learning, particularly in making academic practices explicit for students. Similarly, according to Morrow (2007; 2009) it is imperative that academics take into account epistemological access, or access to and acquisition of knowledge that sustains the academy. A factor that seems to underpin epistemological access is the need for academics to find meaningful and responsive ways of teaching that help students to take on the construction of discipline-specific meanings as opposed to the transmission of knowledge only. Hence, it can be gathered, and to which this chapter now turns, that the approaches to and conception of teaching and learning are central to facilitating students' transition into higher education.

2.3 Teaching and Learning in Higher Education

As in any programme that is vocational or professional in nature, Dental Technology lecturers straddle the fields of higher education and industry, in this case Dental Technology laboratory practice. Consequently, academics need to be knowledgeable about the changes in both academic and professional practices. As outlined in Section 1.3 in Chapter one, an objective of this study is to investigate the quality of teaching and learning in the subjects Tooth Morphology and Oral Anatomy, using the board game and the digital multimedia game. It is therefore important that a wider perspective on teaching and learning be explored in order to achieve nuanced understandings of pedagogy through games. It is anticipated that this understanding will underpin epistemological access, which is a central focus of this study.

Several studies (for example Prosser and Trigwell 1999; Entwistle and Peterson 2004; Haggis 2004b; Carnell 2007) have consistently indicated that academics' approaches to, and conceptions of, teaching directly impact the quality of student learning. While reviewing this area of work Ashwin (2006), Lindblom-Ylanne *et al.* (2006) and Trigwell and Ashwin (2006) reported on teaching from two perspectives namely, from an Information Transfer/Teacher-Focus (ITTF) approach and from a Conceptual Change/Student-Focus (CCSF) approach. Lindblom-Ylanne *et al.* (2006: 286-287) argue that teachers using an ITTF approach operate on the presumption that students do not need to be active in the process of teaching, as it centers on the transmission of knowledge. They elaborate that these teachers focus mainly on how to organise, structure and present the course content in a way that is easier for the students to understand. In contrast, a CCSF approach to teaching centers on developing and/or changing students' conceptions of the course material they are learning. Lindblom-Ylanne *et al.* (2006) are of the view that in a CCSF approach, teachers strive to activate students in their thinking and to encourage them to construct their own, or change, their conceptions of the subject matter. This theory, in line with the initial work of Prosser and Trigwell (1999), is significant as it is closely associated with attaining higher quality learning outcomes where students are able to see relations between elements of their understanding in a subject and are able to apply such knowledge to other contexts.

Strong links have been identified between the ‘what’ (or object of study) and ‘how’ (or approaches) of teaching. Martin *et al.* (2000) and Prosser *et al.* (2005) report that a CCSF conception to teaching relates to what university teachers consider the object of study for students to learn in the classroom. This dimension is a function in determining the quality of teaching and possibly the quality of the learning outcome. For example, Martin *et al.* (2000) believe that teaching is not about just engaging students to think and develop the concepts of the discipline and profession. Instead, it is about attempting to encourage students to conceptually change their thinking beyond the practice of their profession and to include a range of social, political and personal issues. Thus, Martin *et al.* (2000) propose that the way the subject matter is constituted for students needs to be considered prior to teachers contemplating how they should approach their teaching. This study will take their advice into consideration to understand the knowledge structure of Tooth Morphology and Oral Anatomy.

Similarly, and subsequent to the study conducted by Martin *et al.* (2000), Prosser *et al.* (2005) claim that academics who have an integrated and holistic understanding of the subject matter are likely to wholly understand the objects of study for their students. They recognise how the subject matter of a discipline relates to and coheres with the field of study as a whole. From the definitions above it can be gleaned that this facilitates a CCSF approach to teaching. In contrast, Prosser *et al.* (2005) assert that teachers who show little or no understanding of how the subject matter of the discipline they teach relates to the field of study as a whole are more likely to understand the objects of study for their students in less coherent ways. They elaborate that this facilitates an ITFF approach to teaching. Prosser *et al.* (2005) postulate that it is also highly probable that the teacher is unable to engage the student with discipline knowledge and/or the elements of professional practice, even beyond the discipline or practice. Essentially, this can be regarded as a barrier to students learning effectively.

In corroboration with Prosser *et al.* (2005), and reporting from a student’s perspective, Ashwin (2009) suggests that students are more likely to reproduce knowledge for the sake of assessment, or have a surface approach to learning when they perceive that they are being taught poorly. Students also perceive that the assessment of the learning does not focus on evaluating their understanding of the subject matter. They

are therefore less likely to develop a deeper understanding of what they are learning. From an academic perspective there have been frequent debates (Haggis 2006; Biggs and Tang 2007; Kreber and Castleden 2009) around deep and surface approaches to learning in terms of how teaching environments are structured in particular disciplines. One notable example is provided by Hounsell and Anderson (2009) who account on the ways of thinking and practicing, or WTP, to capture what they identify as the characteristics of a particular subject area that students learn. They reported that WTP enables academics to engage in discussions about the disciplinary dimension of their subjects, specifically history and bio-science. Essentially this teaching approach assisted students to understand discipline-specific meaning by actively engaging them into the less familiar discourse conventions of the subjects. This in turn enabled them to learn and think like historians, or like bio-scientists, and to navigate the subject like established practitioners. A discussion on deep and surface approaches to learning is therefore necessary, as it seems to be an underpinning theory into the relationships between the conceptions of, and approaches to, teaching and learning practices in higher education.

2.3.1 Deep versus Surface Approaches to Learning

In the 1970s Marton and Saljo (1976) developed a theory of deep and surface approaches to learning, which showed that students adapt their approach to learning depending on the learning environment and the potential outcomes of the learning. As described by Ashwin (2006: 652), in an ITTF conception of and approach to teaching, students are likely to adopt a surface approach to learning as knowledge mainly centers on the reproduction of information. On the other hand, in a CCSF conception of and approach to teaching, students are more likely to adopt a deep approach to learning as knowledge centers on developing or changing students' understanding of the course material. Similarly, Trigwell and Ashwin (2006) debate that when students perceive the learning environment to be more supportive of their learning, a situated conception of learning occurs. This means that students' prior experiences are evoked in response to their perceived learning context. They also note that there is a greater propensity for students to adopt a deep approach to learning as they expect to attain higher quality learning results. For instance, in his study of academics' experiences of tutorials at the University of Oxford, Ashwin (2006) reports that tutors found students adopted a deep approach to learning during tutorial sessions. This became clearer

when they recognised that the tutorial system is about the development of personal understandings and to think critically of the topics that they studied. In this way it can be perceived that the tutorials served more than just the mere testing of their knowledge as the students understood learning to be within the context of the Oxford tutorial system. In line with this, Haggis (2003) calls on the initial research on approaches to learning to identify, for example, that surface and deep approaches to learning emerge from social contexts and are not inherent to students. The initial research showed that surface approaches to learning emerged from school and students' home contexts, which facilitated memorisation of facts over, for example, understanding of discipline-specific meanings. Other contexts, like the university and some students' home environments, supported other approaches of learning such as seeking to develop, understand and critique the work taught by teachers.

Over a period of time these two approaches to learning have incorrectly become known in the literature as categories of learning, namely deep learning and surface learning. As a consequence of this misappropriation of theory two types of students emerged, namely, deep learners and surface learners, with surface learners perceived as inherently weak students (Haggis 2004a). Of concern, this misunderstanding was prevalent in the data from the Universities of Technology (UoTs), which formed the basis of Boughey's (2010a) analysis of teaching and learning. She noted that in relation to the students' previous and often disadvantaged, educational backgrounds, they, especially the large majority of African students admitted into UoTs, were being characterised as deep learners or surface learners, as if such learning characteristics were inherent in the students themselves. Instead, and resonating with Haggis (2003), Boughey (2010a) argues that the way students learn in higher education is linked to both their school and home experiences. This understanding is significant, particularly when UoTs aspire to develop students with knowledge that takes into account the nature of technology and how it relates to the concept of a career-focused education.

Contrary to the problematic deep learner and surface learner perspectives, Haggis (2006: 532-535) argues for an educational shift towards better understanding lecturers' expectations of how students should function within specific disciplinary areas. She asserts that the lecturer needs to create pedagogical situations that will enable students to think, question, search for evidence, accept evidence and place

evidence together to create an argument that is relevant to that discipline. Her advice aligns to Norton *et al.* (2005), Pickering (2006), and Kreber and Castleden (2009), who claim that the way academics approach their teaching relates to the epistemological structure of their disciplines. An explanation by Donald (2009) notes that although engineering lecturers are often recognised to be practical instructors, their teaching approach changes depending on the orientation of their discipline (mechanical, chemical, civil, computer and electrical). The next section therefore describes the implications of different disciplinary orientations. Cognisance was taken of the orientation of a discipline, particularly in a UoT, during the development of the games in this study and is thus a key concept.

2.3.2 Disciplinary Distinctions and the implications for Teaching and Learning

Disciplines or areas of specialisation are a key tool for differentiating a field of study and generally provide the conceptual frame through which practitioners can understand, value and experience their profession. In his seminal work, Becher (1989: 24) argued that disciplines do not only have a cognitive dimension as originally defined by Biglan (1973a), but have a social dimension as well. He proposed that the social and institutional characteristics of knowledge communities, or academic tribes, affect the epistemological properties of the knowledge they produce. This implies that the task of enhancing teaching and learning within disciplines is not the same across the academy. Arguably, teaching and learning is most likely to improve if lecturers explicitly (rather than tacitly) understand the social and cognitive characteristics of their disciplines. Prior to understanding Becher's (1989) view of how disciplines function and interact as social systems, it is necessary to understand the hard and soft; pure and applied; living and non-living dimensions of Biglan's model (1973a; 1973b). This three-dimensional model has assisted many higher education scholars (for example Muller 2009; Case 2011; Kilpert and Shay 2012; Hlengwa 2013) to broadly frame and analyse the cognitive dimensions of academic disciplines. This model provides an initial insight to understanding the knowledge base of Dental Technology, which will be discussed later in the chapter.

The first of the three dimensions of the model is the distinction between the hard and soft disciplines and the way in which they operated within a paradigm. Collins and O' Brien (2003: 256) define a paradigm as a set of scientific theories or philosophies for

viewing or perceiving how things work in the world. For Biglan (1973b), the hard sciences (or paradigmatic disciplines) permit a greater degree of connecting scholars socially through research publications and funding of research dissertations. Smart and Elton (1982) elaborate that scientific disciplines tend to subscribe to clearly defined paradigms and are more likely to be accepted by all members in the field (social connectedness), hence they are classified as hard subject areas. In contrast, soft subject areas such as philosophy and education have less defined and less unified paradigms, and are likely to be at the opposite end of the continuum from the hard disciplines. For this study, it can be gleaned that Dental Technology is closer to a hard discipline since, and as outlined in the introductory overview in Chapter one: Section 2.1, the fabrication of intra-oral dental appliances involves understanding the abstract theory and linking it to concrete laboratory practice. There is little argument about the theoretical approaches to be taken or the scientific methodologies to be adopted in knowledge production and testing. This seems to suggest that the teaching and learning of Dental Technology is unlikely to demand particular social gazes or positions, as there is general cohesion regarding what counts as knowledge in Dental Technology and how that knowledge should be produced.

The second dimension of the model characterised the practical applications of the subject matter namely, pure and applied. Smart and Elton (1982) point out that academic disciplines such as history and mathematics are traditionally less concerned with practical applications. Agricultural science and accounting disciplines, by contrast, are more concerned with practical applications. Analogous to the hard and soft counterparts, the pure and applied dimensions are found on the opposite ends of the continuum, with any number of gradations possible between the two. Dental Technology is a strongly applied qualification and programme where the knowledge needs to be directly used in the laboratory to meet the needs of industry. The third dimension of the model is the degree of involvement with the study of living or non-living systems of the disciplines. For example, biological sciences and education emphasise the study of living systems and are at one end of the continuum. In contrast, Smart and Elton (1982) note that astronomy and mathematics are considered to be non-life systems and are therefore found on the opposite end of the continuum from the living systems. In summary, Biglan (1973a; 1973b) suggests that the three most important dimensions for characterising the cognitive style of an

academic subject area relates to the extent of the use of a paradigm, attention to practical application, and concern with life systems. As previously indicated, Dental Technology involves applying theoretical knowledge to practical contexts. This study seeks to examine the extent to which alternate pedagogies, specifically games, help students to understand the anatomical and morphological theory, followed by their application to laboratory practice.

Extending on Biglan's (1973a; 1973b) cognitive dimension of academic disciplines that divides disciplines into the hard, soft, pure and applied quadrants to give a four-cell matrix namely, hard pure; soft pure; soft applied and hard applied (Figure 2-1), Becher (1989) describes the social dimension of academic disciplines. He characterises the aforementioned disciplines as academic tribes. Becher (1989) claims that each academic tribe differs socially in terms of its cognitive terrains and cultural elements namely, its traditions, customs and practices, the ways knowledge is transmitted, beliefs, linguistic forms of communication, morals and rules of conduct. Essentially, he advocates that the cultural aspects and cognitive aspects of disciplines are inseparably intertwined. Becher (1989) identifies four social factors along which disciplines varied, namely, convergent and divergent, urban and rural, as illustrated by the pink outer circle in Figure 2-1. He demonstrates this by debating that some of the more theoretical aspects of engineering are purer in character than some of the more practical aspects of physics. Unlike Biglan (1973a; 1973b), and in contrast to the red inner circle in Figure 2-1, Becher (1989) maintains that it is difficult to allocate engineering in a straightforward way as there is an overlapping of boundaries between the hard pure and hard applied disciplinary domains.

Subsequently, and as illustrated by the pink outer circle in Figure 2-1, Becher and Trowler (2001: 46-48) describe the social aspects of disciplines as urban or rural. They characterise urban disciplines by their intense interaction and high people-to-problem ratio. Becher and Trowler (2001: 104-129) elaborate that urban disciplines are close-knit with distinctive modes of communication. They are more likely to typify hard and convergent disciplines. Rural disciplines, by contrast, have larger territories, less interaction and a lower people-to-problem ratio. They have less distinctive modes of communication and are likely to typify soft, and divergent, disciplines. Becher and Trowler (2001) postulate that physics, for example, represents a hard, pure,

convergent and urban discipline, whereas sociology is a soft, pure, divergent and rural discipline. Regardless of this categorisation, they are clear that unlike the hard pure, hard applied, soft pure and soft applied taxonomy of disciplines, there is no clear correlation between the urban and rural and between the convergent and divergent fields.

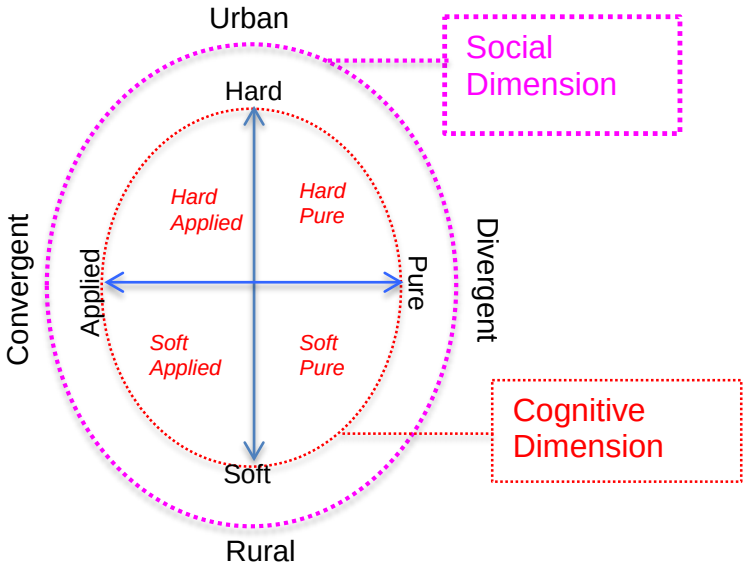


Figure 2-1: Disciplinary orientations
(Adapted from Becher (1989))

In terms of the three-dimensional model (Biglan 1973a; 1973b), Dental Technology appears to be a hard and applied discipline. Notwithstanding this, and as Boughey (2010a) points out, the nature of applied knowledge is more than just the application of knowledge to practical contexts. She argues that applied knowledge and applied learning needs to be appropriately conceptualised and contextualised in UoTs, particularly if the teaching practices used are to achieve the intended learning outcomes. Hence, describing Dental Technology in this way provides only a partial account of its disciplinary orientation and does not take into account differences between and within constituent subjects. Furthermore, it can be argued that Dental Technology is broadly typified as a hard applied discipline (Table 2-1). From a cognitive perspective, Becher (1989) elaborates that the primary pedagogic aim of a hard applied discipline is to produce practitioners, while the primary research aim is to produce useful know-how knowledge. From a social perspective, there are various implications for academic practice in the Dental Technology programme in a UoT. For

example, this suggests that there is a tendency to produce more unpublished research reports that attend directly to the problem-solving needs of the industry.

Table 2-1: Proposed cultural and cognitive styles of Dental Technology *(Adapted from Becher (1989))*

Hard Applied Discipline: Dental Technology	
Nature of disciplinary culture (Cultural Style)	*Nature of knowledge (Cognitive Style)*
Entrepreneurial, cosmopolitan, patents rather than publications, contract work.	Pragmatic (know-how via hard knowledge); uses both qualitative and quantitative approaches; criteria of judgement are purposive, functional; results in products/techniques.

While the seminal work of Biglan (1973a; 1973b) and others provide the underpinning theory of how the cognitive and social elements significantly condition disciplines, it must be acknowledged that disciplines have evolved over time in relation to their own internal dynamics as well as to shifts in the perceived purposes of higher education (the wider political and social structures). For example several studies, such as Northedge (2003a; 2003b), McCune and Hounsell (2005), Davies and Mangan (2007) and Kreber (2009), have argued that changes in higher education influence the way lecturers approach the teaching of their disciplines. Consistent with these studies, Lueddeke (2003) revealed that the disciplinary differences of subjects influence the teaching method adopted by lecturers in the classroom. This, in turn, is likely to impact on the students' orientation into the discipline. Lueddeke (2003) concluded that lecturers teaching hard and pure or hard and applied subjects have a tendency to use an ITTF teaching approach. In contrast, academics teaching soft and pure or soft and applied subjects generally adopt a more CCSF teaching approach. His work suggests that disciplinary distinctions (hard and pure; hard and applied; soft and pure; soft and applied) are closely linked to teaching and learning practices.

Contrary to Lueddeke (2003), Matthew and Pritchard (2009) and Hounsell and Anderson (2009) argue that labels such as hard and soft are not helpful in promoting new ways of thinking about the 'what' (characteristics of a particular subject area being taught) and 'how' (to understand the ways in which students learn) of teaching and learning within particular disciplines. As briefly pointed out in Section 2.3, the aforementioned scholars assert that in conjunction with the characteristic of a discipline, the ways of thinking and practicing or WTP need to be considered. According to Matthew and Pritchard (2009: 62), WTP ranges from the content that is explicitly taught in the classroom to the underlying behaviours and professional skills that students will need in their careers. They posit that WTP is an enriching way to consider the 'what' (structure of a discipline) and the 'how' (to stimulate students in their learning) of teaching in a discipline, particularly in assisting teachers to reflect on some of the tangible and intangible aspects of the discipline to students. In light of this study, and in view of Matthew and Pritchard's (2009) advice, it can be gleaned that to be a Dental Technology student is to understand Tooth Morphology and Oral Anatomy as part of a toolkit that constitutes the WTP of a dental technician. Teaching, including alternative pedagogies such as games, would thus need to induct students into these ways of thinking and practicing.

Matthew and Pritchard (2009) caution against a narrow interpretation of WTP and encourage lecturers to assess the recognised WTP of their disciplines in relation to the current higher education teaching and learning practices. They appeal to university lecturers to think carefully about pedagogical matters and not to limit higher education conversations to just the technical aspects of the educational process. Furthermore, they posit that a shift in thinking needs to be made. This shift should question whether programmes meet scholarly and professional requirements. Similarly Donald (2009: 42), using law as an exemplar, advises that optimum teaching methods through early apprenticeship or simulations of moot court cases can encourage students to examine the social context in which they will be working. This can also provide students with principles needed to guide them in their thinking of their profession and to enable them to determine the purpose of values in their personal and professional lives. The challenge for UoT lecturers is to find the balance between education and training. It is worth noting that one way of safeguarding the academic practices of the Dental Technology programme is through the professional council. The South African Dental

Technology Council (SADTC) regulates Dental Technology and ensures that the curriculum is 'fit for purpose' such that graduate dental technicians are 'fit for practice'. This concept will be discussed later in the chapter. The advice given by Donald (2009) and Matthew and Pritchard (2009) is pertinent to this study because it systematically seeks to understand if discipline-specific games provide ways of thinking and practicing that is meaningful to students while being true to the needs of the profession, in this case Dental Technology.

Equally significant, Hounsell and Anderson (2009: 78) note that students' engagement with WTP is shaped by their background, circumstances, existing knowledge, experience and orientations towards higher education study. Hence, WTP should not be viewed as static objects emergent from the discipline to be passed on to students. Instead, they recommend that the focus should be on performance by using teaching activities, such as games, that will help to facilitate disciplinary ways of thinking and practicing. Consistent with Northedge (2003a), Hounsell and Anderson (2009) conclude that teaching should help students to understand the meaning of their discipline, as well as coaching them to correctly write and speak and act within the discourse conventions of the subject.

Although the aforementioned authors have outlined ways to systematically understand disciplinary differences and their influence on teaching and learning practices, it is evident that a theory underpinning their work is the need to consider the wider social perspectives of teaching and learning. Haggis (2003: 100-101) claims that students can be inducted into their disciplinary practice by making explicit the literacy norms of specific subjects. For this study, the question raised is to what extent do games make the morphological and anatomical abstractions of the subjects more tangible for students, and if so, in what ways and with what consequences. This is a pertinent question in view of several scholars (for example Cope and Kalantzis 2000; Zagal, Rick and Hsi 2006; Buckingham and Burn 2007; Connolly *et al.* 2012) indicating that games can be proponents of contemporary forms of literacy. They postulate that games are different from the traditional understanding of literacy that was seen as an individual process used mainly as a tool for content-area learning. Based on the implications emerging from the work of these scholars, the subsequent discussion addresses the concept of games literacy and takes into account the wider, more social

perspectives of learning. As Boughey (2010b) argues, this understanding is significant particularly as students are enculturated by their social and cultural histories, which are often entrenched in the South African histories of apartheid. Analogous to the earlier argument of Thesen (1997), Boughey (2010b) claims that students bring other understandings of teaching and learning that are different from those needed for the acquisition of higher educational knowledge. In an effort to acculturate students and to enable them to acquire access to the literacy practices of Tooth Morphology and Oral Anatomy, teaching and learning through games is conceived to be a bridge between students and curricular content. Before moving to the discussion of games as a means of literacy development, Figure 2-2 represents a schematic of the main theoretical concepts underpinning this chapter thus far and those that are yet to follow in later sections of this literature review.

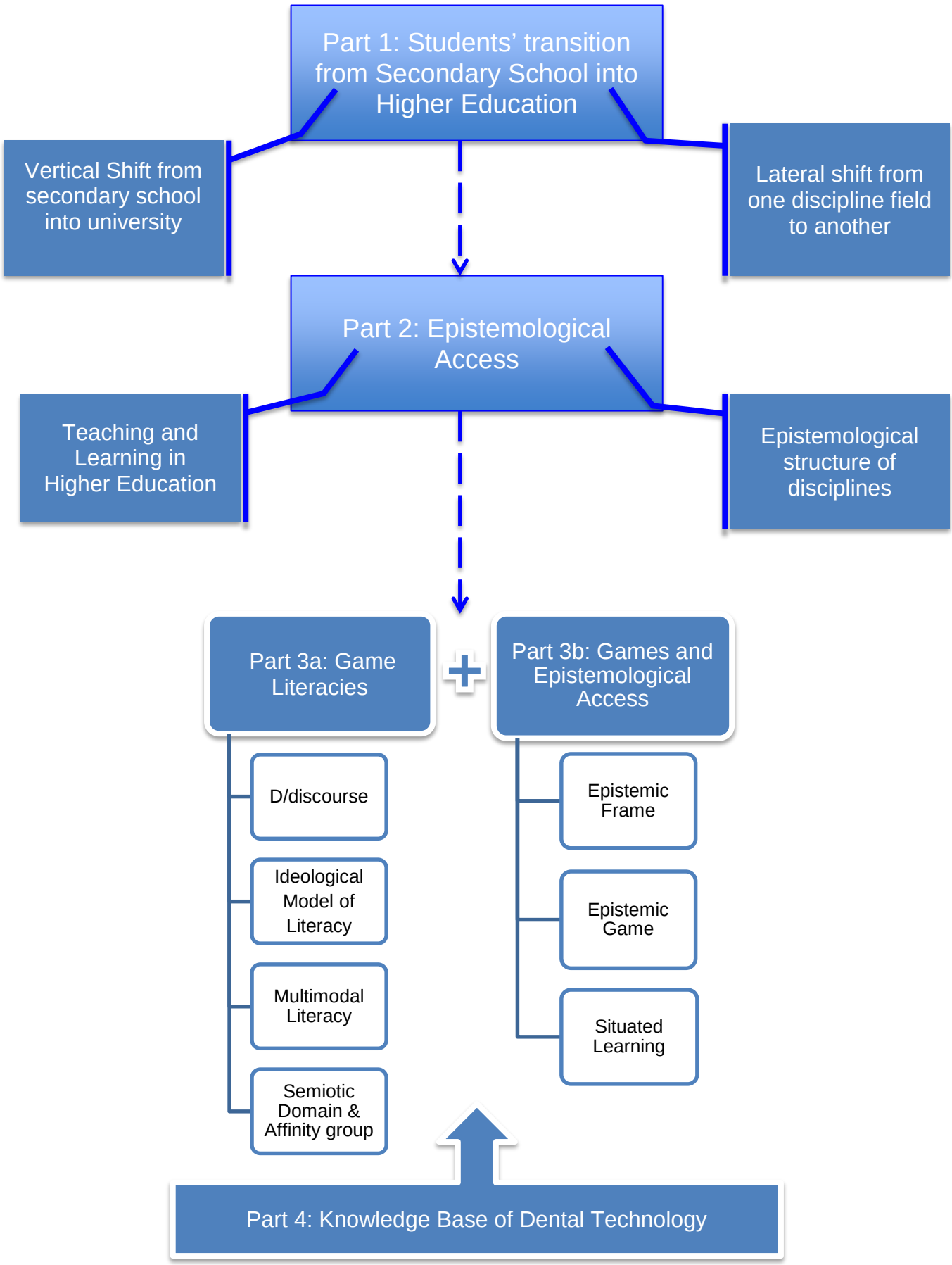


Figure 2-2: Theoretical concepts underpinning this study
(Adapted by the researcher)

2.4 Game Literacies

There is consensus among many scholars from different disciplines that games redefine traditional understanding of what it means to be a literate student in the twenty-first century (see for example Coiro *et al.* 2008; Salen 2008; Janks 2010; Mallinson 2010). In games such as board, computer, video or mobile, the way literacy and technology converge dismisses the conventional idea that literacy is a universal technical skill focused on print decoding and encoding. The assumption that literacy is a neutral technology involving the decoding and encoding of script is defined by Street (1995) as the autonomous model, which ignores the social contexts in which literacy occurs. Instead, and as argued by Conolly and Stansfield (2008), game literacy includes knowing how and when to make a decision about which forms and functions of literacy are most likely to support one's purpose This aligns to the seminal work of Heath (1983) and Street (1995), who define literacy as a social practice and extends it to Gee's (2003; 2007) theory of novel discourses made possible by new technologies. This section therefore seeks to broaden the concept of literacy (Figure 2-2), and literacy teaching and learning, by highlighting the modern social and technological shifts that have created learning spaces mediated through games. Gee's (1992) work on discourses provides the point of departure for this section.

According to Gee (1992: 105) the meaning of texts is not in an individual's head but is embedded in the social practices of socio-culturally defined groups of people. He defines this as Discourse (with a capital 'D'). It is different to discourses (with a lower case 'd') that are the language components of a Discourse. Consequently, two types of Discourses emerge, namely, primary and secondary Discourses. Gee (1992: 108) elaborates that the early apprenticeship of home-based practices is characterised as a primary Discourse. In contrast, secondary Discourse is when individuals enter the public world outside their families and kin group. Knowledge of Gee's 'big-D' Discourse theory provides a useful analytical lens through which to examine how students, who are largely second-language English speakers at DUT (South African Survey of Student Engagment 2010), use language and other modes of meaning-making practices to learn. This is juxtaposed with how discipline-specific games can acculturate students into the literacy practices of Tooth Morphology and Oral Anatomy.

Social accounts of literacy as represented by authors of the New Literacy Studies (NLS), such as Cope and Kalantzis (2000), Barton, Hamilton and Ivanic (2000), Brandt and Clinton (2002) and Street (2003), offer an initial insight to investigate and rethink what lecturers could do with alternate classroom-based practices such as games. In particular, how to engage students from diverse backgrounds and who have different understandings of the world. Researchers who have taken this approach recognise that reading and writing are always situated within specific social contexts, and that it is these contexts that give meaning to the practices of reading and writing. Extending on the work of the NLS, Gee's more recent work (2003; 2007; 2010) considers games as sites for studying emerging literacies. Together with other educational theorists and researchers (such as Aarseth 2005; Shaffer and Gee 2005; Squire and Giovanetto 2008; Mills 2010), he argues that game literacies include a constellation of literacy practices that can potentially help students, particularly from culturally and linguistically different backgrounds, prepare for life in an information/knowledge-rich economy. From a game literacies perspective, it can be argued that games transcend traditional views of print and book-based literacies, and provide students with an alternate teaching space in which to learn. The Tooth Morphology board game (TMBG) and Oral Anatomy multimedia game (OAMG) in this study can be seen as alternate classroom-based practices which can actively engage students through social interaction. Concomitantly, it is anticipated that some of the game characteristics that could come to the fore are whether the different communicative modes, such as multimedia graphics, sound, playing tokens, still images, and reading cards, help students to acquire the ways of thinking and practicing Dental Technology. To some extent, these inquiries align to the work of the New Media Consortium (NMS).

Jenkins *et al.* (2009: 28-34) explain that the NMS defines literacy as encompassing a set of abilities and skills that intersects aural, visual and digital literacy. They clarify that in the twenty-first century literacies encompass textual and multimedia literacies. Jenkins *et al.* (2009) assert that prior to engaging with new forms of literacies, students need to be able to read and write. After interviewing parents, teachers, and leading game designers, Jenkins *et al.* (2009) advocate that an effective way to engage learning, to explore and process knowledge and to problem-solve, is by playing games. Students are more likely to learn valuable skills that will enable them to

participate in their disciplines and to help prepare them for their subsequent roles and responsibilities in professional practice.

Equally important, scholars (The New London Group 2000; Gee 2003; Coiro *et al.* 2008; Jenkins *et al.* 2009) have intimated that another dimension of game literacy is multimodal literacy. They describe this literacy genre as using different modes of communication, such as visual, audio, spatial, and gestural modes, to enrich, augment and modify words. Jenkins *et al.* (2009: 88-90) report that multimodal literacy does not displace printed texts with images. Instead, it develops more complex vocabulary for communicating ideas that require students to be equally adept at reading and writing through images, texts, sounds and simulations. Multimodal literacy also includes interacting with multimedia and digital texts. Gee (2003: 18) posits that games are multimodal texts that operate within a semiotic domain. He defines this as any set of practices that recruit one or more modalities, such as oral or written language; images; equations; symbols; sounds; gestures; graphs; artefacts; and others, to communicate distinctive types of meanings. Consequently, and similar to his ‘D’ and ‘d’ discourse distinction, he thought it was critical to distinguish between game with a little 'g', and the Game with a capital 'G'.

According to Gee (2007: 135), the game is the software and all the elements of the in-game design. The Game is the social setting into which the game is placed and all the interactions that go on around that game. He points out that players use a multimodal code to interpret aspects of the design of the game in order to understand and play the Game to achieve their goals. They learn to decode and understand game design when they make decisions and take actions in the game. Essentially, Gee (2007) postulates that games for learning should be contextualised in a capital ‘G’ Game if they are to promote a learning ecology with a social aspect, instead of a simple little ‘g’ game. This theoretical orientation aligns to the work of game scholars, as well as game designers, such as Squire and Jenkins (2003), Shaffer (2005), Buckingham and Burn, (2007), Salen (2008) and Zimmerman (2009), among others.

In addition, Gee (2003; 2007; 2010) describes the association of students in a given semiotic domain as an ‘affinity group’. He explains that irrespective of race, class, socio-economic status or background, students have an affinity for the content of a

domain and are likely to share endeavours with regard to that content. This suggests that being literate in a semiotic domain of a game can help students to prepare for future learning, how to problem-solve and to become empowered learners. It can be argued that the concepts of an affinity group and a semiotic domain offer a different perspective with which to look at classrooms and other learning sites. Cognisance of these concepts will be taken in the analysis of the two games in this study, TMBG and OAMG.

It is evident from the research work of the aforementioned authors, particularly Gee (2008a; 2008b; 2010), that games have the potential to immerse players into an environment that is engaging, challenging, fun, and most importantly, educational. In particular, these authors explain that the ability to decode information is analogous to the ability to acquire knowledge. From a game literacies perspective, to be able to decode information is also akin to being able to play a game and to participate in the social and communicational practices of play. This suggests that teaching through games facilitates an engaging and interactive environment for students to discuss, understand and learn subject-specific knowledge. Hence, in examining the general theories of games, the subsequent discussion addresses epistemological access in relation to games as it could possibly open new horizons on its pedagogical value. Unforeseen aspects of this study could also emerge in the examination of epistemological access.

2.5 Epistemological Access and Games

Scholars of game literacies postulate that games are more than just physical or digital materials. They, together with various medical and health science professionals briefly outlined in Table 2-2, see games as fertile ground for the development of resources to support learning. Several other studies (for example Allery 2004; Eckert *et al.* 2004; Oblinger 2004; Henderson 2005; O'Leary *et al.* 2005; Zagal, Rick and Hsi 2006; Bochennek *et al.* 2007; Wideman *et al.* 2007; Killi and Lainema 2008; Kovalik and Kovalik 2008; Hromek and Roffey 2009; Pivec 2009) have also indicated that the salient features of games are that they are inherently student-centered and interactive, and generate enthusiasm, excitement and enjoyment. Regardless of these positive attributes, the literature is unclear as to what extent games enable students to make

meaning and sense of their discipline-specific knowledge. Shaffer (2005) is particularly influential in this respect and his work will lead the discussion for this section.

Shaffer (2005) contends that the traditional understanding of a vocational education in terms of knowing the curriculum content only is insufficient. Instead, he proposes that lecturers need to develop a system in which students learn to think and work as reflective practitioners through an epistemic frame. According to Shaffer and Gee (2005: 9-11) an epistemic frame is a mechanism that mimics the real-world in order to allow students to have rich experiences of their domain-specific subjects. A corollary to this is an epistemic game, which provides students access to a particular form of thinking by enabling them to connect knowledge in context to knowledge-in-action. They elaborate that epistemic games facilitate the emergence of disciplinary thinking and acting that can also transfer to other contexts. Consequently, students are more likely to develop domain-specific expertise under realistic conditions. Shaffer (2005) also suggests that epistemic games can help to acculturate and socialise students by providing them access to an epistemic frame that explicitly links identity, understanding and practice. This aligns to the concept, coined by Morrow (1993; 2007; 2009), of epistemological access as allowing access to the ways of constructing knowledge that is valuable to the discipline.

According to Morrow (2007: 63), the aim of teaching for a profession is to systematically develop conceptual frameworks that render the world of work less opaque to students. He believes that this will ultimately enable students to become successful participants in both academic and industry practice. Although Shaffer (2005) does not explicitly discuss the concept of epistemological access in his study, he alludes to it through his discussions on epistemic games that help students learn to work and thus think like professionals in action. This can be supported by his claim that games “make possible for students to learn through participation in authentic recreations of valued reflective practices – a new model of learning for an era of dramatic social and economic transformation brought about by new technology” (Shaffer 2005: 4).

Table 2-2: A brief overview of studies on the effectiveness of learning through non-digital and digital educational games *(Adapted by the researcher)*

Author(s)/ Year	Genre	Game description outlined in the study	Research findings and/or conclusions
Fukuchi *et al.* (2000)	Non-Digital and Digital	Teaching a Multidisciplinary Approach to Cancer Treatment during Surgical Clerkship via an Interactive Board Game.	The computer assisted interactive board game enabled third-year medical students to learn about basic oncology principles. The game provided active participation, student-student interaction and self-directed learning. Collegiality among teammates was also fostered.
Moy *et al.* (2000)	Non-Digital	Who wants to be a physician? An educational tool for reviewing pulmonary physiology.	Students reported that the game encouraged collaboration. In turn, this facilitated improved understandings of basic pulmonary physiology concepts. This educational tool made learning fun and promoted the development of collaborative social skills among students.
Steinman and Blastos (2002)	Non-Digital	A trading-card game teaching about host defence.	The biomedical interactive training cards facilitated learning of both facts and biomedical concepts.
Ballon and Silver (2004)	Non-Digital	Context is key: an interactive experiential and content frame game.	This game was designed to illustrate the complexities of understanding the differential diagnosis of bipolar disorder in adolescents. 'Context is Key' optimised the students' background knowledge to help contextualise new information, thereby actively engaging with the content, with the teacher and with each other.
Eckert *et al.* (2004)	Non-Digital	Learning from panel boards: T-lymphocyte and B-Lymphocyte self-tolerance game.	Students acknowledged that the panel boards made learning complex concepts of T-lymphocyte and B-Lymphocyte fun and easy to learn.
Ogershok and Cottrell (2004)	Non-Digital	The paediatric board game.	Preliminary evaluation of the board game suggests that students were motivated to advance their knowledge of paediatric medicine.
O'Leary *et al.* (2005)	Non-Digital	Educational games in an obstetrics and gynaecology core curriculum.	Although this Jeopardy style game about ectopic pregnancy was not statistically different from a standard lecture in the effect on knowledge, students reported more meaningful learning and higher motivation.
da Rosa *et al.* (2006)	Non-Digital	Viral Hepatitis: An Alternative Teaching Method.	Students actively learned Viral Hepatitis through the competitive elements of the card game, active listening to their monitors, collaboration, and active feedback.
Beylefeld and Struwig (2007)	Non-Digital	A gaming approach to learning medical microbiology: students' experiences of flow.	This quiz-type board game. 'Med Micro Fun with Facts', enabled student engagement and positively assisted them to learn medical microbiology. This study also suggests that a gaming approach provides a variety of opportunities for practicing and enhancing lifelong learning habits and skills.
Meterissan, Liberman and McLeod (2007)	Non-Digital	Games as teaching tools in a surgical residency.	The games 'Who wants to be a Surgeon' and 'Senior Face-off' enhanced the learning experience of medical residents.

Persky, Stegall-Zanation and Dupuis (2007)	Non-Digital	Instructional Design and Assessment.	The PK Poker game, Clue Game and Pharmacy Scene Investigation Game promoted decision-making, communication and knowledge acquisition of pharmacy education.
Reese and Wells (2007)	Non-Digital	Teaching academic discussion skills with a card game.	The card game created student-centered interactions as students mastered expressions that led to fluency of English grammar. This made learning fun.
Selby, Walker and Diwakar (2007)	Non-Digital	A comparison of teaching methods: interactive lecture versus game playing.	A charades game for teaching child development was statistically superior to an interactive lecture in the effect on knowledge but not in the effect on objective structured clinical examination assessment.
Akl *et al.* (2008)	Digital	An educational game for teaching clinical practice guidelines to Internal Medicine residents: development, feasibility and acceptability.	This TV game show used a multimedia interactive tool to teach clinical practice guidelines in Internal Medicine residency programmes. The reported strengths of the educational game were that it could be used for two competing single users or for individual play.
Begg (2008)	Digital	Leveraging game-informed healthcare education.	A computer game such as Labyrinth can be successfully integrated into the Health Care curricular. Consequently, learning is fun, promotes active engagement among students and provides compelling experiences. This study suggests that successful games like Labyrinth are highly adept at contextualizing player interaction and is intrinsically motivating.
Weisskirch (2009)	Non-digital	Playing Bingo to Review Fundamental Concepts in Advanced Courses.	The Bingo board game successfully increased students understanding of fundamental theoretical concepts. They found the activity engaging and enjoyable
Girardi *et al.* (2010)	Non-Digital	T- and B-Cell Ontogeny: An Alternative Teaching Method: T- and B-Cell Ontogeny game.	Through the use of the board game, student grades significantly improved in the field of medical biochemistry and immunology. The game was an effective teaching aid as it helped to consolidate knowledge schematically, and elucidate complex concepts such as T-cell and B-cell ontogeny.
Telner *et al.* (2010)	Non-Digital	Game-based versus traditional case-based learning: Comparing effectiveness in stroke continuing medical education.	Although knowledge gained through game-based learning was comparable to case-based learning, the 'Snakes and Ladders' concept of the game facilitated a more interactive participation when learning continuous medical education.

As mentioned in Chapter one (Section 1.5.2), using the Madison 2200 game as an exemplar Shaffer (2005) describes how the epistemic frame of this game tightly links urban science practices and ways of knowing about urban ecological issues and its impact on the environment. In other words, an epistemic frame is the organising principle for practice that helps students internalise and become acculturated to that practice. The Madison 2200 game, which was mediated by the instructor, enabled

students to access knowledge and develop ways of thinking that are similar to that used by urban planners. It was evident that working and thinking like urban planners helped them to think about problems, as well as to care about economic and social issues in particular ways. With respect to this study, it was anticipated that the TMBG and OAMG could help students to think and act like dental technicians, and to use concepts and procedures within the scope of activities that constitutes Dental Technology. Hence, guidance from the Madison 2200 game was considered during the design of the games in this study.

In addition, Squire and Jenkins (2003) posit that games are micro-worlds that enable students to develop a much firmer sense of how different bodies of knowledge are interwoven with each other. Learning through games may have little to do with increasing factual recall or the ability to choose correct answers. They suggest that games have more to do with making complex ideas accessible to a different kind of student and to assist them to participate in discipline discourses. Notably, Squire and Jenkins (2003) suggest that developing robust games will help to map situations and afford students the opportunity to learn in and across the disciplines, and to engage in concepts, debates and methods of the field of study. From these authors, it can be gathered that the development of high quality learning materials, such as games, indeed facilitates epistemological access.

Gee (2007: 112-143) contends that specific games connected to a particular science support situated meanings and understandings. He elaborates that a situated understanding is the ability to associate a concept or word with specific images, actions, experiences, or dialogue, in ways that enables one to apply the word/concept in specific contexts to solve problems or accomplish goals. For example, Gee (2007: 119) typifies the Supercharged! Game as a specific game developed to help students learn electrostatic physics. He uses this game to illustrate where the game succeeds, where it does not, and how to understand this in educational terms. In the game Supercharged! students explore electromagnetic mazes by piloting a spaceship that has the power to adopt the properties of charged particles. They build their conceptual understandings of electrostatics by working through a series of maze-based levels where each level contains obstacles common to electromagnetism texts. This includes points of charge, planes of charge, magnetic planes, solid magnets, and electric

currents. Consequently, and as initially reported by Squire *et al.* (2004), students, particularly lower achieving students, developed better conceptual knowledge of electric fields and the influence of distance on the forces that electrical charges experience. They also showed improved understandings of why representations in their textbooks appeared the way they did. Subsequently, Squire (2005; 2008) proposed that discipline-specific games situated students to recall experiences, and challenges, that are part of game design and game play. This enables them to gain improved understanding of fundamental discipline-specific concepts.

Equally significant, there were certain weaknesses identified by the pilot study of Squire *et al.* (2004). On the first day of playing Supercharged! students did not understand the value of the game as they were expected to participate in a non-teacher led activity. Consequently, students did not see the purpose of the game and how it applied to the learning of physics. It was only on the third day of game play when the teachers provided more structure and assisted students on how to interpret the events of Supercharged! that they began to see and understand the complex physics concepts. This finding of the pilot study suggests that adopting a CCSF teaching and learning approach helped teachers to make the contents of the game explicit to students, which in turn encouraged them to collaborate through game play. Evidently, the teachers' approaches to teaching and learning through games were not related solely to the use of a computer game for learning. Cognisance of the lecturer's role will be taken into consideration when analysing the two games in this study, TMBG and OAMG.

It can be argued that in conjunction with students experiencing situated meanings of discipline-specific concepts, the teacher needs to know how to make the content accessible to the students. This entails having an articulated conceptual understanding of the content and being able to teach it in an active and critical way. Squire (2005; 2008) is of the view that students will be less inclined to learn and repeat such knowledge in a passive and rote manner when taught through interactive games. In addition, his work advocates that adept game players are more likely to appropriate game representations as tools for thinking, which can later be applied in solving other discipline-specific problems. It is highly probable that this increases students' opportunities of becoming successful participants in academic practice.

While the aforementioned scholars such as Gee (2007), Shaffer (2005) and Squire (2005; 2008) suggest that games make provision for students to access knowledge, in a higher education context more work needs to be done to develop appropriate evidence to support this claim. This study examines whether the TMBG and OAMG games facilitate students' epistemological access, particularly by minimising the perceived disconnection between textbook knowledge and applied knowledge. It also seeks to understand the pedagogical potential, and limits, of the games in the teaching and learning of discipline-specific subjects. Pertinent to this inquiry, and given that the researcher is the game designer in this study, understanding the knowledge base of Dental Technology is useful. In particular, and as de Freitas (2006) argues, understanding the knowledge base of vocationally orientated programmes can help lecturers to effectively contextualise games into the curriculum in order to facilitate a smoother transition from the underpinning discipline to the professional field of practice. In attempting to understand the knowledge base of Dental Technology at DUT, the next section draws on the sociology of knowledge, specifically the conceptual framework of Bernstein (2000).

2.6 Bernstein's Theoretical model of knowledge: A sociological perspective

The preceding discussion suggests that the use of games in higher education raises novel issues, particularly in how games can empower students to access ways of constructing knowledge that is valuable to the discipline. An underlying educational premise, and as proposed by Sandford *et al.* (2006) and de Freitas (2006), is that the successful achievement of educational objectives through games occurs if instructional designers of the game have a clear understanding of the knowledge base of the subject material. Consistent with these authors, Stainton, Johnson and Borodzicz (2010: 708) posit that the designer must have sufficient knowledge and experience in the subject to be able to judge the effective level of realism and complexity required to accurately achieve learning outcomes. Arguably, if the lecturer is the instructional designer of the game, which is the case in this study, overtly understanding how knowledge is structured in Dental Technology could facilitate a coherent theory of teaching and learning Tooth Morphology and Oral Anatomy through games. This is particularly important against the backdrop of the students' problematic transition from secondary school into higher education, as described in section 2.2.

This calls for a sociological understanding of the relationship between the theoretical and practical knowledge of Dental Technology. Examining the sociological perspective could potentially open a discussion on the caveats and problems on the quality of teaching and learning through discipline-specific games, and whether it improves students' epistemological access to the morphological and anatomical knowledge. Bernstein's theory (2000) on knowledge structures therefore provides a point of departure for this section.

As illustrated in Figure 2-3: Level 1, Bernstein (2000: 157) first distinguishes two kinds of discourses, namely, vertical discourse and horizontal discourse. A vertical discourse is a coherent, explicit, and systematically principled structure that is hierarchically organised. Using the pure sciences as an exemplar, he reports that a vertical discourse is a form of professional or scholarly knowledge. It is different from the everyday understanding of knowledge, which Bernstein (2000) defines as a horizontal discourse. Muller (2001: 138-140) elaborates that horizontal discourse does not have knowledge structures because it is common to all who belong to the 'domus'. It can therefore be gathered from Table 2-1 that Dental Technology is a vertical discourse.

Furthermore, and as illustrated in Figure 2-3: Level II, Bernstein (2000: 161-167) argues that there is a hierarchical/horizontal knowledge structure distinction to describe the two modes of a vertical discourse. Horizontal knowledge structures, such as the disciplines of social sciences and humanities, have a series of specialised languages that are discrete and non-translatable. Bernstein (2000) elaborates that the discreteness of the language usually occurs to such an extent that the speakers of such language become as specialised and as excluding as the language. He argues that hierarchical knowledge structures, like pure physics develop through the integration of knowledge at lower levels and across an expanding range of phenomena. Wignell (2007: 184-204), expanding on Bernstein's hierarchical/horizontal knowledge structure, posits that a hierarchical knowledge structure like pure physics seems to correlate with discourses that have an elaborate technical framework as a means of categorising and interpreting the world. Humanities, by contrast, are horizontal knowledge structures that somewhat link to discourses that use abstraction as their major source of interpretations. Applying this

language of description, the vertical (or formal) discourse of Dental Technology is acquired by learning the procedures of investigation and instruments of observation, together with understanding the theory (Bass 2007).

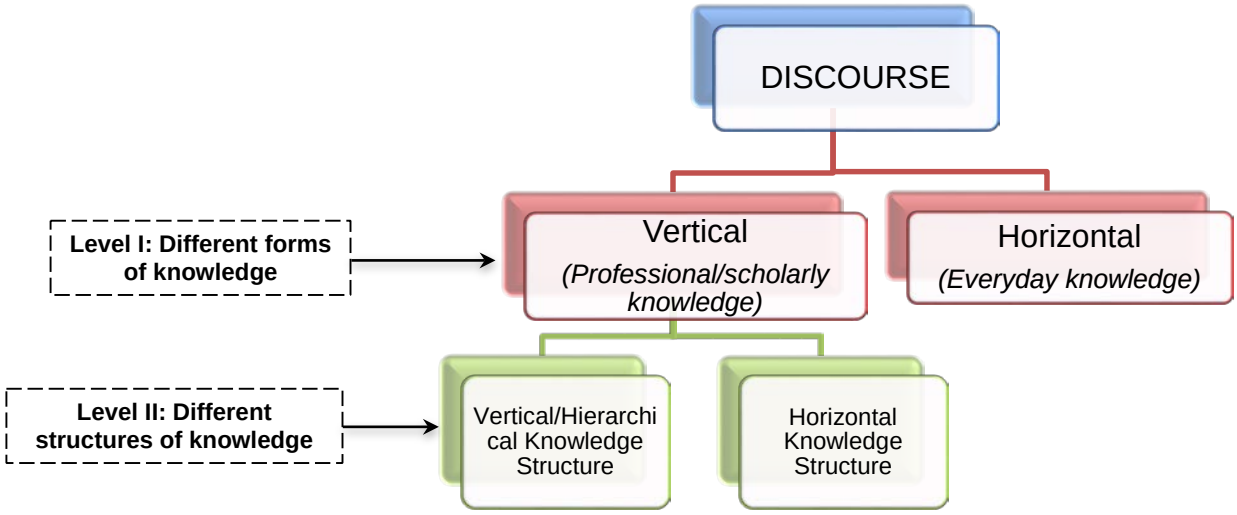


Figure 2-3: Visual mapping of Discourse
(Adapted from Bernstein (2000))

Bernstein (2000: 164) also examines the process of acquisition of a vertical knowledge structure, such as Dental Technology. He maintains that work in a laboratory does not proceed only by a mechanical regulation of the procedures but also relies on acquiring a developed sense of the potential phenomenon arising out of practice. Wheelahan (2007: 640-642) extending on Bernstein's work, asserts that instead of learning isolated and unconnected contents of disciplinary knowledge only, students need to learn the systems of meaning and not only have an understanding of their disciplinary knowledge restricted to the level of events and experiences. It is worth noting that this aligns to what Squire *et al.* (2004) and Shaffer (2005) intended to achieve through the Supercharged! game and Madison 2200 game, respectively.

Literature abounds on the challenges experienced in providing students with epistemological access to the sophisticated concepts of a hierarchical knowledge structure. For example, Herbert *et al.* (2011: 8) claimed that students seldom succeed in acquiring epistemological access to Physics, a strongly hierarchical discourse, as little attention is given to making explicit the links between concepts and the structure of knowledge in the discipline. Aligned to this and as outlined in Chapter 1-Section

1.1, assessments of students during Tooth Morphology carving sessions showed that they were unable to connect their theory lectures to their laboratory practice, particularly drawing exercises and practical carving exercises. Perhaps students struggled to carve teeth as the links between the concepts and structure of knowledge in Tooth Morphology were not made explicit to them. This unclear relationship between theoretical knowledge and practical knowledge can be further explained in terms of Bernstein's (2000) characterisation of knowledge singulars and knowledge regions.

Bernstein (2000: 52) states that singulars are disciplinary knowledge practices that maintain their unique specialised voice. Using Physics and Chemistry as exemplars, Ashwin (2009: 94) clarifies that these discourses are singulars as they are insulated from the discourses of other disciplines. This aligns to Bernstein's (1999: 164) earlier work, where he posits that the acquirer of such discourses does not doubt that he/she is speaking physics or writing physics. The main reason is that the strong grammar of physics visibly announces what it is. Subsequently, Bernstein (2000: 44) describes the teaching and learning of physics as a performance or visible pedagogical practice. He argues that students need to demonstrate mastery (emphasis is on performance) of their disciplinary knowledge text within a specified timeframe. Hence, lecturers assessing students in a subject like Physics are more likely to use a performance-based model, as emphasis is upon a specific output of the student (acquirer).

In contrast, Bernstein (2000: 53-54) clarifies that where there is a strong interface between singular knowledge structures (organised as academic disciplines) and the field of external practice (technologies), then this is a 'region'. For him, a region is a set of recontextualised singular(s). He describes recontextualisation as a process whereby knowledge is selected, de-contextualised and then placed into a new context. Essentially, recontextualisation involves a transformation of the original selection. While all disciplines, whether singulars or regions, have a process of recontextualisation from the field of knowledge production to the classroom, regions take on a very different position, or gaze, in their recontextualisation from the world of work. Regions are far less concerned with the norms and practices of the disciplinary-focused knowledge practices of singulars. Since the two-faced nature of a region, to the disciplines of the academy and the world of work is inclined to be more responsive

to the industry they serve, it is reasonable to assume that regionalised knowledge is likely to focus on the competence of each individual student in terms of industry norms and practices. As reported by Bernstein (2000: 44-49), and subsequently reviewed by Ashwin (2009: 99), a competence-based model centers on assessing the extent to which internal procedures are taking place within each student. It can therefore be garnered that Dental Technology is a region, since disciplinary knowledge is recontextuliased to address the practical skills demanded in the workplace.

Usually in Dental Technology negotiations around content, processes of learning and assessment are achieved through consultative and collaborative processes between the professional bodies[4] and the university. This collaborative relationship guides and structures the disciplinary base of the programme, and in the process ensures that the focus of the curriculum is to develop workplace expertise. As the regulatory body of Dental Technology, the SADTC also ensures that curriculum changes are about inclusion of technological advancements currently impacting on professional practice (South African Dental Technicians Council 2011). In attempting to achieve a clearer understanding of Dental Technology facing both inwards towards the academic disciplines from which it emerges, and outwards towards its professional field of practice, the chapter turns to Barnett's (2006) work on the process of recontextualisation.

2.7 The Two-step Recontextualisation Process: A conceptual framework

As an extension to Bernstein's work, Barnett (2006: 144-149) asserts that discipline knowledge is initially recontextualised to produce a pedagogical university curriculum, and subsequently recontextualised for relevance to the professional practice (vocational field). He clarifies that higher education lecturers who teach application-orientated subjects should make their selection of what to teach based on both scientific disciplinary knowledge as well as knowledge for professional practice. This suggests that the pathway between vocational pedagogy and disciplinary knowledge involves two distinct recontextualisation processes. Resonating with Barnett (2006), Young (2006: 55) asserts that due to the two steps in the recontextualisation of

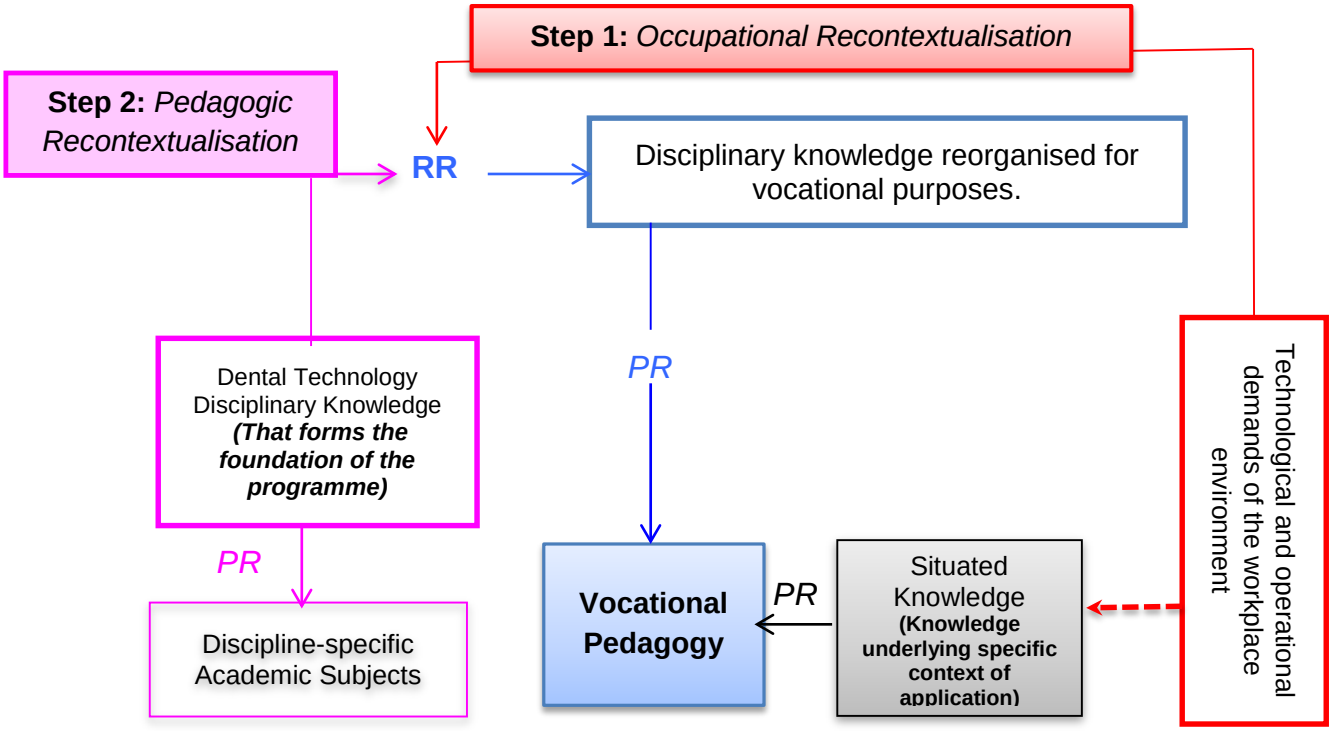
[4] South African Dental Technicians Council (SADTC) and the Dental Technology Association of South Africa (DENTASA).

disciplinary knowledge vocational curricula should take account of the occupational sectors they relate to, not just the institutional context of colleges.

In depicting the strong relationship to professional practice, the two-step recontexualisation framework of Barnett (Figure 2-4) is used to illustrate the two distinct pathways of Dental Technology. This involves the pedagogic recontextualisation and the occupational recontextualisation of disclipinary knowledge. In light of Barnett (2006: 146), the first stage of disciplinary knowledge is occupational recontextualisation. Essentially, the sciences are transformed into applied sciences or technologies (Figure 2-4: Step 1) as the operational demands of workplace activities are considered. The second stage is pedagogic recontextualisation (Figure 2-4: Step 2), which makes disciplinary knowledge more readily teachable and learnable in particular educational contexts. Barnett (2006: 148) posits that the process of occupational recontextualisation of knowledge has implications for the process of pedagogic recontextualisation. This recontextualised arena becomes a complex space for curriculum as it places more pedagogic demands on vocational lecturers than on those teaching a single discipline.

Equally significant, Wheelahan (2009) argues that to analyse the theoretical basis of a practice the occupationally recontextualised disciplinary knowledge has to relate to an occupational field of practice. In essence, and as Barnett (2006: 146) states, vocational pedagogy needs to provide for the situated knowledge that is usually closely associated with particular job tasks. Gamble (2006: 89-94), who builds on and extends Bernstein's (2000) theorisation of knowledge, distinguishes between two types of knowledge-practice relationships, namely, context-independent general knowledge and context-dependent particular knowledge. She elaborates that context-independent knowledge relates to a general or universal knowledge that goes beyond what can be observed or touched or experienced. Context-dependent knowledge, by contrast, is developed through the experiential world to which craft and work practices belong. As illustrated in Figure 2-6, depending on the pedagogical route adopted, Gamble (2006: 90-91) argues that context-independent (or theoretical know-why) knowledge and context-dependent (or practical know-how) knowledge is further divided into principled (whole) knowledge and procedural (parts) knowledge.

Basically, principled-situated knowledge centres on related disciplinary forms of knowledge, whereas procedural-situated knowledge is acquired through practice.



Note: PR = Pedagogic Recontextualisation; RR = Two-Stage Recontextualisation

The dotted arrow suggests that elements of the professional practice impact on the situated knowledge field.

Figure 2-4: Two-Step Recontextualisation of Dental Technology
(Adapted from Barnett's (2006: 148) generic model)

Significantly, Gamble (2006) points out that knowledge developed in practice is generally tacit, tactile and context-specific. She explains that theoretical knowledge could be proceduralised through repetitive teaching. For example, this would mean that a concept such as percentage (%) is likely to be understood by doing percentage calculations over and over again. Conversely, Gamble (2006: 92-93) contends that procedural knowledge could be principled. She clarifies that even though knowledge of craft workers is largely tacit, it is also deeply principled as it relies on understanding the part - whole relationship. She also notes that craft workers understand the particular principle of arrangement in a practical manner, and they pass on this knowledge through modelling rather than through verbal instruction.

From a higher educational perspective, and in view of Gamble's (2006) conceptual distinctions, students can memorise a set of instructions but may be unable to link the theory to the practice unless there is a balance of situated and disciplinary knowledge. This can be a site of struggle for Dental Technology students who, when considered against the work of Reeson and Jepson (2005) and Evans, Henderson and Johnson (2010), are largely recognised to be better at practical work than they are at expressing or writing down what they do. One way of reducing this challenge and to improve student learning is to build clear linkages between the professional practice field (Figure 2-4: Step 1) and the academic field (Figure 2-4: Step 2). According to Muller (2009: 205-226), this can be achieved by framing the balance between the two fields in terms of the two principles of coherence, that is, conceptual coherence and contextual coherence.

As shown in Figure 2-5, Muller (2009: 214-217) defines a curriculum as conceptually coherent when it is predominantly orientated by the conceptual building blocks of its discipline. In contrast, when the knowledge-base is more contextually rooted in the practice itself and is less conceptually driven, the curriculum is described as contextually coherent. This means that knowledge is strong on practice-orientated know-how necessary for professional tasks. The curriculum knowledge base, or know-why, could be considered to be weak as there is a thin disciplinary base to the curriculum. Furthermore, he argues that a thin disciplinary base could lead students to develop a relatively weak professional identity since they are unable to connect the social knowledge to the cognitive. Perhaps this is a reason for Skea (2010: 142) advising higher education institutions that to effectively train dental technicians for industry, Dental Technology theory content needs to increase and be sufficiently integrated with laboratory practice. She concludes that this attribute is necessary to enhance the professionalism of Dental Technology, and ultimately the professional identity of dental technicians. Skea (2010) also intimates that regardless of whether the coherence of the curriculum is contextual in nature, it is equally important that the curriculum be conceptually coherent with a stronger disciplinary core. She believes this could improve the professionalism of Dental Technology. It is worth noting that the findings of Skea (2010) align to Muller's (2009: 217) theory that contextually coherent curricula benefit from having a conceptual coherence or disciplinary core, and *vice versa*.

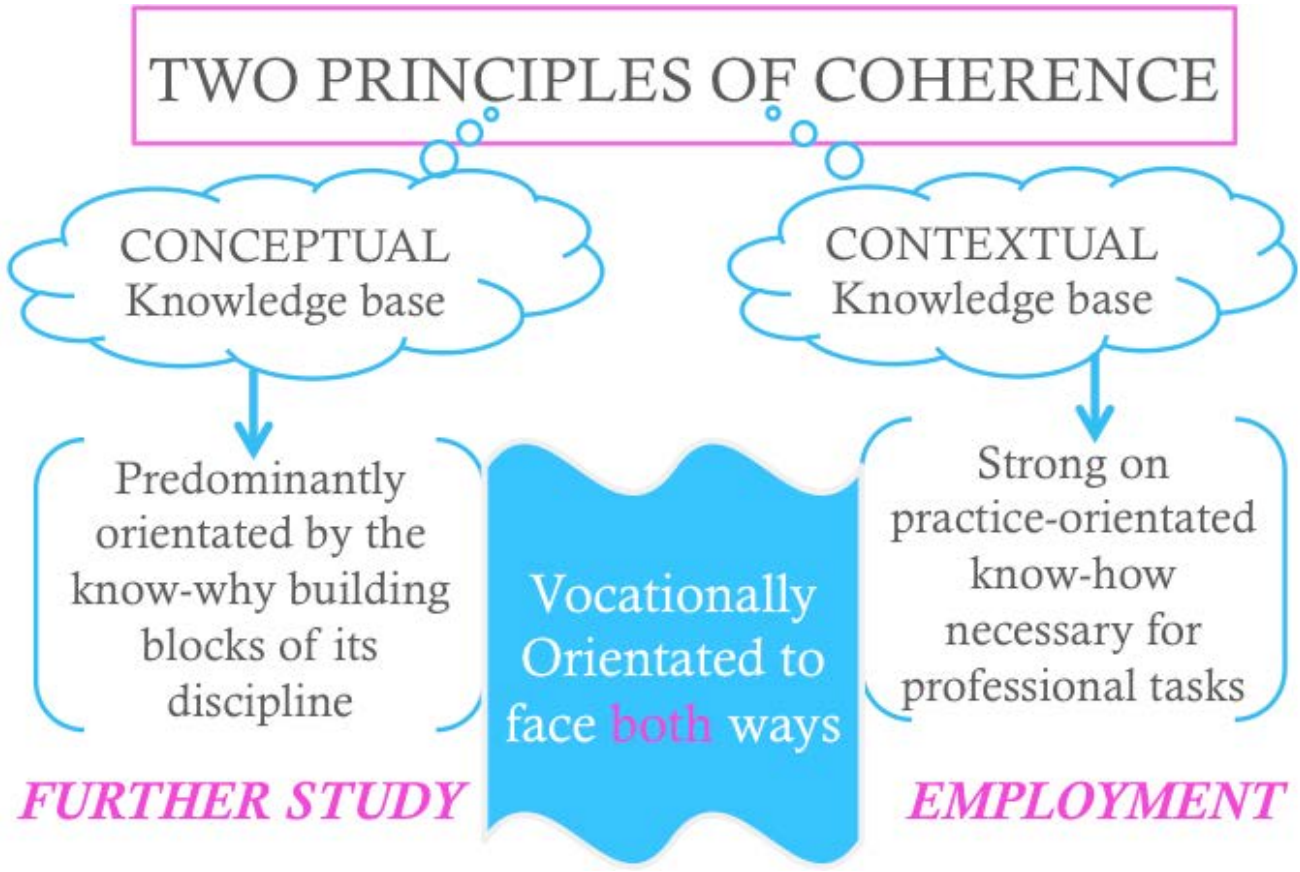


Figure 2-5: Two Principles of Coherence
(Adapted from Muller (2009) and Gamble (2006))

As pointed out by Muller (2009), when practice is elevated above theory a consequence is that the disciplinary base becomes relatively weak. From a UoT perspective McKenna and Sutherland (2006), along with the previous vice-chancellor of DUT (du Pré 2009), have expressed their concerns around the propensity to neglect the conceptual coherence of the curriculum and focus only on the context in which the knowledge will be used. McKenna and Sutherland (2006: 23) assert that if UoTs are confined to their own training discourses, they may fall into the trap of simply transferring to their students the mechanics of the current processes of their target industry. The student would then be unable to call on principled knowledge to adapt to the frequent changes occurring in the workplace. Nuanced understandings of how to reduce the conceptual and contextual tensions, such as through the use of games, becomes key to quality teaching.

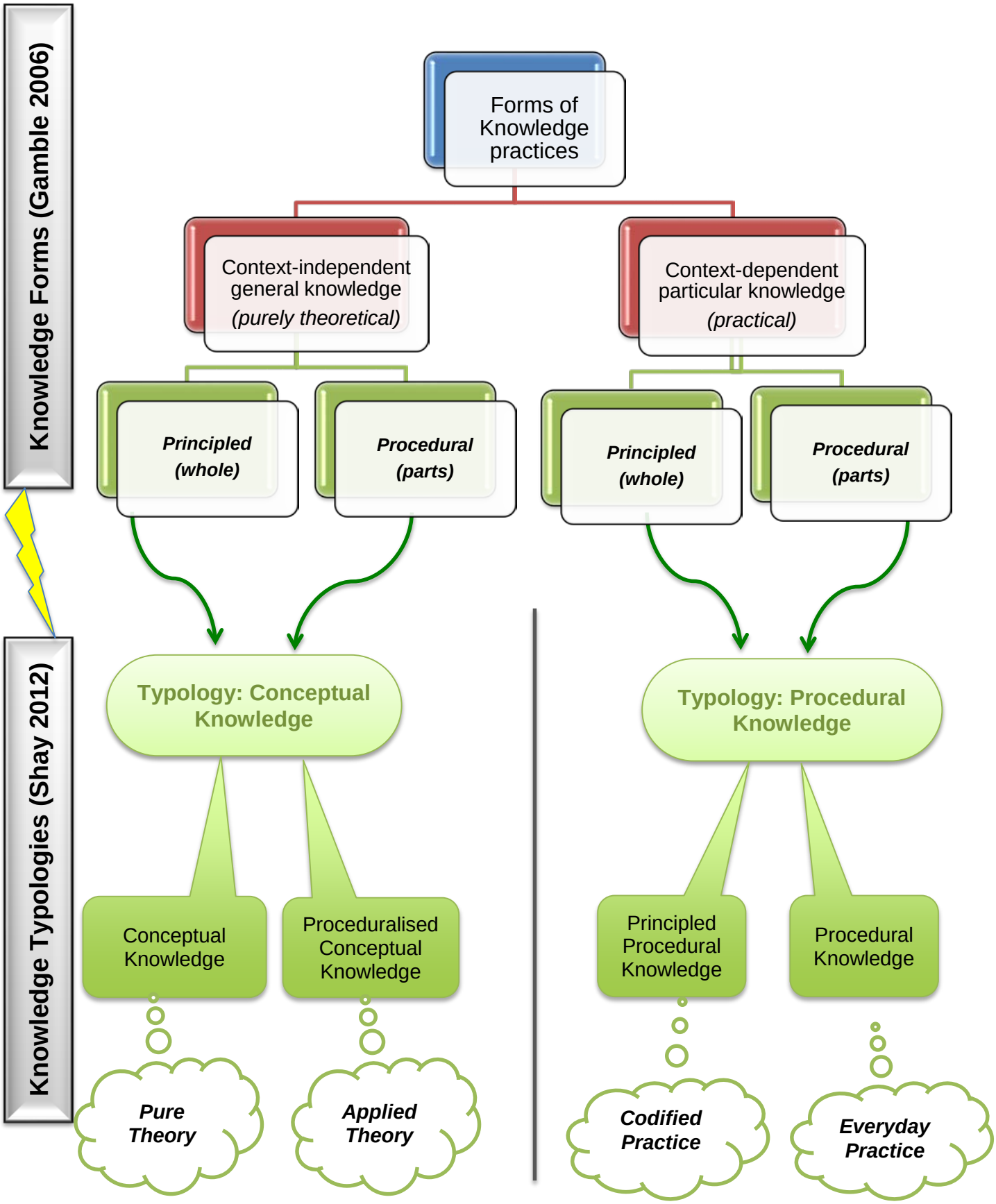


Figure 2-6: Different knowledge typologies

Consistent with Muller (2009), and extending on Gamble's conceptual framework, Shay *et al.* (2011: 97-99) elaborate that a further distinction can be made between conceptual knowledge and procedural knowledge. As shown in Figure 2-6, they explain that knowledge could be typified into four parts, namely, conceptual knowledge (or pure theory), proceduralised conceptual knowledge (or applied theory), principled procedural knowledge (or codified practice) and procedural knowledge (or everyday practice). According to Shay (2012: 316-317) there is a distinction between conceptual knowledge and procedural knowledge. She argues that the principles of practical knowledge emerge from the procedures themselves as codified practice. In contrast, applied theory (or procedularised conceptual knowledge) uses principles that emerge from the conceptual domain, that is, from theory.

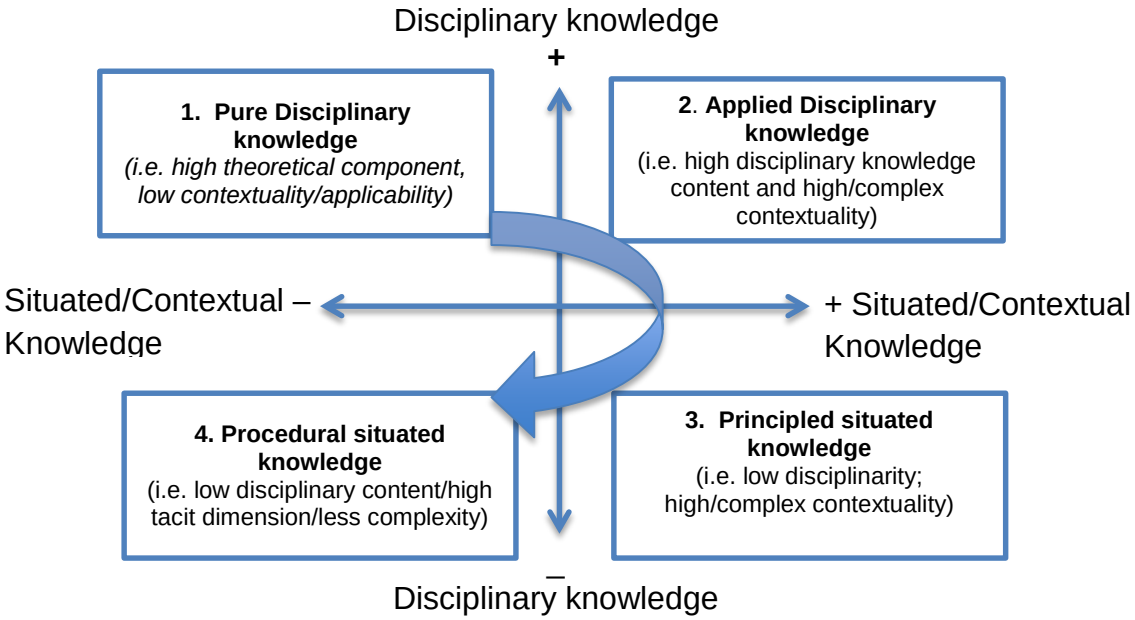


Figure 2-7: A model of professional knowledge
(Winberg et al. 2013)

Similarly, Winberg *et al.* (2013: 110) propose a model (Figure 2-7) that brings disciplinary and situated knowledge into a clearer relationship. Basically, Figure 2-7 shows the potential relationships between domains by differentiating between the pure and applied disciplines, as well as principled and procedural situated knowledge. It appears that this model is underpinned by the work of Gamble (2006), and to some extent it also relates to the work of Shay *et al.* (2011). It is worth noting that each

knowledge typology in Figure 2-6 corresponds to a quadrant in the model proposed by Winberg *et al.* (2013) in Figure 2-7. For example, conceptual knowledge (or pure theory), relates to quadrant one, whereas principled procedural knowledge (or codified practice) relates to quadrant three.

Skea (2010) explains that most of the time in a Dental Technology programme is generally spent engaging in laboratory practice. Applying the principles of the Winberg *et al.* (2013) model, she indicates that there is a propensity to over-emphasise the practice-orientated know-how knowledge (Quadrant 3 and 4) necessary for professionally orientated tasks. Sufficient attention is not given to the disciplinary core areas (Quadrants 1 and 2) and this is likely to cause the knowledge-base of Dental Technology to be weak on the conceptual know-why knowledge. At recently-held Dental Technology liaison committee meetings (Briscoe 2012; 2013), and resonating with Skea (2010), industry experts reaffirmed the importance of the conceptual 'know-why' knowledge of Oral Anatomy. They asserted that dental technicians are increasingly expected to work more closely with specialist dental clinicians. Using Oral Anatomy as an example, industry experts emphasised that the conceptual know-why knowledge of this subject needs to be maintained because it is central to the contextual know-how knowledge of implant-supported denture work. Hence, they advised lecturers to use pedagogical endeavours that will introduce the principles of, or knowledge about, the practice (Quadrant 2). They cautioned, however, that discipline knowledge must be tempered with the practices and the requirements of work and industry that is needed to provide authentic learning in the dental laboratory (situated knowledge).

Similarly, at a DENTASA summit the eminent dental clinician Beere (2012) reiterated the significance of maintaining the context-independent meanings of Oral Anatomy. He stated that dental technicians need to understand that "the bone sets the tone, and the soft tissue is the issue" when fabricating intra-oral dental appliances. It can therefore could be inferred that one way of bringing the disciplinary core area and situated knowledge of Dental Technology into a clearer relationship is to consider the advice given by Winberg *et al.* (2013). As indicated by the arrow in Figure 2-7 they recommend that a logical movement from the disciplines to practice should occur

when designing the curriculum, rather than the other way around. Their advice was considered in the analysis of the games in this study.

Furthermore, and as depicted in Figure 2-6, Shay (2012: 317) concludes that procedural knowledge does not lead to conceptual knowledge and conceptual knowledge does not lead to procedural knowledge. This is significant in terms of understanding the knowledge base of Dental Technology, particularly as this study intends to de-contextualise the theoretical content of Tooth Morphology and Oral Anatomy and re-contextualise that into a game. Equally significant, Barnett (2006: 154-155) claimed that training students for future employment and study involves an unavoidable boundary-crossing between the conceptual discipline-specific knowledge and the contextual professional practical knowledge. He elaborates that the connection between workplace activity and disciplinary knowledge involves the crossing of various boundaries between bodies of knowledge, languages, people and identities.

Evidence of students' inability to connect workplace activity to disciplinary knowledge exemplifies the higher education debate of the theory - practice dualism of knowledge. This potentially increases the teaching and learning challenges in higher education. From a game design perspective the how, where, and why knowledge is used could likely affect the way students engage with the content of the game. As his research on games shows, Gee (2007: 172) states that learning a new domain of knowledge, whether physics or furniture making, requires students to see and value work and the world in new ways, in the ways in which physicists or furniture makers do. He therefore advises lecturers who use games for learning to assess the effectiveness of the whole system, not the game alone. Cognisance of the models illustrated in Figure 2-6 and Figure 2-7 will therefore be taken in the analysis of the TMBG and OAMG.

As pointed out by de Freitas (2006) further research work is still required to examine how games help to support professional and vocational training needs, especially in a climate where greater relevance of work-based learning is being heralded as important for both students (and their orientation into work) and industry (and their requirements for specific skill-sets). In spite of the claims by game experts Conolly and Stansfield (2008), and others, that playing games (non-digital and digital) leads to a variety of

positive outcomes and impacts, it is evident that the literature on games is fragmented and lacking coherence, particularly in showing the links between game literacy, epistemological access and knowledge structures. As this study intends to develop an organised framework, more rigorous evidence is needed to show that the quality of pedagogy supports the provision of epistemological access, specifically in relation to Tooth Morphology and Oral Anatomy.

Overall, this literature review has outlined the higher education teaching and learning debates, particularly with reference to the provision of epistemological access and the growing body of research on games. In understanding the concept of epistemological access, this chapter has linked teaching and learning theories to game literacies, while underlining the concept of knowledge structures in Dental Technology. This chapter has described the theoretical potential of games as an alternate classroom-based practice that needs to be underpinned by an effective pedagogy, as evidenced in the literature. As the review shows, however, there are still many unanswered questions. Hence, Chapters Four and Five systematically investigate the pedagogical potential of games in providing students with epistemological access to Tooth Morphology and Oral Anatomy. The link between game literacy, epistemological access and knowledge structures is revisited in Chapter Six, where a framework is presented to support the design of games for quality teaching and learning of vocational subjects. Prior to these chapters, the philosophical stance of the research design and methodological rationale used in the present study are described in Chapter Three.

Chapter Three – Research Design and Methodology

This chapter details the research design and the methodological rationale adopted in this study. The preliminary and pilot studies conducted will be reviewed and the main study will be introduced. The theoretical and empirical investigations examine the pedagogical value of games in the provision of epistemological access within a vocational programme. Literature suggests that epistemological access is extremely difficult to measure (Bozalek, Garraway and McKenna 2011). Hence, Bernstein's (2000) educational knowledge codes (Figure 3-3) and Maton's (2007) Legitimation Code Theory (Figure 3-4) have been selected to investigate the extent to which games enable students' access to the epistemologies, and their related knowledge structures and literacies of the discipline. These investigations will build theory on the use of educational games and, ultimately, assist in the development of a framework for the design of pedagogical games within similar contexts for this study.

3.1 Introduction and Background to the Research Methodology

Advocates of educational games (Garris, Ahlers and Driskell 2002; Eckert *et al.* 2004; Reese and Wells 2007; Begg 2008; Killi and Lainema 2008) argue that games grounded in subject domains offer unparalleled opportunities, such as situating students' experiences within their content-specific subjects, encouraging deep and engaging approaches to learning, and preparing students for actual practice. Equally significant, they posit that along with stimulating students' interest in subjects that have a high theoretical and complex content, games can facilitate the explicit teaching of linking theory to practice. In this way, and as indicated by Killi and Lainema (2008), games become practical and relevant to real life as they are situated in a certain context, which is an essential prerequisite for learning. Consistent with these authors, and using card and board games as exemplars, Reese and Wells (2007) and Bochennek *et al.* (2007) reported that games support student-centered interactions as they improve communication skills, motivate students to engage in conversations, and promote active learning through co-operation and collaboration with other students. Furthermore, other studies have revealed that games which are underpinned by an effective pedagogy could convey different literacy forms and support academic learning (Fukuchi *et al.* 2000; Ballon and Silver 2004; Eckert *et al.* 2004; da Rosa *et*

al. 2006) and socio-cultural learning (Squire and Jenkins 2003; Shaffer and Gee 2005; Reese and Wells 2007).

Despite the growing enthusiasm of the aforementioned game scholars, research illustrates that there is a dearth of empirical evidence to support the inclusion of games into a structured curriculum. In particular, there is an inadequate integration of pedagogical principles and game design elements. It also seems to suggest that there is a lack of robust reporting on whether games are suitably designed, executed and evaluated to determine the extent to which they enable access to discipline-specific knowledge and, ultimately, its impact on the way students learn. This study therefore endeavours to move beyond this descriptive reporting to provide a more rigorous and robust account of the pedagogical potential of discipline-specific games.

Concomitantly, the study will also consider the advice given by Garris, Ahlers and Driskell (2002: 461) that, "We must temper our enthusiasm for the gaming approach with the knowledge that instructional games must be carefully constructed to provide both an engaging first-person experience as well as appropriate learner support". The research approach adopted for this study therefore uses both deductive processes (testing ideas against observations) and inductive processes (developing ideas from observations). Deductive processes are generally associated with quantitative research, and inductive processes with qualitative research (Creswell *et al.* 2011; Check and Schutt 2012). Creswell and Plano-Clark (2011) point out that by combining both deductive and inductive processes, the researcher tends to base knowledge claims on pragmatic grounds.

According to Check and Schutt (2012: 11) quantitative and qualitative methods are frequently combined to enrich research, particularly in education. They maintain that both these research methods are guided by the researcher's philosophy, or a viewpoint, on what constitutes reality. In order to understand the methodological paradigm or philosophical stance of this research, it is first necessary to explain the alternative research philosophies that are prevalent in research in general.

3.2 Research Philosophies or Worldviews

Cohen, Manion and Morrison (2007: 78) state that research design is governed by the concept of 'fitness for purpose'. For educational research, this implies that the investigative approach that is adopted must best suit the problem and its setting in order to make the research credible, legitimate and practicable. Essentially, there are three broad methodological approaches or traditions that manifest differently in terms of the relationship between the researcher and the social world. As illustrated in Figure 3-1, there are three different research approaches namely: qualitative; quantitative; and mixed methods.

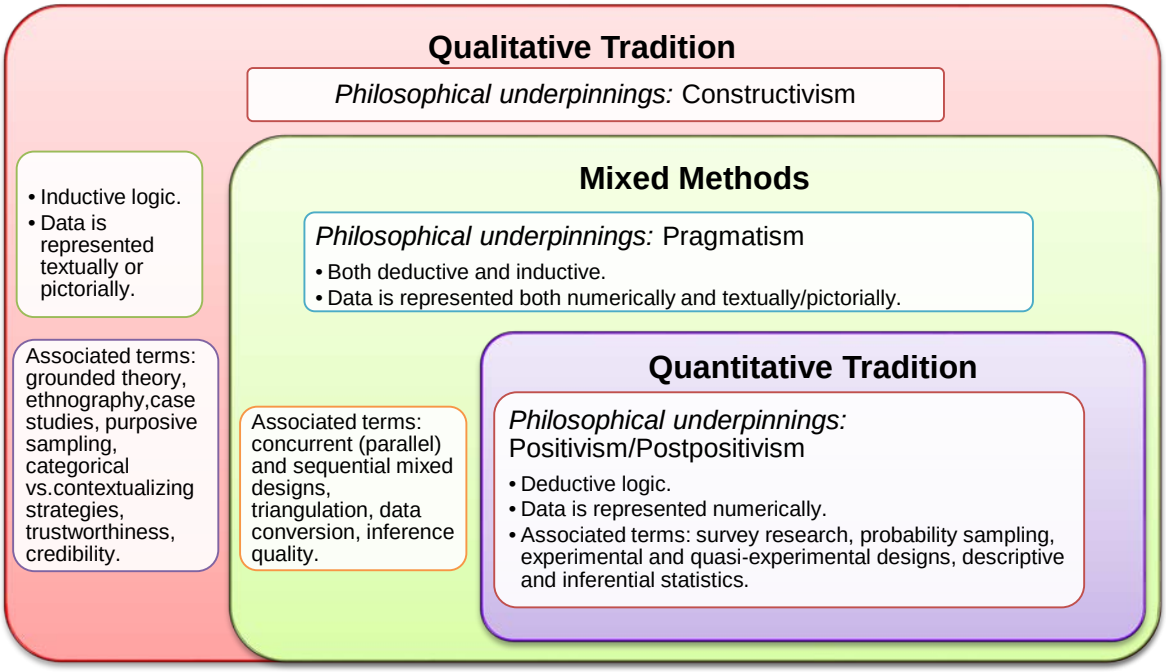


Figure 3-1: Research Typologies[5]
(*Adapted by the researcher*)

Patton (2002) and Creswell (2009) described a paradigm as a worldview, a general perspective and a way of breaking down the complexity of the real world. For example, and as depicted in Figure 3-1, a qualitative approach to inquiry is more likely to lead to a choice of theoretical or purposive case selection, open-ended measures, semi-structured data-collection methods and qualitative data analysis methods. The epistemology (conception of knowledge) that underpins the qualitative paradigm underlines the perspective of the insider. A salient feature of qualitative research is

[5] New philosophical positions such as those offered by social and critical realism have called into question the constructivist-positivist divide. In taking a pragmatist stance in this study, the researcher has not engaged with the ontological deliberations in this regard.

its focus on the contexts and meaning of human lives and experiences in natural settings (with little or no researcher control). Creswell (2009: 8-9) elaborates that in qualitative research the inquirer generates meaning or inductively develops a theory or pattern of meaning from the data collected in the field.

In quantitative research, by contrast, the inquirer begins with a theory and collects data that either supports or refutes the theory. As reported by Mouton (2001) a quantitative approach is likely to use probability sampling methods, structured measures (as in structured scaled items and limited response options), structured data-collection methods, and some set of statistical analytical techniques. Here, the philosophy that underpins the quantitative paradigm underlines the perspective of the disinterested outsider. On the other hand, in a mixed method approach the researcher builds the knowledge on pragmatic grounds and draws from both quantitative and qualitative assumptions (Creswell 2009; Creswell and Plano-Clark 2011; Johnson and Christensen 2012). Since this approach is underpinned by the philosophy of pragmatism, it seeks to reduce the strong criticisms often associated with only using a positivist framework, or an interpretative framework (Check and Schutt 2012).

According to Henning, Wilhelm and Smit (2004: 17-19) a criticism of using a positivist framework is that excessive assumptions and claims are made to the validity and accuracy of scientific knowledge. For example, questions about how people make meaning, or how culture influences interpretation, are kept outside of science. Similarly, and as argued by Creswell (2009: 70), a naïve interpretative framework tends not to include an explicit theory, and may present descriptive research of a central phenomenon with fallacious reasoning. Hence, the rationale for mixing methods in this study is that it is perceived that neither quantitative nor qualitative methods are exclusively sufficient to capture the novelty of the games, and to detail the complex pedagogical and epistemological issues. Essentially, and as maintained by Creswell (2009), pragmatist researchers use diverse approaches to derive knowledge about, and to provide a more rigorous analysis of, the research problem.

Creswell (2009) and Teddlie and Tashakkori (2009: 74) convey some of the general features of pragmatism. These include: preferring action and ‘practical theory’ to philosophising; and that knowledge is both constructed and based on the reality of the

world one experiences and lives in. They also assert that pragmatism tests an individual's beliefs and theories through experience and experimenting, by checking to see what works, what solves problems, what answers questions and what helps for survival. It must be noted that as a research approach, mixed methods focuses on collecting, analysing, and using both quantitative and qualitative data in a single study or series of studies. Creswell and Plano-Clark (2011: 69-70) identified six mixed methods research designs, which are briefly described in Table 3-1.

Table 3-1: Types of Mixed Methods Research Designs
(Adapted from Creswell and Plano-Clark (2011))

Six Types of Mixed Methods Research Designs	
The convergent parallel design	Uses concurrent timing to implement the quantitative and qualitative strands during the same phase of the research process.
The explanatory sequential design	Occurs in two distinct phases. This design starts with the collection and analysis of the quantitative data, followed by the subsequent collection and analysis of the qualitative data. Of significance, the qualitative results builds on the initial quantitative results.
The exploratory sequential design	Starts with the collection and analysis of the qualitative data, followed by the subsequent collection and analysis of the quantitative data. In contrast to the explanatory sequential design, the quantitative results builds on the initial qualitative results.
The embedded design	Collects and analyses the quantitative and qualitative data within a traditional quantitative or qualitative design. For example, a qualitative strand may be added within a quantitative design, such as an experiment.
The transformative design	Uses a theoretical perspective as an overarching framework to quantitatively and qualitatively analyse the data.
The multiphase design	Combines both sequential and concurrent strands over a period of time to address a programme objective. This design is generally used in programme evaluation where quantitative and qualitative approaches are used over a period to support the development, adaptation, and evaluation of specific programmes.

Equally important, literature has documented that the strengths of using a mixed methods research design is its straightforwardness and opportunities for the exploration of the quantitative results in more detail (Creswell and Plano-Clark 2011; Johnson and Christensen 2012). In spite of this, Ivankova, Creswell and Stick (2006) reported that there are several methodological challenges in using a mixed methods design. This includes decisions related to prioritising the quantitative or qualitative approach, implementing the data collection and analysis sequentially or concurrently, connecting the quantitative and qualitative phases during the research process, and integrating or mixing the results of the two phases of the study. Hence, they propose using a visual presentation of the study's procedures to ensure a better conceptual understanding of the research design and to produce more meaningful study outcomes. A broad overview on the mixed method design of this study is illustrated in the next section. It is worth noting that a major tenet of a mixed methods strategy of inquiry or approach is to understand the realities of the world more fully.

3.3 Methodological Paradigm of this study

The central premise of this study is that games can promote academic and sociological conceptions of teaching and learning, an idea that has some support in the literature (Garris, Ahlers and Driskell 2002; Zimmerman and Fortugno 2005; de Freitas 2006; Chang, Peng and Chao 2009; Wilson *et al.* 2009), but requires further empirical evidence and theoretical interrogation. As this study sought to understand the empirical value and pedagogical value of games in the provision of epistemological access, a mixed methods sequential explanatory research design was used, consisting of two distinct phases (Ivankova, Creswell and Stick 2006; Teddlie and Yu 2007; Teddlie and Tashakkori 2009; Creswell and Plano-Clark 2011). It is reportedly the most popular mixed methods design in educational research (Cohen, Manion and Morrison 2007; Check and Schutt 2012; Johnson and Christensen 2012) and in health sciences research (Creswell *et al.* 2011).

In line with Ivankova, Creswell and Stick (2006) and others (Ivankova and Stick 2007; Creswell *et al.* 2011; Creswell and Plano-Clark 2011), a visual presentation of the procedures for the sequential explanatory mixed methods design for this study is presented in Figure 3-2 .

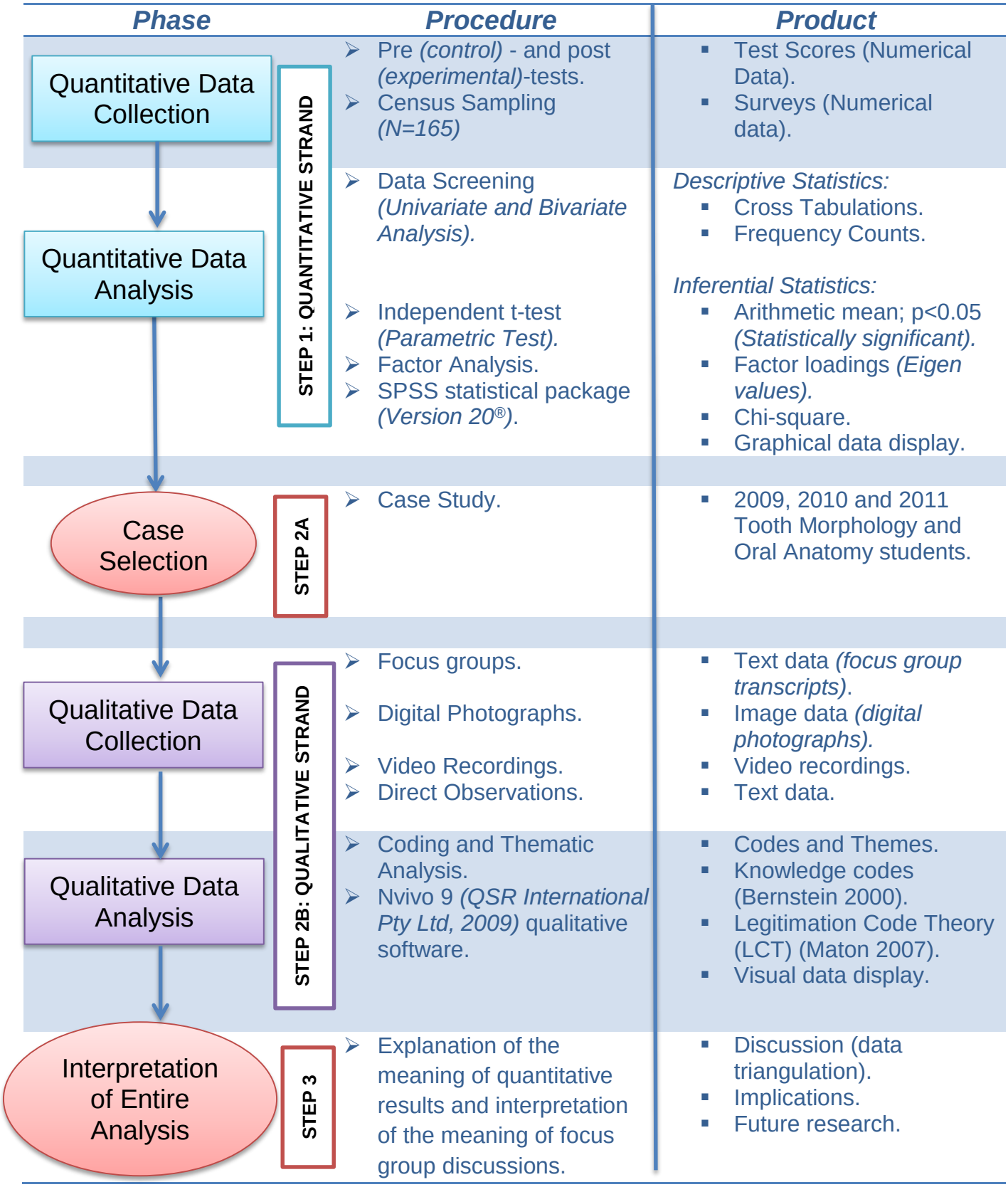


Figure 3-2: Sequential Explanatory Mixed Methods Research Protocol
(Adapted from Ivankova and Stick (2007: 98))

In the first phase of the mixed methods sequential explanatory research design, the quantitative (numerical data) is collected using pre- and post-tests and surveys. Pre- and post-testing of students is typically used to practically assess the extent to which an educational intervention impacted on student learning (Cohen, Manion and Morrison 2007; Check and Schutt 2012; Johnson and Christensen 2012). In determining the relationship between games and student learning (epistemological access), descriptive and inferential statistics are used to analyse the quantitative data. This enables the researcher to meet the first and second research objectives of this study, namely:

1. To investigate the quality of teaching and learning in the subjects Tooth Morphology and Oral Anatomy using the board game and the digital multimedia game, through questionnaire surveys and interviews.
2. To evaluate the efficacy of the board game and the digital multimedia game by pre- and post-tests in assessing epistemological access in the subjects Tooth Morphology and Oral Anatomy in the Dental Technology programme.

The second, qualitative, phase of this study builds on the quantitative results obtained in the first phase. Subsequently, a qualitative case study strategy is adopted and data is generated through focus groups. A case study, by definition, is focused on a single, relatively bounded unit (Gerring 2007) or system "of interrelated elements that form an organized whole" (Johnson and Christensen 2012: 395). Focus groups provide a naturalistic way of exploring students opinions of teaching and learning through games. Similarly, Williamson (2005) maintains that focus group data helps to illuminate issues that surveys present in less accessible ways.

From Ivankova, Creswell and Stick (2006) the rationale for using a sequential explanatory mixed methods research approach is that the quantitative data and their subsequent analysis provides a general understanding of the research problem. This analysis alone could not sufficiently explain the theoretical concept of epistemological access. Hence, this study used a socio-cultural analytical framework to empirically and theoretically understand the scarcity of information regarding how games support students in the provision of epistemological access to morphological and anatomical knowledge. To conceptually elaborate on the students views of accessing knowledge through games, Bernstein's (2000) concept of educational knowledge codes and

Maton's (2007) Legitimation Code Theory were used to develop a more cogent explanation of the association between games and epistemological access. These theoretical concepts enabled the researcher to expand on the statistical results of the quantitative phase by exploring the contextual and explanatory factors perceived to underlie the relationship between games and epistemological access.

Finally, and as illustrated in Figure 3-2: Step 3, the results of the two phases are mixed or integrated during the discussion of the whole study. It is anticipated that this will enable the researcher to meet the third research objective, which is to develop a framework to support the development of games for quality teaching and learning of vocational subjects, particularly in the provision of epistemological access to content knowledge. In view of the research aim and objectives of this study (Chapter one, Section 1.3), the researcher considers the value and representations of the quantitative and qualitative phases as equal.

3.4 Preliminary and Pilot studies

This chapter turns to a discussion of the preliminary and pilot studies that in an introductory fashion fundamentally determined the potentialities and perils of the main study. It is well documented (Blanche and Durrheim 2002; Cohen, Manion and Morrison 2007; Johnson and Christensen 2012) that pilot testing a study predominantly increases the reliability, validity and practicability of the research. Pilot tests are trials that sharpen the procedures, inform one of the permissions and approvals needed, examine likely costs in time, and check the feasibility of a larger study (Johnson and Christensen 2012). Essentially, it can be inferred that investment of time and energy in a pilot study is more likely to enhance the quality of the main study and minimise any unexpected delays and possible failure.

3.4.1 Background: Preliminary and Pilot studies

During the period 1999 – 2002, the researcher[6] observed that students struggled to learn the morphological features of teeth in the subject Tooth Morphology. Similarly, the researcher also observed that students experienced difficulty in learning the muscles of mastication and facial expression, a sub-content of the subject Oral

[6] To date, the researcher continues to teach the subjects Tooth Morphology and Oral Anatomy.

Anatomy. In probing the student learning, teaching and assessment experiences, the Dental Technology games were developed. The morphological information from the Tooth Morphology subject was developed as a board game called the Tooth Morphology board game, while the anatomical content from the Oral Anatomy subject was developed as a multimedia game called Muscle Mania. Games are different from the conventional ways of teaching Dental Technology. It was perceived that, and as indicated in Chapter Two, games could make the morphological and anatomical knowledge more tangible, and may even entice students to think and express themselves in a new and different way. Table 3-2 shows the evolution of the games through the preliminary and pilot work that was conducted. Appendix 1 presents a detailed report of the preliminary and pilot work of the Tooth Morphology board game (TMBG). Similarly, Appendix 2 presents a detailed report of the preliminary and pilot work of the Oral Anatomy multimedia game (OAMG).

Table 3-2: Overview of Preliminary and Pilot studies

Tooth Morphology board game	**Oral Anatomy multi-media game**
1. Preliminary work: Years 2003, 2004, 2005 & 2006. ➢ Action research: Improvement to the instructional and technical designs of the game. ➢ Pre- and Post-game surveys used; and ➢ Observations of students playing the game. ➢ N=128	**1. Preliminary work:** Year 2007. ➢ Action research: Improvement to the technical and instructional designs of the game. ➢ Post-game surveys used; and ➢ Observations of students playing the game. ➢ N=30
2. Pilot Work: Years 2007 & 2008. ➢ Quantitative: Post-game surveys. ➢ N=41	**2. Pilot work:** Year 2008. ➢ Quantitative: Post-game surveys. ➢ N=22

3.4.2 Overall findings of the Preliminary and Pilot studies

As described in Appendix 1, the preliminary work primarily concentrated on improving the design of the TMBG. Similarly, the preliminary work for the OAMG centered on evaluating the appropriateness of the design elements, which is detailed in Appendix 2.

The pilot study used a 14-question survey with four closed-ended and three open-ended questions. Further information on the surveys are detailed in Appendices 1 and 2. The pilot work, where the goal was to validate the instrument and to test its reliability, crucially highlighted the following pitfalls of the descriptive survey that was used post-game play:

- Students indicated that the 4-point rating scale was not always suitable, particularly when they were unsure of their opinions. In the debriefing session, students further reported that they did not fully agree or fully disagree with some of the points.
- Taking into consideration that the survey used to analyse the game was a new construct, statistical analyses revealed that the number of statements of the Likert Scale questions, especially for the TMBG, could have been insufficient. Consequently, certain questions showed low Cronbach's alpha reliability scores. Cronbach's alpha reliability test was used to assess the internal consistency of the survey. Low alpha scores reported for the TMBG ranged from 0.3 to 0.4.
- In the debriefing sessions, students indicated that they found the written survey items ambiguous. This may also have contributed to the low reliability test scores. Hence the grammar and questionnaire structure, particularly the Likert Scale statements, were revised in terms of simplicity, ease of reading and clear understanding.

3.4.3 Further development of the survey

Based on the pilot survey results, the following improvements were made to the questionnaire of the main study.

- The language structure in terms of ambiguities and irrelevant items were removed from the survey. Clearer and more succinct questions were introduced. For example, question 12 in Appendix 3 was revised to provide more structured Likert Scale questions as shown in Appendix 7 (See questions 8, 9 and 11). The re-worked statements of the survey would also avoid items with low reliability.
- To provide more choices, the survey used a 5-point Likert Scale (Strongly Agree; Agree; Undecided; Disagree; and Strongly Disagree).
- The sequencing and layout of the survey changed to include main headings to sections. It was anticipated that by informing students in advance of the sections

it would help them to see the link of the Likert Scale questions to the section. In turn, this would help them to focus when answering questions.

3.4.4 Overview of positive attributes of the pilot study

The following section summarises the pilot study, as it had a critical bearing on how the research design of the main study was designed. The attributes outlined below report on skills acquired by the researcher through the pilot work.

- Pre- and post-tests were used in the main study to provide a more robust analysis of games, possibly supporting the provision of access to knowledge.
- The introduction of debriefing sessions in the pilot study enabled the researcher to listen to students' opinions of the survey, together with their thoughts and feelings of using games to learn. Through these sessions, the researcher realised that students found learning stimulating and fun, for example, when a state of competition is set-up between teams by introducing time frames when answering questions. Consequently, the researcher introduced this idea in the main study. Students who adopted this game strategy in the main study were cautioned not to abuse this approach, as it could prevent them from interacting meaningfully in learning the morphological and anatomical content.
- The researcher learnt to practically observe student behaviour through the capturing of images and videos. This proved useful in the main study, as an overload of unnecessary visual data capture was prevented.
- The duration of game play was assessed in terms of it being too long or too short. It is worth noting that the pilot work showed the 120 minutes duration of game play for the TMBG and 90 minutes for the OAMG was deemed appropriate. This, in turn, empowered the researcher to plan her game sessions and added confidence to collect data for the main study.
- Observations of students during game play revealed to the researcher the possible social dimensions of learning that emerge during gaming. It became apparent from this that literacy is not a set of cognitive abilities that students somehow come to possess. Instead, the way students engaged with their peers in the learning of content knowledge in the pilot study suggests that in games, literacy and technology converge in ways that dismiss the traditional understanding of literacy as a universal technical skill mainly used as a tool for content-area learning. Therefore, the main study took into account how the

different communicative modes of the games facilitated learning in the provision of access to discipline-specific knowledge.

From the above, it can be concluded that the lessons and insights obtained from the pilot study were two-fold. The first three points above assisted the researcher to improve the research design of the main study, particularly the preparation and planning for data collection and data analysis procedures. The last two points related to the execution of the games, in terms of determining the appropriate duration of game play as well as to consider the social aspects of how students interact during game play.

3.5 Research Methods: Main Study

A hallmark of mixed methods is that there is a relationship between theory and practice (Greene, Kreider and Mayer 2011: 261). In seeking to maintain this relationship, the following sections detail the data collection and analysis procedures for both the quantitative and qualitative phases. Prior to collecting data, ethics approval was obtained from the Research Ethics Committee of the Faculty of Management Sciences (DUT) and the Head of Department (Dental Sciences, DUT).

Ethical issues were addressed in various ways. In the first experimental phase, each student signed a consent form and was informed that participation in this study was voluntary and that the anonymity and confidentiality of information would be maintained (Appendix 5). Students also consented to be video taped during game play (Appendix 6). Anonymity of the students was further protected, as the surveys did not require their names (Appendices 7 and 8).

In the second inferential phase, each student who participated in the focus groups signed a consent form (Appendix 9). The consent form described all the features of the study in terms of its purpose, procedures and benefits, as well as the student's rights to participate voluntarily and to withdraw at any time. Taking into consideration that most DUT students are English second - language speakers, clarifying the contents of the consent form before conducting the focus group enabled the researcher to explain terms such as epistemological access and pedagogy. Other

areas that were unclear to the students were also clarified. Overall, the confidentiality and anonymity of students, together with their informed consent to participate in this study, ensured that the study complied with ethical codes of practice.

Table 3-3: Total Target Population

	Tooth Morphology	Oral Anatomy
2009	24	27
2010	39	39
2011	27	29
Total	**90**	**95**

Table 3-4: Total number of respondents

Year	Tooth Morphology	Oral Anatomy
2009	24	24
2010	35	33
2011	24	25
Total	**83**	**82**

3.5.1 Target population

The criteria for selecting the participants included being a Dental Technology student who was registered for the first time in the subjects Tooth Morphology and Oral Anatomy in the years 2009, 2010 or 2011. A total of 185 students (Table 3-3) met this criterion. Overall, 164 students responded to the survey, which constituted a response rate of 88.6% (Table 3-4). It is worth noting, and as pointed out by Lewin (2011: 226), that there is no acceptable response rate as there is evidence that a low response rate does not necessarily lead to poor quality data. She therefore advises that a good practice to aim for is the highest possible response rate. The response rate of 88.6% in this study was deemed to be acceptable. The small student numbers (Table 3-3) in Dental Technology supported census sampling (Check and Schutt 2012: 96).

*3.5.2 Data Collection Procedures: **Quantitative Phase 1**-The Experimental Stage*

In examining the relationship between games and epistemological access, data was collected in 2009, 2010 and 2011 using pre- (control) and post- (experimental) tests. Figure 3-3 illustrates the experimental design employed to evaluate the efficacy of the TMBG and OAMG.

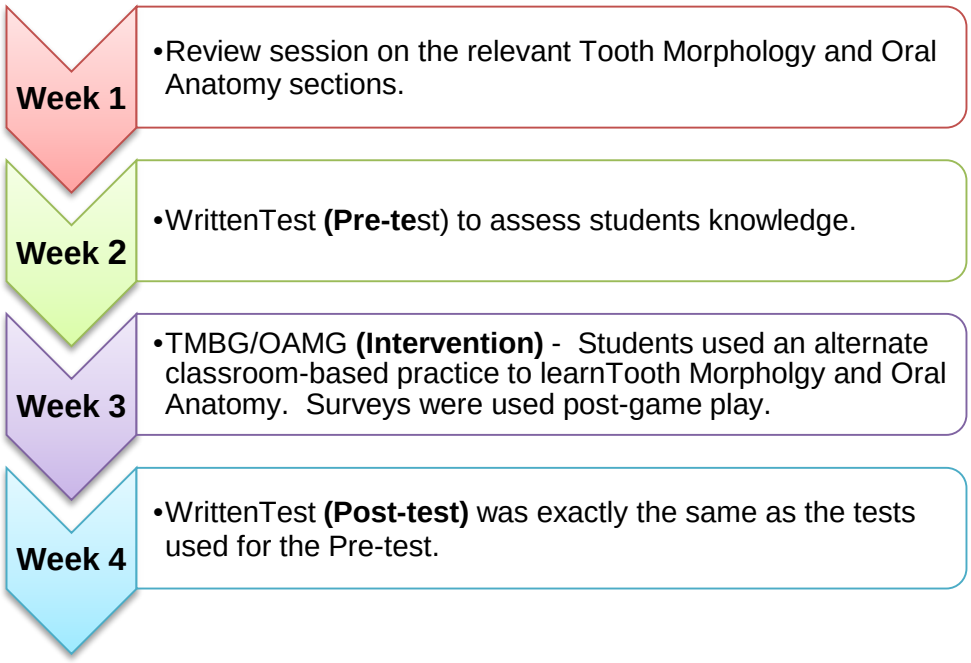


Figure 3-3: Pre- and Post-tests experimental design.
(Adapted by the researcher)

At the intervention phase, descriptive surveys were used post-game play. Surveys were adopted from readings of Check and Schutt (2012: 160), who noted that surveys can enhance understandings on pedagogical practices and efficiently measure many variables without substantially increasing time and cost. Therefore, a 14-question survey was used in 2009, 2010 and 2011 to assess the Tooth Morphology board game (Appendix 7), and the Oral Anatomy multimedia game (Appendix 8).

The surveys for the Tooth Morphology board game (TMBG) and Oral Anatomy multimedia game (OAMG) included three main sections, namely:

- Section A, which asked for demographic[7] details.
- Section B, a closed-ended question measured by a five-point Likert Scale (1 = Strongly Disagree; 5 = Strongly Agree) was used to gain information on students' perceptions of the discipline-specific subject.

[7] This study uses the 'race' or 'population group' categories of Statistics South Africa, namely: Black African, Coloured, Indian or Asian, and White Statistics South Africa. 2003. *Census 2001: Census in brief/Statistics South Africa*. Pretoria: Statistics South Africa. Available: http://www.statssa.gov.za/census01/html/CInBrief/CIB2001.pdf (Accessed 2 September 2010).

- Section C, two closed-ended questions measured by a five-point Likert Scale (1 = Strongly Disagree; 5 =Strongly Agree) was used to gain information on the perceptions of students on the instructional and technical designs of the board game/ multimedia game.

Three open-ended questions enabled free responses regarding learning through games and whether students acquired any skills from playing the game.

3.5.3 Data Analysis: ***Quantitative Phase 1****-The Experimental Stage*

Statistics has two broad categories namely, descriptive and inferential. The purpose of descriptive statistics is to describe, organise and summarise a particular set of quantitative data (Lind, Mason and Marchal 2002). Although such statistics make no inference or predictions, they are useful in summarising results for an experiment. Both univariate and bivariate descriptive statistical procedures were used to analyse the survey data in this study. Cross-tabulation and frequency counts were used to analyse the survey demographic information and the students' responses to separate items on each survey subscales (Tashakkori and Teddlie 1998: 117). The data was analysed using SPSS (Version 20®). Bar graphs were used to present the data in Chapter 4.

Johnson and Christensen (2012: 481) state that inferential statistics, by contrast, goes beyond the immediate data and uses the laws of probability to make inferences and draw statistical conclusions about populations based on sample data. Essentially, inferential statistical tests are used to examine the hypothesis in a study (Creswell 2009). In testing the hypothesis for this study (Chapter One, Section 1.6), the independent t-test was deemed the most appropriate parametric test for comparison of the means, and for testing any significant difference between two variables (Lind, Mason and Marchal 2002: 348-351). In particular, a paired t-test was used to analyse the pre- and post-test scores with $p<0.05$ set as statistically significant. The arithmetic mean and Chi-square analysis was computed to test the correlation between the demographic data and students' perceptions. Factor Analysis was performed for the data obtained from the Likert Scale to identify underlying variables, or factors, and to explain the pattern of correlations within a set of observed variables.

*3.5.4 Data Collection Procedures: **Qualitative Phase 2**-The Inferential Stage*

As mentioned in Chapter Two, little is known on the pedagogical value of games in the provision of epistemological access to students. Hence, in seeking a more comprehensive and complete understanding of learning through games and whether it enables students' access to knowledge, a case study strategy was adopted in the second, qualitative phase. A distinguishing feature of a case study approach is that it relies on using multiple sources of evidence to "retain the holistic and meaningful characteristics of real-life events" (Yin 2009: 4), such as students interacting in a classroom. This entire study was a single case as it examined Dental Technology students' perceptions at the Durban University of Technology. This study also exhibited the essential boundedness of a case study as it was confined by time-and place and, as indicated in Section 3.5.1, was limited to Dental Technology first-year students.

Stake (1995: 3-4) presents three case study typologies namely, intrinsic, instrumental and collective. He reports that the researcher's primary interest in an intrinsic case is to understand a particular case, which could be a problem in a particular work situation (context). An intrinsic case study is often used in exploratory research by studying a single case in-depth (Johnson and Christensen 2012). Stake (1995) describes the second type of case as instrumental since certain contexts may be important, but other contexts that may be regarded as important to the case are of little interest to the study. His explanation notes that in researching Swedish pre-college teachers and the way they assess, a teacher may be chosen as the case study. Particular attention is given to looking broadly at how the teacher assesses the students work and whether or not it affects her/his teaching style. It is instrumental to accomplishing something other than understanding this particular teacher. Johnson and Christensen (2012: 396-398) elaborate that researchers doing instrumental case studies are primarily interested in understanding something more general than they are in making conclusions that are specific to the case and its particular setting. Finally, a collective case study centers on finding out about a particular phenomenon from a number of different cases (Stake 1995), hence they are usually studied instrumentally rather than intrinsically (Johnson and Christensen 2012). It is worth noting that the case study in the present investigation can be described as instrumental.

From a sociological perspective, Chadderton and Torrance (2011: 53-54) provide another important characterisation of a case study. They maintain that it is an approach that seeks to engage and report on a complex social and educational activity. This approach privileges an in-depth enquiry of the case study by identifying and describing before attempting to analyse and theorise the case. Hence, Cohen, Manion and Morrison (2007) caution that the significance, rather than frequency, of observations in a case study offers insight into the real dynamics of situations and participants.

3.5.4.1 Data Collection-The Inferential Stage

In wanting to make sense of the phenomenon under study, specifically understanding the pedagogical potential of discipline-specific games in the provision of epistemological access, this research aligns to Chadderton and Torrance's (2011) understanding of a case study. Johnson and Christensen (2012) and Gerring's (2007) in-depth focus of 'the case' within a bounded system also supports this case study approach. This study also aligns to Stake's (1995) claim that qualitative orientation (preferring an inductive approach) toward case study research, enriches studies.

As previously noted in Chapter Two, the research into students' learning through games in the provision of epistemological access is under-theorised, with studies generally focused upon the representational dimension of the game. Therefore, to develop holistic understandings of the pedagogical value of games required theorising students' experiences by drawing insights from the case study investigated. Consequently, this study used multiple data sources (Stake 1995; Yin 2009; Creswell and Plano-Clark 2011; Johnson and Christensen 2012) to provide richness of data and in-depth descriptions of students' experiences of learning through games. Specifically, these included focus groups, direct observations of students in their naturalistic classroom settings, and visual data such as digital photographs and video recordings. These characteristics are expanded in the section below.

3.5.4.2 Focus Groups

Focus groups are frequently used in mixed methods research to facilitate dialogue (Roulston 2010) and to elicit in-depth information in a way that would not be possible in a one-to-one interview situation. Cohen, Manion and Morrison (2007: 376-377)

report that focus groups are useful to triangulate qualitative data with more traditional forms of surveys and observations. It can also strategically encourage quiet and shy students to voice their opinions. Equally important, the adoption of focus groups as a data collection tool also served to investigate the assumptions outlined in Chapter One (Section 1.7), that the integration of realistic morphological and anatomical representation in discipline-specific games intimates that Dental Technology concepts are situated in their meanings. It is hoped that the games will therefore facilitate the contextual embedding of formal knowledge and in the process will possibly enable students to behave and express themselves in the context of Dental Technology.

The selection of focus groups followed the procedures and guidelines as outlined by various scholars such as Johnson and Christensen (2012: 204-205), Check and Schutt (2012), Roulston (2010: 35-49) and Cohen, Manion and Morrison (2007). As outlined in Table 3-3, based upon the number of students per subject per year, twelve focus groups emerged, each of which included between eight to twelve students. Prior to conducting the focus groups, and to maintain anonymity, students were assigned numbers. As previously mentioned, participation in the focus groups was voluntary, and with the students' permission (Appendix 9) the discussions were digitally recorded. The focus group comprised of a 60-90 minute discussion with the researcher on how the students characterised their experiences of learning through games.

To systematically explore the connection between games and epistemological access, the content of the focus group discussion on the TMBG and OAMG games was guided by the following set of broad, open-ended questions:

1. What is it like to learn Tooth Morphology or Oral Anatomy? Are they difficult/easy subjects? Why are they so difficult or easy?
2. In what way is learning with the games different from learning the same material in class?
3. I know I made the games and I was there, but it would really help me if you could describe what happens when you play the games.
4. How have games affected, or not affected, learning Tooth Morphology and Oral Anatomy? Please explain.

5. Do you, or do you not, believe that games can help students improve their learning of the morphological and anatomical content? Please explain.
6. What were the academic benefits of learning through games? Please explain.
7. Apart from the academic benefits, did the games provide any other benefits? Please explain.
8. What improvements do the games need? Please explain.
9. Do you have any other comments on learning through games?

3.5.4.3 Direct Observation of Students in the Classroom

By studying the students in their actual or natural settings in the classroom the researcher was able to observe students directly in terms of what was taking place *in situ.* This practice is consistent with Cohen, Manion and Morrison (2007: 396). Direct observations of students playing the TMBG and OAMG therefore assisted the researcher to assess student conceptions of teaching and learning through games, and to capture such meaning that is beyond a level of description only. The students' behaviour and extracts of their conversation during game play were also noted.

3.5.4.4 Visual Data

Evidence, such as that obtained from digital photographs and videos, are rich sources of data collection (Johnson and Christensen 2012: 211). The researcher acted as a participant observer (insider) and took visual data in the form of photographs and videos to capture how students behaved while learning Tooth Morphology and Oral Anatomy using games. Student responses to the open-ended questions on the surveys in the quantitative first phase also contributed to the multiple data.

3.5.5 Data Analysis: ***Qualitative Phase 2-****The Inferential Stage*

From a sociological perspective, the discussion that emanated from the focus groups was assessed in terms of students' perceptions of learning through games and its ability to enable them to gain access to morphological and anatomical knowledge. Due to a lack of research in this regard, this study required a theoretical perspective to analyse the descriptions of the students' learning experiences through games. Therefore, Bernstein's (2000) concepts of educational knowledge codes and Maton's (2007) Legitimation Code Theory was found to be appropriate and is elaborated in the section below.

3.5.5.1 Organisational and Analytical Coding of Data

Digitally recorded discussions of the focus groups were transcribed verbatim. It must be noted that students' verbatim transcriptions indicated that most of them had difficulty in understanding the questions. This possibly links to the South African Survey of Student Engagement (2010) institutional report which showed that 16.23% of DUT students are English first-language speakers, while 69% are IsiZulu first-language speakers.

The transcripts were analysed by thematic coding. This process consisted of two stages. The first stage entailed using a form of data reduction, through applying codes to the data. This form of data reduction was obtained from Roulston (2010: 150). Coding was conducted by phrasing or paraphrasing the key words of the students, in order to identify conceptual categories. During this coding process, the researcher systemically developed descriptive code labels for the categories, which were manually recorded in the first stage. Nvivo 9 (QSR International Pty Ltd, 2009) was used in the second stage to electronically apply descriptive code labels and to organise the categories in terms of generating two levels of coding, namely: (1) Bernstein's concept of classification and framing; and (2) Maton's Legitimation Code Theory. This entailed analytically coding the data to develop a language of description for the focus group data, which according to Bernstein (2000: 133) is characterised as a translation device that describes the relationship between theory and empirical data. He also outlined that theory has an internal and external language of description.

Ashwin (2009: 134) elaborates that an internal language of description, or L^1, is the way in which theory, or a conceptual language, simplifies the social world. In contrast, the external language of description, or L^2, is what would count as empirical support of the theory. Ultimately, L^2 serves as a translation device that activates dialogue between L^1 (theory) and L^2 (empirical data). In essence, and gauged from Chen, Maton and Bennett (2011: 133) , this makes it possible to "generalise and abstract away from the particularities of the case studied without losing its specificities". The insights from Chen, Maton and Bennett (2011) guided the development of the translation device in this study, the results of which are discussed in Chapter 4. The remainder of this section presents the language of description developed in this study for Bernstein's concepts of classification and framing, and Maton's epistemic and social relations.

3.5.5.2 Characterising the pedagogical potential of learning through games

As indicated in Chapter Two, vocational programmes such as Dental Technology are characterised as a region since it faces to the disciplines of the academy and the world of work. In seeking to understand the underlying knowledge structure of a region and how it relates to the outcomes of the students' learning experiences through games, Bernstein's (2000: 7-13) principles of classification and framing were used. Classification (C) refers to the strength of boundaries between categories of knowledge or contexts. Bernsteinian scholar Barnett (2006) notes that classification refers to the 'what' of knowledge, and in pedagogic terms, the way in which knowledge is presented in the curriculum. In this study, classification is how bounded Dental Technology is from other programmes, or how bounded the disciplines within it are. Stronger and weaker values may be assigned for classification (+C/-C) depending, for instance, on the degree of differentiation of disciplines in a curriculum. For example, stronger classification (+C) can be used to describe a context where the boundaries between the content of a discipline-specific subject and other kinds of educational knowledge are clearly defined. As a result of these distinct boundaries, the content knowledge of a discipline-specific subject is highly insulated from the content knowledge of other kinds of educational knowledge, or from knowledge learned outside the educational context (namely: everyday knowledge). Conversely, a relatively weaker classification (-C) indicates blurred boundaries, thus reducing insulation between categories of content. The intention of understanding the concept of classification was to determine the boundaries of Tooth Morphology and Oral Anatomy within Dental Technology.

Bernstein (2000: 12) claims that framing (F), by contrast, is concerned with 'how' meanings are to be put together and the forms by which they are to be made public. As outlined in Figure 3-4, in pedagogic practice framing is the selection of what goes into the course (or game); sequencing (who decides what comes first, what comes second) in the course (or game); pacing (who decides the rate of expected acquisition) of the course (or game); the criteria of the knowledge to be acquired; and the relations between categories (between academics and students) within the curriculum. It can be inferred that framing is therefore the internal logic of the pedagogical practice because it involves methods that transform the knowledge into the messages of the curriculum. Stronger and weaker values may also be assigned for framing (+F/-F),

depending on whether the lecturer or the student is in control (or in perceived control) of the communication.

For example, stronger framing (+F) can be used to describe a context where the control over communications in pedagogic relations (for example: the selection, sequencing and pacing of the content of a discipline-specific subject) is clearly controlled by the lecturer. In contrast, relatively weaker framing (-F) refers to where the roles between lecturer and student are less hierarchical or defined, and students appear to be in control. Bernstein (2000) further clarified that it is possible for the framing values to vary with respect to the elements of the practice. For example, he explains that there could be a weak framing over pacing but strong framing over other aspects of the discourse. This explanation was valuable in this study as it provided a clearer understanding of the pedagogical practice of using games in Dental Technology.

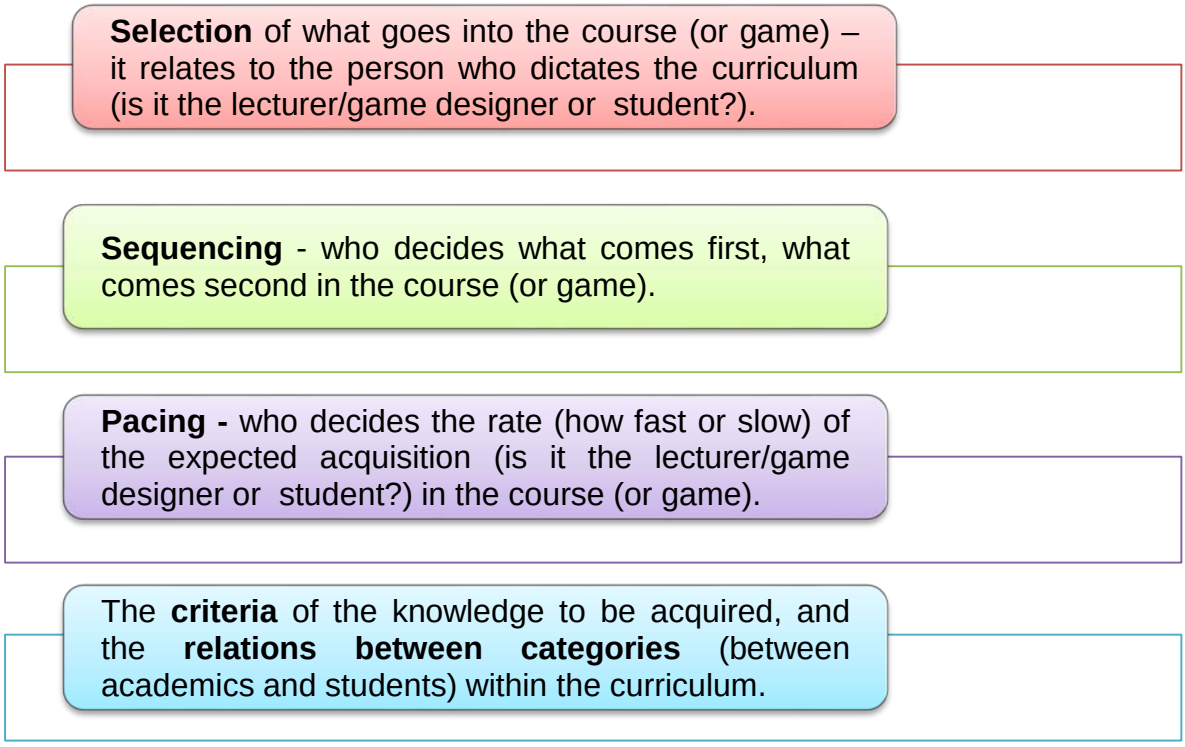


Figure 3-4: Framing the control within the course (or game)
(Adapted from Bernstein (2000))

In addition, strengths of classification and framing may vary independently of each other. As illustrated in Figure 3-5, the combination of these differing strengths produces four potential knowledge code modalities, namely: **+**C, **+**F; **-**C, **+**F; **+**C, **-**F;

and -C, -F. Diaz (2007: 90-92) explained that codes are the underlying principles that transform subjects into meanings at the reproduction and acquisition levels. At the reproduction level codes are concerned with the principles of classification and framing. At the acquisition level codes are concerned with the recognition and regulation rules.

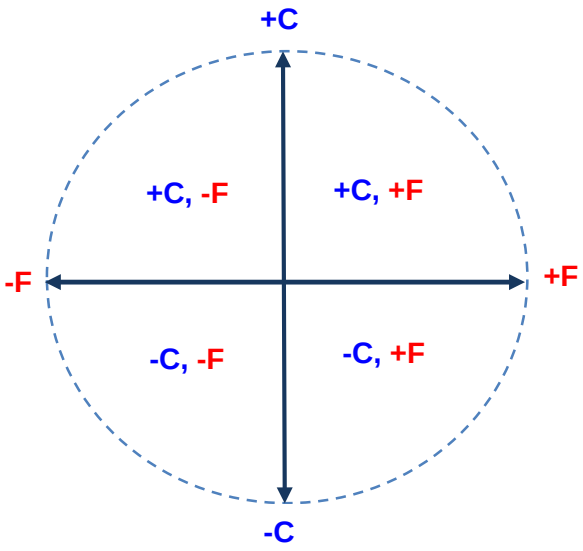


Figure 3-5: Knowledge Codes
(Adapted from Bernstein (2000))

According to Bernstein (2000: 17), recognition rules are the means by which students "are able to recognise the specialty of the context that they are in", and the realisation rules enable them to produce "the expected legitimate text". Notably, the recognition rule is derived from the classification principle and the realisation rule is derived from the framing principle. To be able to speak and act appropriately in a particular educational context, it is necessary that the student is able to recognise the context (recognition rule). Following this, the student must be able to communicate what he or she knows in a way that is understandable and acceptable to people in this context (realisation rule). The concepts of recognition and realisation rules were deemed valuable to this study, as they facilitate an enriching understanding of the underlying structuring principles of the students' learning experiences through games. Classification and framing have been widely applied in educational research and is evident in the work of Wheelahan (2009), Case (2011) and Shay (2012), amongst others.

Extending on Bernstein's work, Maton (2007) presents a conceptual framework named the Legitimation Code Theory (LCT). This theory brings the structure of the knower (student or teacher) into the analysis. He argues that disciplinary knowledge practices may contain assumptions about who is a legitimate knower, as well as their impacts on their qualities and the qualifications required to legitimately teach and learn a discipline. For LCT, knowledge and educational practice are conceived as 'languages of legitimation'. Epistemological access is thus understood as students' acquisition of such languages and how they legitimately realised this through games. Maton's Legitimation Codes Theory provided an explanatory and conceptual toolkit to analyse knowledge and educational practice (languages of legitimation) along five dimensions, namely: Autonomy, Density, Specialisation, Temporality and Semantics. This study drew upon one dimension only, that of Specialisation. It must be noted that from all the dimensions LCT (Specialisation) is the most researched, followed by LCT (Semantics). The other dimensions are yet to be more fully investigated and further developed (Maton 2013).

As elaborated by Carvalho, Dong and Maton (2009), the dimension of Specialisation is based on the premise that every practice, belief or knowledge claim is about or orientated towards something and by someone, and thus sets up an epistemic relation [ER] to the object (what knowledge is being studied and how it is obtained - knowledge codes) and a social relation [SR] to the subject, author or actor (who is studying the particular knowledge-knower codes). Notably, LCT Specialisation subsumes Bernstein's knowledge codes as it uses the concepts of classification and framing to examine the strengths of the epistemic and social relations. Each relation can exhibit relatively stronger (+) or weaker (-) classification and framing, and consequently the strengths between the relations generates four principal legitimation codes of Specialisation (Figure 3-6), namely:

- *Knowledge code* (ER+, SR-) is given when possession of specialised knowledge, skills or techniques is emphasised as the basis of achievement, while the attributes (or dispositions) of knowers are viewed as less significant;

- *Knower code* (ER-, SR+) is given when attributes (or dispositions) of knowers are emphasised as the basis of achievement, whether these attributes are

viewed as natural, cultivated or related to the knower's social position. Specialist knowledge is less significant;

- *Élite code* (ER+, SR+) is where legitimate insight and membership is based not only on possessing specialist knowledge but also being the right kind of knower; and

- *Relativist code* (ER-, SR-) is where legitimacy is outwardly determined neither by specialist knowledge nor by particular dispositions. Basically it is a form of 'anything goes'.

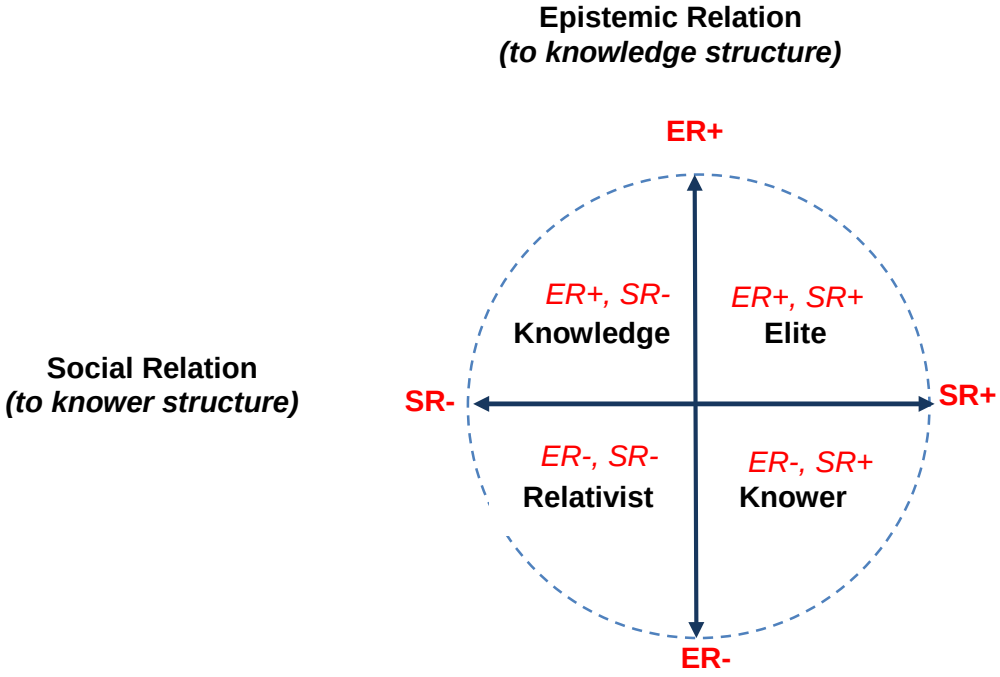


Figure 3-6: Legitimation codes of Specialisation
(Adapted from Maton (2007: 96))

Note: The + and – draws from Bernstein's work to show the relative strengthening and weakening of classification and framing in the four codes.

While different uses of LCT have been demonstrated in various studies (Lamont and Maton 2008; Thornton 2008; McNamara 2010), Carvalho, Dong and Maton (2009: 488) cautioned that there may be struggles over which code is dominant, thus causing what is termed a code clash. They elaborated that every educational practice or context is dominated by a specific code that embodies the unwritten rules of the game.

Not everyone is able to recognise or is able to realise these rules or underlying principles. It is worth noting that the concept of a code clash subsumes Bernstein's concept of the recognition rule and the realisation rule. Significantly, Dental Technology students' perception of knowledge is central to LCT in terms of demonstrating possession of specialist knowledge (knowledge code); attributes and dispositions (knower code); both (elite code); or neither (relativist code). The specialisation code of the discipline would thus have a direct influence on the appropriateness of games as an alternate pedagogy.

In summary, Bernstein's concepts of educational knowledge codes and Maton's knower legitimation codes worked together to provide a language of description to richly describe and explain the discussions of the focus groups. In particular, these concepts provided productive insights on what students regarded as legitimate access to morphological and anatomical knowledge through games. This analysis aimed for a rigorous theorisation by examining empirical relations and conceptual relations and their interactions.

3.5.5.3 Analysis of data from Direct Observation of Students in the Classroom

In considering the advice of various scholars (Cohen, Manion and Morrison 2007; Check and Schutt 2012; Johnson and Christensen 2012), the observational data of students playing the games in the classroom was generated into texts to provide a reflexive assessment of the pedagogical practice. This analysis included organising and categorising the data into manageable themes, patterns, trends and/or relationships. The analysis of the observations occurred at two levels. Firstly, they captured features of the classroom-based practice. Secondly, they served as an enquiry into the observation itself, where attempts were made to reveal aspects of the quality of pedagogy through games. This two-level analysis valuably created a conceptual space in providing a creative way of supplementing the focus group data. This practice could be supported by the work of Roulston (2010).

3.5.5.4 Data Triangulation

Triangulation of the different data sources is important to qualitative case study analysis (Creswell and Plano-Clark 2011). In this study, and as observed in Figure 3-7, focus group discussions, together with the observational data, conceptually

enriched the pre- and post-test scores and survey data. The visual data supplemented the observational data in an effort to find alternate interpretations of the events being investigated. This is in accordance with Green, Kreider and Mayer (2011). The open-ended data of the survey was also analysed by thematic coding and augmented the discussions of the analysis.

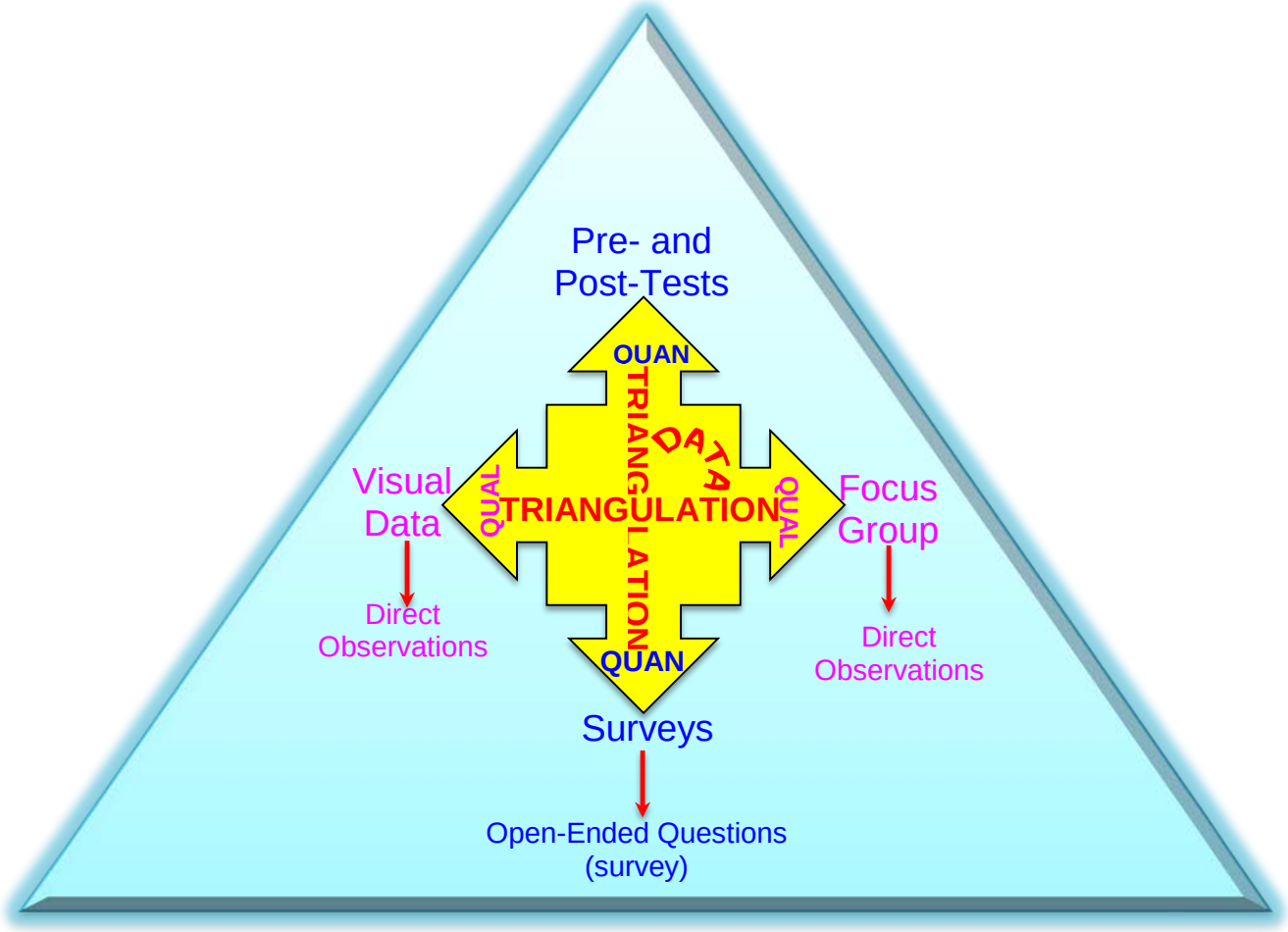


Figure 3-7: Data Integration

3.6 Validity and Reliability: Main Study

Advocates of mixed methods research (Creswell 2009; Teddlie and Tashakkori 2009; Creswell and Plano-Clark 2011; Graff 2014) have clarified the differences of quality in quantitative and qualitative data. They described that data quality in quantitative research is based on validity (that is whether the data represents the constructs they were assumed to capture) and reliability (that is whether the data consistently and accurately represents the construct under examination). Data quality in qualitative research, on the other hand, is based on trustworthiness (are findings credible

interpretations of the participants' data) and dependability (the quality of the integration of data collection, data analysis, and formulation of a conclusion or theory).

Furthermore, the aforementioned methodology experts have cautioned that mixed methods research needs to address internal (contextual) validity threats and external validity (generalisability and transferability) threats. According to Creswell (2009: 162), "internal validity threats are experimental procedures, treatments, or experiences of the participants that threaten the researchers ability to draw correct inferences from the data about the population in an experiment." In contrast, external validity threats emerge when incorrect inferences from the sample data are made to other persons, other settings, or to past or future situations. In attempting to reduce these threats, the following validity and reliability procedures were used in this study.

3.6.1 Quantitative phase

Content validity ensured that the survey focused on concepts and constructs that emerged from the review of literature on games. The internal consistency of the survey was assessed through Cronbach's alpha. Cronbach's alpha reliability coefficient normally ranges in value from 0 to 1 and may be used to describe the reliability of factors extracted from dichotomous and/or multi-point formatted questionnaires or scales. The closer Cronbach's alpha coefficient is to 1.0, the greater the internal consistency of the items in the scale. To determine acceptable reliability coefficients, George and Mallery (2011) propose the guideline in Table 3-5. For the data in this analysis, the value exceeds acceptable standards, which means that the underlying construct for this study was scored in a consistent manner, and that results obtained from the analysis can be considered reliable.

After the students played the game and completed the survey, a debriefing session followed. This educational opportunity, and as presented by Crookall (2010), allows students to reflect on and share their views of their game experiences with the researcher. Debriefing, together with the video recordings and digital images, was used to enhance the validity of the students' opinions.

Table 3-5: Cronbach's alpha coefficient

Cronbach's alpha	Internal consistency
α ≥ .9	Excellent
α ≥ .8	Good
α ≥ .7	Acceptable
α ≥ .6	Questionable
α ≥ .5	Poor
α ≤ .5	Unacceptable

3.6.2 Qualitative phase

Lincoln and Guba (1985 as cited in Tashakkori and Teddlie 1998: 91) claim that the purpose of a peer examiner is to explore "aspects of the inquiry that might otherwise remain only implicit within the inquirer's mind". Creswell (2009: 192) concurs with the authors above. He also believes that using peer debriefing will validate the study as it involves the interpretation beyond that of the researcher. Trustworthiness of the qualitative results and inferences was corroborated by the use of a peer examiner during the student focus group discussions. This was adopted during the study to ensure that the researcher's personal beliefs and knowledge that are shaped by her dental technology background did not interfere with the discussion of the focus groups.

Triangulation, as reported by Roulston (2010: 84), shows that the researcher does not only rely on claims made within the focus group settings to generate assertions. As illustrated in Figure 3.5, the researcher used methodological (quantitative and qualitative methods) triangulation and data (converging different sources of information) triangulation techniques to further aid in strengthening the reliability. In addition, interrater reliability was used to evaluate the degree of agreement of two raters observing student interactions during focus group discussions. Visual data from digital photographs was used, together with spending time in naturalistic classroom settings observing student interactions. This could have further enhanced the reliability of this study.

3.7 Summary of the chapter

This chapter explained the "epistemological home of this inquiry" (Henning, Wilhelm and Smit 2004: 36) in terms of the theoretical and methodological approaches used in this research. In seeking to understand the empirical value and pedagogical value of games in the provision of epistemological access, the study adopted a mixed methods sequential explanatory research strategy. The data collection and data analysis methods for the main study were guided by the outcomes of the preliminary and pilot work conducted.

In the first, quantitative phase, data was collected from pre- and post-tests, surveys, direct observations of students in the classroom and visual data. Statistical analysis techniques were used to interpret results. In the second, qualitative phase, data was collected from focus groups. In seeking to rigorously theorise student opinions, Bernstein's (2000) concepts of educational knowledge codes, specifically classification and framing concepts, and Maton's (2007) Legitimation Code Theory, particularly the dimension of specialisation, were used. These two sets of theoretical concepts enabled the researcher to characterise the underlying structuring principles of games supporting the provision of epistemological access to students. Finally, the chapter outlined various measures that were undertaken to enhance the quality of the research.

The remaining chapters of the thesis are structured as follows:

- Chapter 4 analytically assesses games that are the focus of this study: the TMBG and OAMG and the extent to which students acquire epistemological access to Tooth Morphology and Oral Anatomy. The data presented is from the pre- and post-tests and surveys supplemented by debriefing sessions, video recordings and digital images.

- Chapter 5 conceptually characterises, in-depth, the extent to which students acquire epistemological access to Tooth Morphology and Oral Anatomy. The data that is presented is obtained from focus groups.

- Chapter 6 aims to make sense of the data in light of the theories that inform the research. Consequently, it presents the developed framework to support the design of games for quality teaching and learning of vocational subjects.

Chapter Four – Results and Discussion: Quantitative Phase One

This chapter presents the results and discussion of the research by addressing two of the three objectives outlined in Chapter One, that is: (1) to investigate the quality of teaching and learning in the subjects Tooth Morphology and Oral Anatomy, using the board game and the digital multimedia game, through surveys; and (2) to evaluate the efficacy of the board game and the digital multimedia game by pre- and post-tests in assessing epistemological access in the aforementioned subjects. Specifically, and as illustrated in Figure 4-1, this chapter addresses the statistical results by reporting the themes that were drawn from the surveys conducted in phase one, supplemented by the results of the pre- and post-tests and observational data. Sections two and three in the diagram will be addressed in Chapter Five.

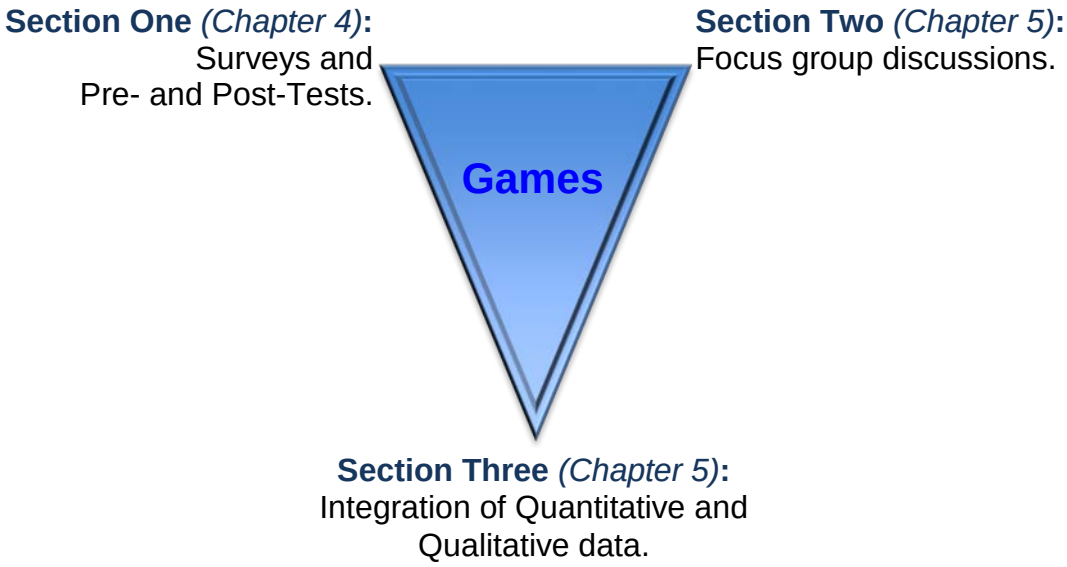


Figure 4-1: Overview of Results and Discussion

Excluding the observational data, all the data in the sections below were statistically analysed in an attempt to determine the quality of teaching and learning through games in the subjects Tooth Morphology and Oral Anatomy. All student quotations from the open-ended questions of the survey are given verbatim and are italicised. By drawing on the literature, this chapter concludes with a summary of the analysis. From this point forward, the tooth morphology board game is referred to as the TMBG and the oral anatomy multimedia game is referred to as the OAMG.

4.1 Demographic information of students playing the games: TMBG and OAMG[8]

From 90 potential participants, 83 students responded to the survey after playing the TMBG, which constituted a response rate of 92.2%. Students were described in terms of the following demographic characteristics: race, age and gender. Students were predominantly Black Africans (75.9%), with Indians constituting 18.1%; Coloureds 1.2%; and Whites 3.6%. In terms of age groups, 72% of students were between 17 – 20 years old; 25.6% were between 21 – 23 years old; and 1.2% were between 24 – 27 years old. Nearly two-thirds of the students were males (64.6%). The majority (86.7%) were first-time registered students and 73.2% reported that they had never played educational board games before.

Similarly, there were 95 potential participants for the OAMG survey, of which 82 responded. This constituted a response rate of 86.3%. In terms of demographic attributes, students were described in terms of race, age and gender. Generally, most students were Black Africans (58.5%), with Indians constituting 34.1%; Coloureds 1.2%; and Whites 4.9%. In terms of age groups, 75.6% were between 17 – 20 years old; 18.3% were between 21 – 23 years old; and 3.7% were between 24 – 27 years old. Nearly two-thirds of the students were males (64.6%). The majority (88.8%) were first-time registered students and 64.6% reported that they had never played educational board games before.

4.2 Correlations: TMBG and OAMG

The Bivariate Spearman's Rho analysis, which is used to quantify the relationship between two variables that are not measured on continuous scales (Johnson and Christensen 2012) , yielded several correlations. It is worth noting that this test does not assume that the relationship between the variables is linear. As presented in Appendix 10, this study highlights only the highest linear correlations above r=0.4 at the significance level of 0.01. Variables rendered output with a significant (2-tailed) value of 0.000 ($p<0.01$). The conclusions of this analysis are summarised in the following sections. A noteworthy attribute of this summary is that the relatively high

[8] Students who were repeating Tooth Morphology and Oral Anatomy were not duplicated in the statistical analysis.

correlations indicate that access to content knowledge was reasonably consistent through games, thus supporting the hypothesis that the games facilitated the provision of epistemological access to discipline-specific knowledge.

*4.2.1 **TMBG**: Overview of correlation analysis*

With reference to Table 2 in Appendix 10, students agreed that:

- The questions included in the TMBG helped them to understand, as well as to recall, morphological knowledge (Row 1 and 2). Consequently, this encouraged them to consult with the Tooth Morphology lecturer.
- The information gained from theory lecture classes was shown to facilitate application to practical sessions (Column 2; Row 3).
- They effectively learned difficult morphological concepts through multiple-choice quiz games (Column 2; Row 4).
- Collaboration with peers was encouraged, as instructions of the TMBG were clear (Column 2; Rows 6-8). Consequently, it was evident that they did not necessarily need the guidance of the lecturer (Column 2; Row 9).
- They were encouraged to use their notes without the lecturer's assistance, as the content of the TMBG was clearly relevant to their level of study (Column 2; Rows 10-13).
- The TMBG, particularly its game design elements, was better than traditional tutorials (Column 2; Row 14). Consequently, they agreed that learning was fun (Column 2; Row 17).
- Access to morphological knowledge through the TMBG not only made learning fun (Column 2; Row 15 and 16), but also enabled students to acquire difficult morphological concepts (Rows 18 and 19), and helped them to recall content knowledge (Column 2; Row 20). This encouraged students to learn collaboratively (Column 2; Rows 21-23).

*4.2.2 **OAMG**: Overview of correlation analysis*

With reference to Table 3 in Appendix 10, students agreed that:

- Clear questions included in the OAMG facilitated understanding and recall of content knowledge (Column 2; Rows 1-3). Consequently, this could have encouraged students to consult with the Oral Anatomy lecturer.

- Access to anatomical knowledge was a function of the instructional design of the game, which they believed was presented clearly and logically (Column 2, Rows 4-10, 29-35 and 41-48). Perhaps, this enabled students to acquire the language of anatomy (Column 2; Rows 36-39). The aforementioned characteristics made learning enjoyable (Column 2, Rows 25-28). Hence, it could be inferred that the OAMG could be a better classroom-based practice than traditional tutorials (Column 2, Row 35 and Row 47). Analogously, the discipline-specific language used in the OAMG possibly facilitated access to learning the structural and functional anatomy of the muscles of mastication and facial expression. The graphics used in the OAMG were deemed meaningful because they believed that the appropriate language was used. Consequently, learning through the OAMG could be regarded as fun as students recalled anatomical knowledge and were able to track their own progress (Column 2; Rows 11-17 and Rows 22-24). Overall, it was concluded that the anatomical language enhances the efficacy of the OAMG (Column 2, Row 18).
- The multimedia sounds of the game enhanced the graphics and helped them to track their progress in the game (Column 2; Rows 19-22). Perhaps, these game characteristics promoted its use as an improved classroom-based practice.

4.3 Hypothesis Testing

4.3.1 Pearson Chi Square Tests

As indicated by the levels of significance, Chi squared analyses in Appendix 11 (Table 4 and Table 5) revealed that the students' scoring patterns by years exhibited no statistically significant relationship between the variables ($p>0.05$). This means that the year of the study did not impact on the manner of scoring for the variable(s).

On the other hand, and in terms of the students' ratings of the perceived effectiveness of the four closed-ended questions highlighted in Table 4-1, results were statistically significantly different by age, race and gender. It can be inferred that across race groups, students held different opinions on whether the board game: made learning fun; can be used without the lecturer; and helped them to learn difficult morphological

concepts. It is worth noting that of the 5.2% of students who disagreed that the game can be used without the lecturer, 3.9% were black African students and 1.3% of the students were Coloured. Moreover, 2.7% black African students were undecided as to whether they learned difficult concepts through the TMBG.

Similarly, across age groups students held different beliefs on the concept of fun learning. The students in the 21-23 age group described the games *as "fun and helpful in terms of preparing for tests"*, as well as *"challenging and funny when removing the dice from the arch"*. The 17-20 year old students enjoyed the games when played with a partner. On the other hand, and as illustrated in Graph 4-1, across gender the student opinions on the TMBG were prominently positive as they indicated that the questions in the game helped them to easily recall morphological knowledge.

Table 4-1: Chi Square results - TMBG

TMBG: Likert Scale Items	Race (p-value)	Age (p-value)	Gender (p-value)
9. I liked the board game because:			
9.4 The materials were sufficient and can be used without the assistance of the lecturer.	0.005		
11. The board game:			
11.1 Made learning fun.	0.002	0.022	
11.2 Had questions that helped recall information easily.			0.009
11.3 Helped me to learn difficult morphological concepts.	0.000		

With reference to the OAMG, Chi squared analyses yielded a statistically significant relationship ($p<0.05$) in the results by years with regards to two statements (Appendix 11, Table 5), namely: 'appropriate sound was used' and 'provide any other reason as to why you could play the game'. To be specific, and as indicated in Graph 4-9, 4.2% of the 2009 students were undecided about the significance of sound, while a large number of students (53.6%) in 2010 found the sound used was inappropriate. Over the three-year period, 21.7% of the students recommended that the designer should: *"Improve sound effects for correct and incorrect answers".*

With regards to the perceived effectiveness of the OAMG by the students' age and race, results were statistically significantly different. It can be gathered from Table 4-2 that across race groups, there were differences in opinions with regards to the layout of the OAMG and whether learning through the game was fun and encouraged students to use their notes. In spite of the differences across race groups on the game layout and fun learning, student opinions were positive as responses ranged between agree to strongly agree (See Graph 4-7 and Graph 4-9). A small percentage of the students (3.9%), specifically 1.3% Black Africans, 1.3% Indians and 1.3% Coloureds, were undecided as to whether the TMBG encouraged them to use their notes to learn.

Table 4-2: Chi Square results - OAMG

OAMG: Likert Scale Items	Race (p-value)	Age (p-value)
8. I could play the multimedia game because: 8.5 The instruction was relevant to my level of study.		0.027
8.6 The anatomical language used was relevant and easy to understand.		0.028
8.7 Provide any other reason as to why you could play the game.	0.047	
9. I liked the multimedia game because: 9.1 The layout was creative & very effective.	0.035	0.011
9.3 Relevant & "eye catching" graphics were used.		0.007
11. The Muscle Mania multimedia game: 11.1 Made learning fun.	0.028	0.014
11.2 Helped me to learn difficult anatomical concepts related to the muscles of mastication and facial expression.		0.044
11.3 Improved my terminology while learning the anatomical concepts related to the muscles of mastication and facial expression.		0.000
11.7 Encouraged me to consult my lecture notes to clarify my understanding on the function of the muscles of mastication and facial expression.	0.000	
11.9 Provides a better tutorial alternative than the regular "old fashion" Tutorial class.		0.050

Similarly, and regardless of the differences in student opinions across age groups, student responses with regards to the anatomical language used (Q8.6), game layout (Q9.1) and fun learning (Q11.1), were prominently positive, as responses ranged between agree to strongly agree. Graphs 4-7, 4-8 and 4-9 further corroborate this.

Moreover, and as illustrated in Table 4-2, a very small percentage of students across age groups were generally 'undecided' on the instructions of the game (Q8.5=1.2%); graphics used (Q9.3=3.9%); learning of difficult anatomical concepts (Q11.2=3.9%); learning improved terminology (Q11.3=1.3%) and if the OAMG is a better tutorial (Q11.9=2.6%). Table 4-3 provides a further breakdown of the analysis across age groups. It can be inferred that the majority of students in this study who were 17-20 years old (75.6%) contributed to this analysis being statistically different.

Table 4-3: Differences across Age groups

OAMG	AGE		
	17 – 20	21 – 23	24 – 27
Q8.5-Instructions of the game		1.2%	
Q9.3-Graphics used	1.3%	1.3%	1.3%
Q11.2-Learning difficult anatomical concepts	2.6%		1.3%
Q11.3- Terminology	1.3%		
Q11.9-Better Tutorial	1.3%	1.3%	

4.3.2 Pre- and Post-Tests

To supplement the analysis of the perceived efficacy of the TMBG and OAMG, the following null hypothesis was proposed:

H_0: Students will not acquire epistemological access to Tooth Morphology and Oral Anatomy through the board game and digital multimedia game, respectively.

The most noteworthy feature in Table 4-4 is the direction of the differences in student performances, particularly the mean values of the pre- and post-test results. The 2-tailed t-tests revealed that students' performance improved significantly after playing the TMBG and OAMG ($p < 0.05$). The alternate hypothesis (H_1) was therefore accepted, as results suggest that students acquired access to morphological and anatomical knowledge through the TMBG and OAMG, respectively.

Table 4-4: Hypothesis Test results-TMBG and OAMG

TMBG	2009	2010	2011
Mean: Pre-test	44.95	58.89	50.89
Mean: Post test	49.80	72.76	84.19
p-value	0.037	0.000	0.000

OAMG	2009	2010	2011
Mean: Pre-test	36.04	31.94	56.48
Mean: Post test	48.35	60.41	70.52
p-value	0.000	0.000	0.002

Indeed, questions and claims on attributing changes in mean performance on tests to a single factor of playing the games are likely to be expected as there may be other factors influencing the way students learn through games. Hence, the aforementioned results need to be considered in light of the full range of findings and discussion in this study. Ultimately, this will provide a more rigorous analysis and in-depth description of the ways in which the games impact on student learning.

4.4 Reliability: TMBG and OAMG

Before discussing the findings of the Factor Analysis, this section will deliberate on a few issues of reliability. Table 4-5 presents the relationship between survey scales, subscales and variables, and lists the survey items measuring each variable, as well as reliability indexes for each subscale. With regards to the TMBG, the low alpha scores for Questions 8 and 9 indicate that the underlying construct was scored in an inconsistent manner. Specifically, the low alpha scores may have resulted from the inconsistent scoring patterns by the students, as indicated by the varied frequency counts in Appendix 12. Regardless of this, it is worth noting that the reliability of question 11 (α=0.817), which mainly addresses access to morphological knowledge (Appendix 7), together with the overall reliability of the survey as a new construct (α=0.794), was acceptable. This indicates that there was a level of consistent scoring by the students. Similarly, the reliability of Question 11 in the OAMG survey (Appendix 8), which mainly addresses access to anatomical knowledge (α=0.875), and the

overall reliability coefficient of the survey (α=0.868) were good. This implies that students scored consistently.

Table 4-5: Survey Scales and Predictor Variables in Quantitative Analysis

Survey scales/Factors	Subscales/Predictor variables	Cronbach's alpha α		Survey items	
		TMBG	OAMG	TMBG (Appendix 7)	OAMG (Appendix 8)
Related to Perceptions of the subject.	Overall assessment of the subject.	0.626	0.561	**Q6** 1-4	**Q6** 1-4
Related to Instructional Design.	General understanding of instructions.	0.567	0.696	**Q8** 1-6	**Q8** 1-6
Related to Technical Design of the game.	Design elements of the game.	0.338	0.603	**Q9** 1-4	**Q9** 1-5
Related to Learning through games.	Access to discipline-specific knowledge.	0.817	0.875	**Q11** 1-8	**Q11** 1-9

4.5 Factor Analysis: Perceived effectiveness of games in accessing knowledge

This section reports on the overarching themes that emerged from the data obtained from the Likert-scale.

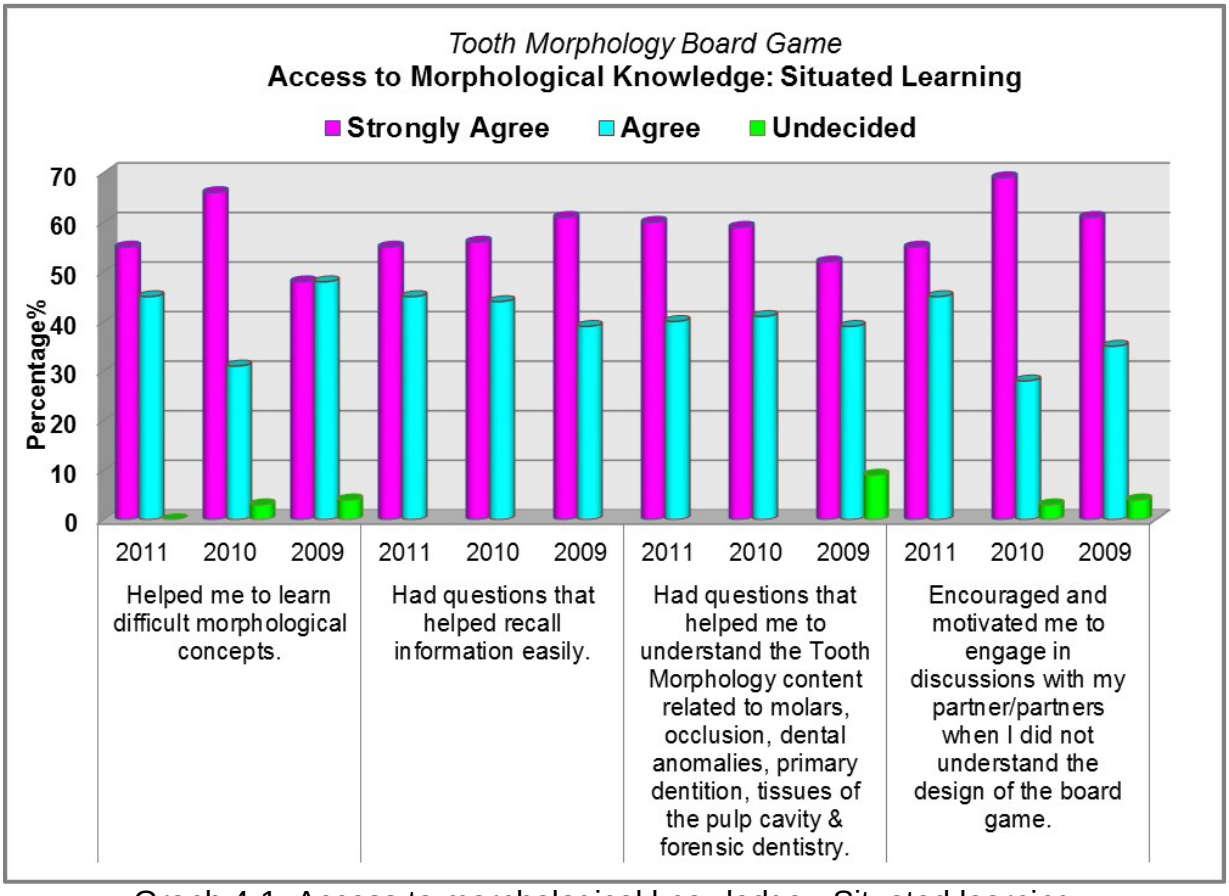
TMBG:

In general, and as derived from the rotated varimax Factor Analysis, the survey elicited students' perceived effectiveness of the TMBG in terms of three main critical themes, namely: access to morphological knowledge, instructional design of the TMBG, and technical design of the TMBG. The average loading of items per theme was above the acceptable Eigen values (> 0.5). Notably, all of the factors that constituted the components (themes) had factors that overlapped, indicating a mixing of the components. This means that the statements in the overlapping components did not specifically measure what it set out to measure, or that the component split along sub-themes. Perhaps a reason for this is that the majority of Black African students (75.9%), who are predominantly English second-language speakers (South African Survey of Student Engagment 2010) may have interpreted questions differently as expected. Consequently, each of the aforementioned themes had two sub-themes and is explained below. A noteworthy feature in the graphs below is that the strength of the mean response rate captured per theme was mainly between Strongly Agree and Agree.

Overall, 95.65% students indicated that the TMBG enabled them to access the content knowledge that was relevant to their study (Graph 4-1). The following written student comments further support this:

> *"Helped me learn different morphological concepts".*
>
> *"Acquired Tooth Morphology knowledge as how to answer the questions".*
>
> *"It had contents that are very important to understand morphology, for example, the ability to distinguish between 1st and 2nd molar".*

Consistent with Lean *et al.* (2006): 230, it can be inferred that the key elements of the TMBG involved interaction within a predetermined morphological context. Students maintained that the game: *"had questions that assisted with recalling the information easily"* and *"encourages me to engage with the material"*. As illustrated in Figure 4-1, student extracts are supported by all students agreeing that the TMBG: "*Had questions that helped recall information easily*".



Graph 4-1: Access to morphological knowledge - Situated learning

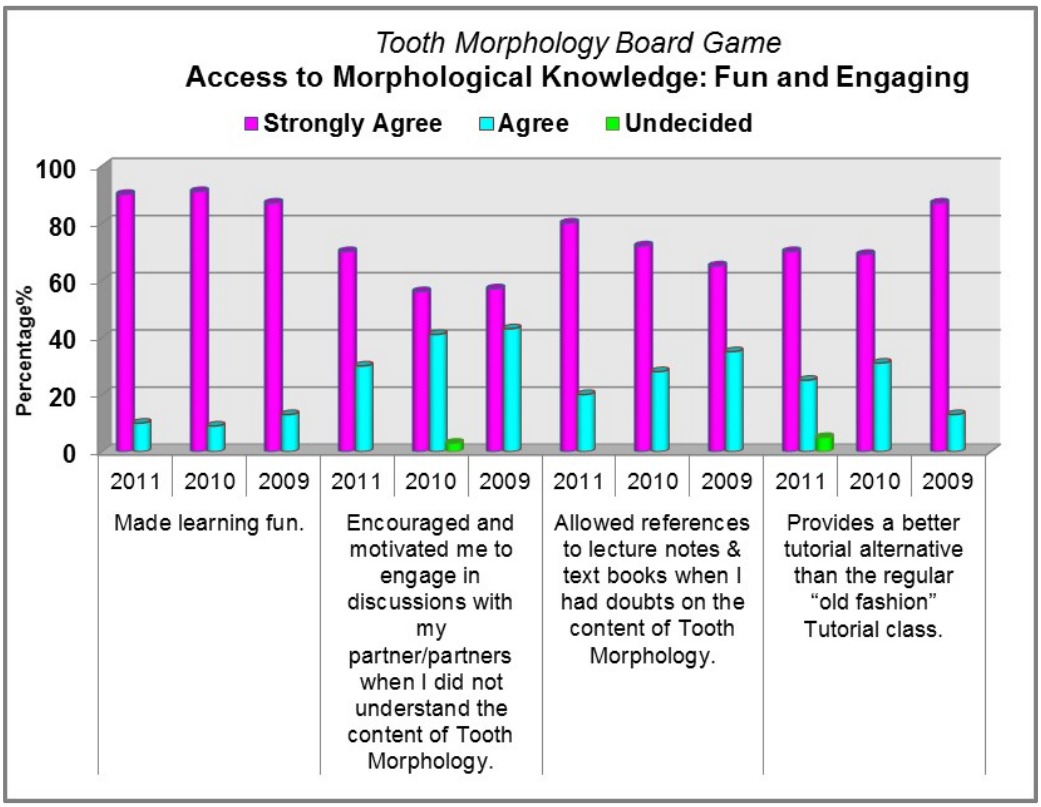
Dieleman and Huisingh (2006) believed that the concept of fun learning generates positive mental energies and enthusiasm for students to engage with complex content.

In support of their claim, it can be inferred from Graph 4-2 that learning morphological content through the TMBG was found to be academically fun, as students (99.3% overall) confirmed that they were encouraged to use their textbook and notes while discussing content knowledge with their peers. Student excerpts from the open-ended questions further corroborate this:

> *"Questions asked made me refer to my notes at the same time that is a learning technique".*

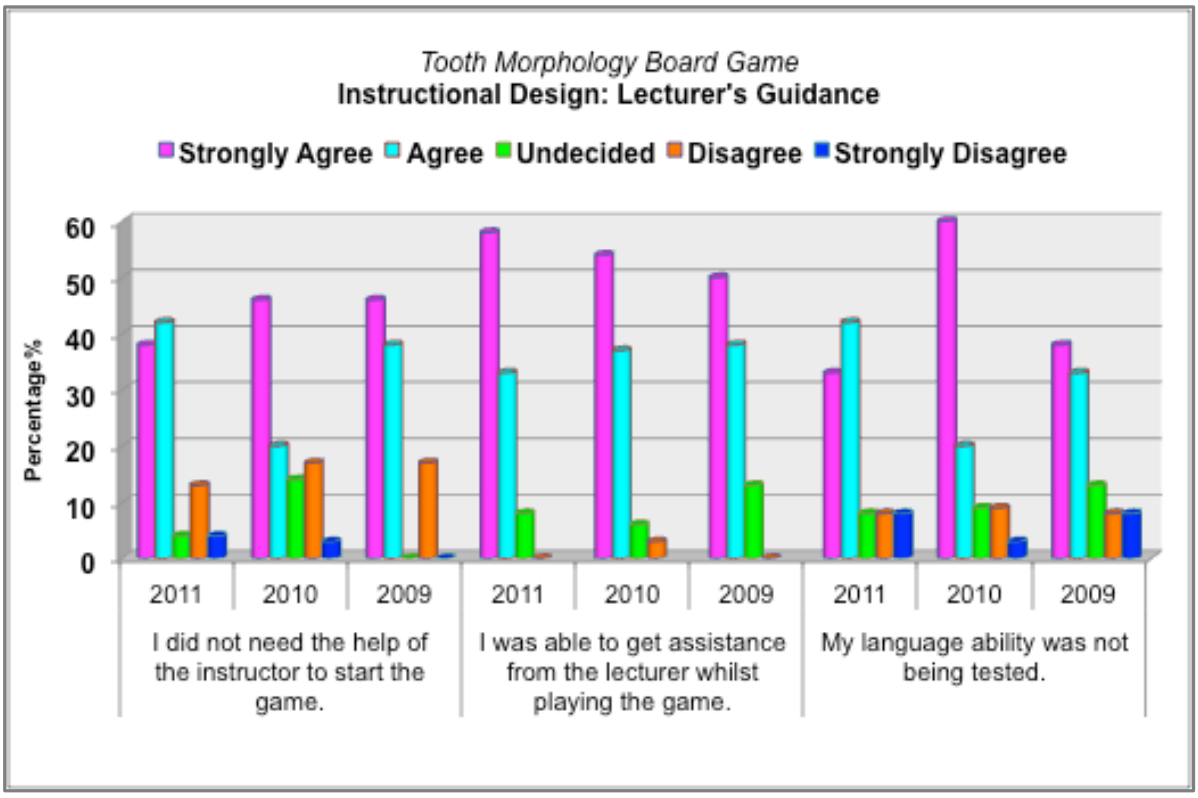
> *"Materials used was based on Tooth Morphology, required me to go over my notes before attempting to answer...learnt how to look up information in my notes".*

Conversely, some of the students noted, *"You should not be allowed to consult the notes for answers - instead think of the answers."* Consistent with Beylefeld and Struwig (2007), this result also suggests that students were engaged in learning beyond increased factual knowledge. It can therefore be argued that this is a positive indicator as to why most students (98.7% overall) agreed that the TMBG is an improved classroom-based practice in learning Tooth Morphology.

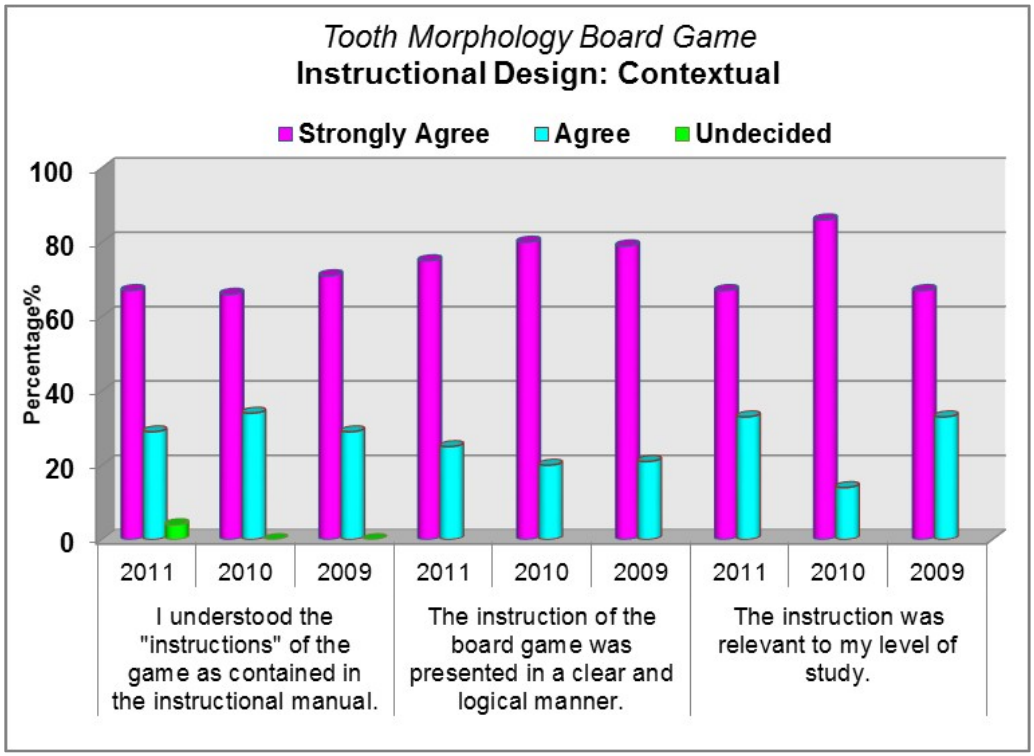


Graph 4-2: Access to morphological knowledge - Fun and Engaging

From an instructional design perspective, and as is shown from Graph 4-3, 90% of the students agreed that while they were able to get help from the instructor, 75% of them did not necessarily need this assistance. They also indicated that the game did not test their language ability. Perhaps this was the reason for students being able to work independently of the lecturer. Even though 76% of students felt that their language ability was not being tested, 24% were either 'unsure' or 'disagreed' with this finding. This negative response could possibly be attributed to, and as argued by Boughey (2002; 2005), Thesen and van Pletzen (2006) and Buckingham and Burn (2007), students struggling to understand content, in this case Tooth Morphology, that is different from their primary discourse. Hence, considering that 75% of the students who played the TMBG have English as a second language, it is reasonable to assume that 23% required the guidance of the lecturer. Conversely, and as inferred from Graph 4-4, it can also be argued that students did not require the lecturer's guidance, as the instructions of the TMBG were "*clear and easy to understand*". All students confirmed that the instructions were relevant to the level of study further supported this. Consequently, the game was *"easy to play"*.



Graph 4-3: Instructional Design - Lecturer's Guidance



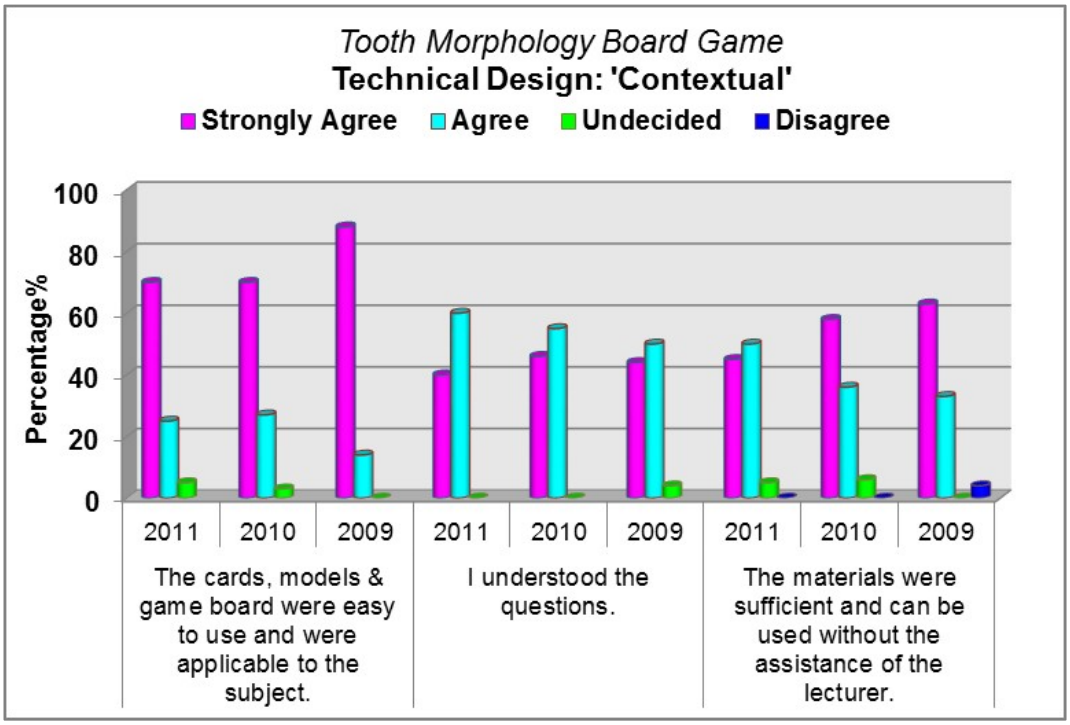
Graph 4-4: Instructional Design - Contextual

As gleaned from Graphs 4-5 and 4-6, the prominently positive student responses on the perceived effectiveness of the TMBG suggests that the use of applicable game tools (cards, models and playing tokens) and attractive colours enhanced an understanding of the multiple choice questions as was indicated in: *"It tested my ability to read and understand multiple choice questions"*. This finding can be supported by Beylefeld and Struwig (2007) and Girardi *et al.* (2010), who devised board games to engage students with core knowledge in medical microbiology, medical bio-chemistry and immunology, respectively. They noted that creative game design elements served as a bridge to access knowledge in a playful way. The qualitative reporting of the students' experiences, which will be discussed later in this chapter, adds further support to this.

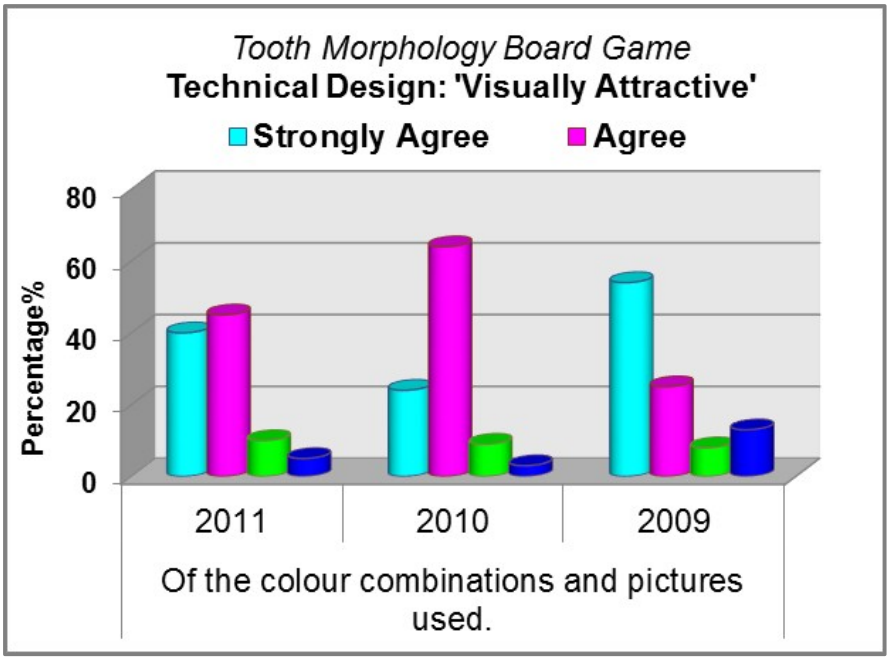
Consistent with Zagal (2010), as well as the aforementioned medical scholars, it can be argued that in conjunction with the abstract and formal content of Tooth Morhpology, the realistic game design elements makes knowledge more tangible for the students to access. The following student excerpts noted in the open-ended question related to the technical design of the board game exemplify this (Appendix 7: Section C-Q9.5):

"The design is very organised and understand much better".
"Challenging and funny when removing the dice from the arch."
"Assisted in learning difficult concepts."
"The rewards and penalties make the game unpredictable."

It is therefore reasonable to assume that realistic representations in a game was likely to stimulate conversations among students to work collaboratively, competitively or co-operatively.



Graph 4-5: Technical Design - Contextual



Graph 4-6: Technical Design - Visually Attractive

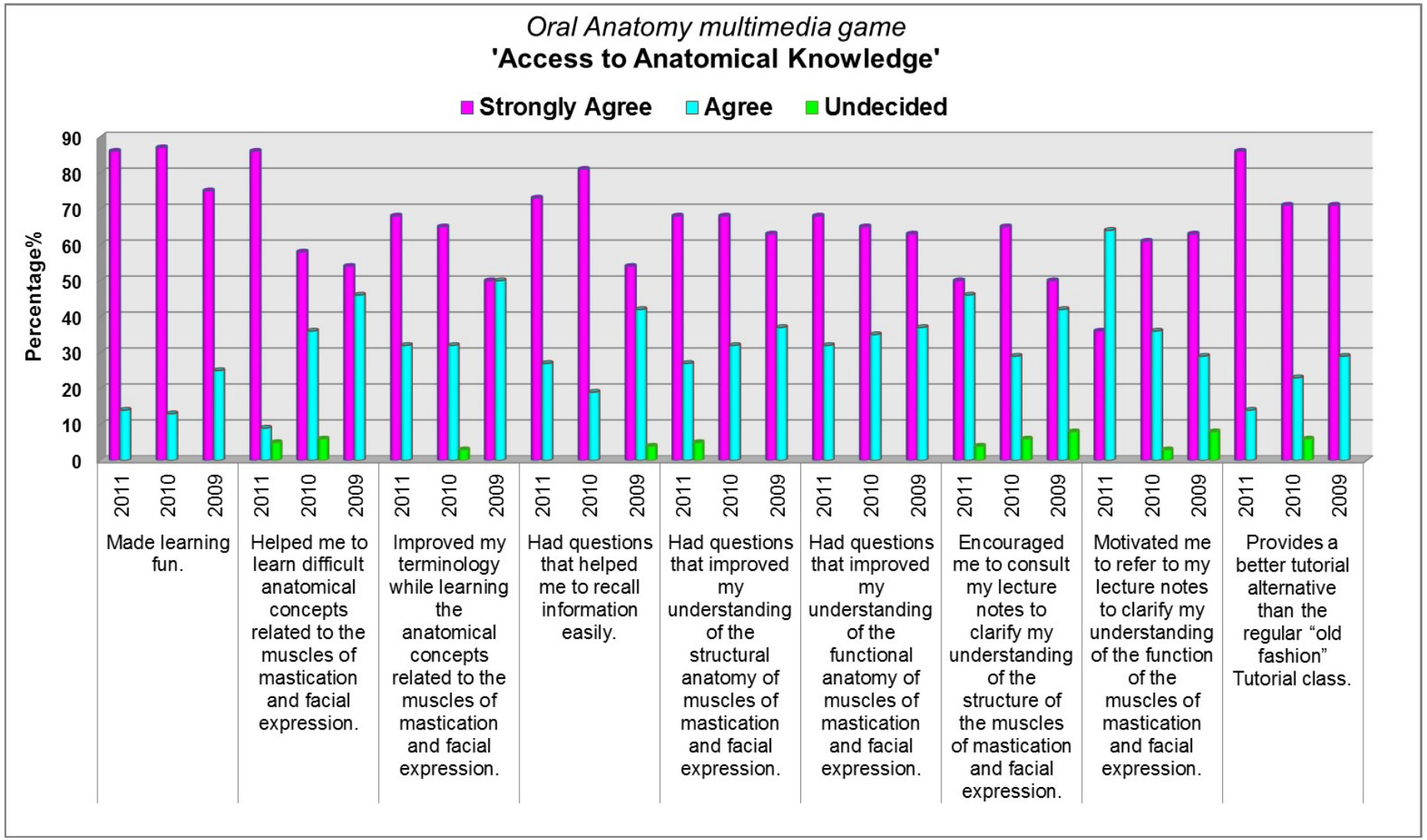
OAMG:

Generally, and as derived from the rotated varimax Factor Analysis, the survey elicited students' perceived effectiveness of the OAMG in terms of three main critical themes, namely: access to anatomical knowledge, instructional design of the OAMG, and technical design of the OAMG. The average loading of items per theme was above the acceptable Eigen values (> 0.5). It is worth noting that factors wholly loaded along a single component, implying that the components of the survey measured what it set out to gauge. Analogous to the TMBG, a noteworthy feature of the graphs in the section below is that the strength of the mean response rate captured per theme was mainly between Strongly Agree and Agree.

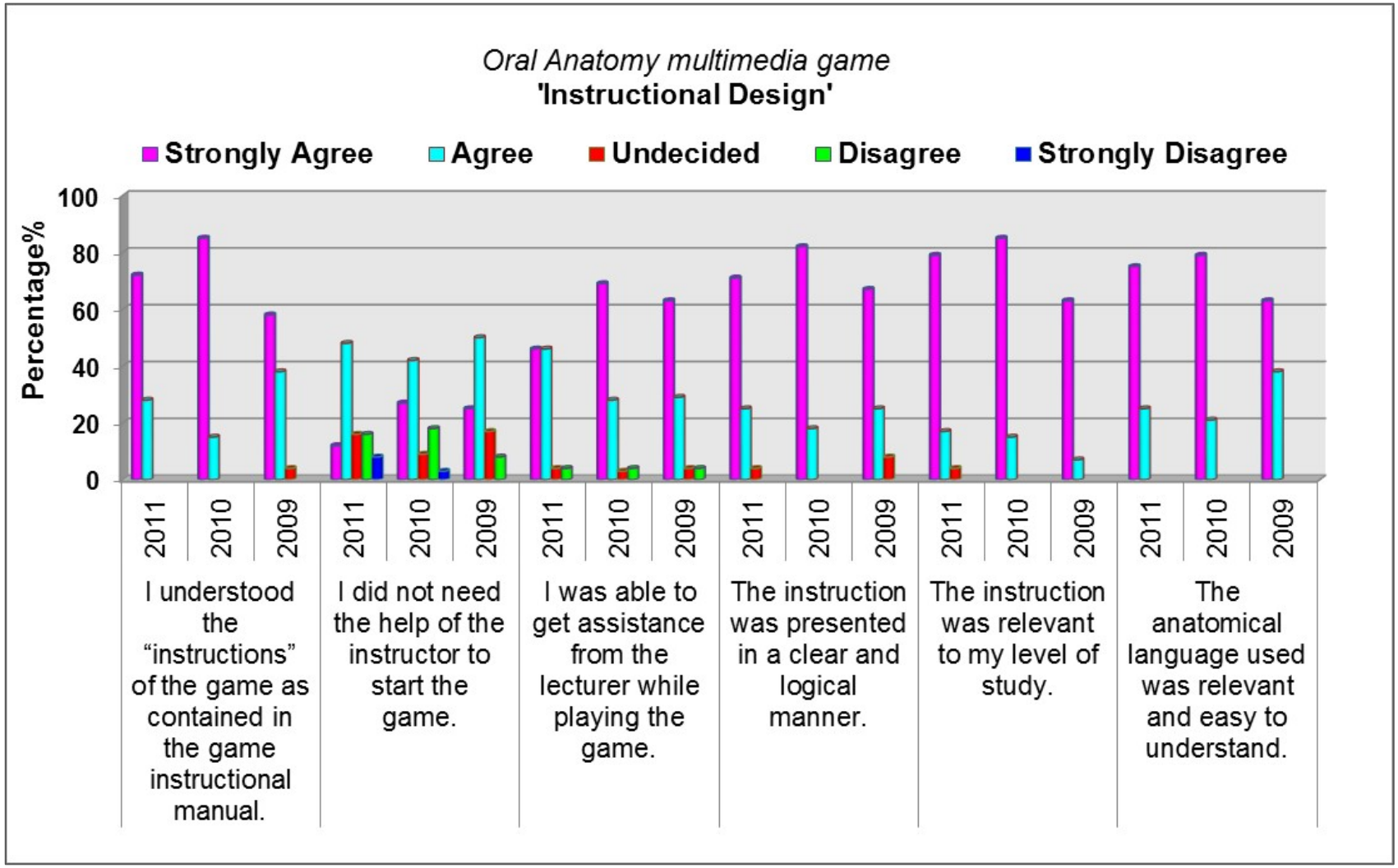
Significantly, it can be gleaned from Graph 4-7 that students accessed content knowledge through the OAMG. It is notable that there is almost complete agreement with all of the statements in Graph 4-7. Students indicated that the OAMG had elements of realistic and relevant contexts of practice that helped them to understand, learn and recall difficult concepts. Student accounts from the open-ended questions corroborated this and are demonstrated in the excerpts below:

> *"It showed the origin, insertion and action - more effective in colour - understand better."*
>
> *"Acquired additional knowledge about muscles that was not known".*
>
> *"Helped recognise muscles and their location - much easier. Being able to recall my notes".*

Although Moreno and Mayer's (2005) discussion centered on cognitive theory of multimedia learning, specifically meaningful learning in terms of structured guidance (students are provided with guided explanations of their choices), reflection (asking students to justify their answers) and interactivity (encouraging students to actively construct answers to problems), aspects of their work give additional support to the findings illustrated in Graph 4-7. In particular, meaningful learning manifested when students engaged with content knowledge and interacted by selecting the right answer.



Graph 4-7: OAMG - Access to anatomical knowledge



Graph 4-8: OAMG - Instructional design

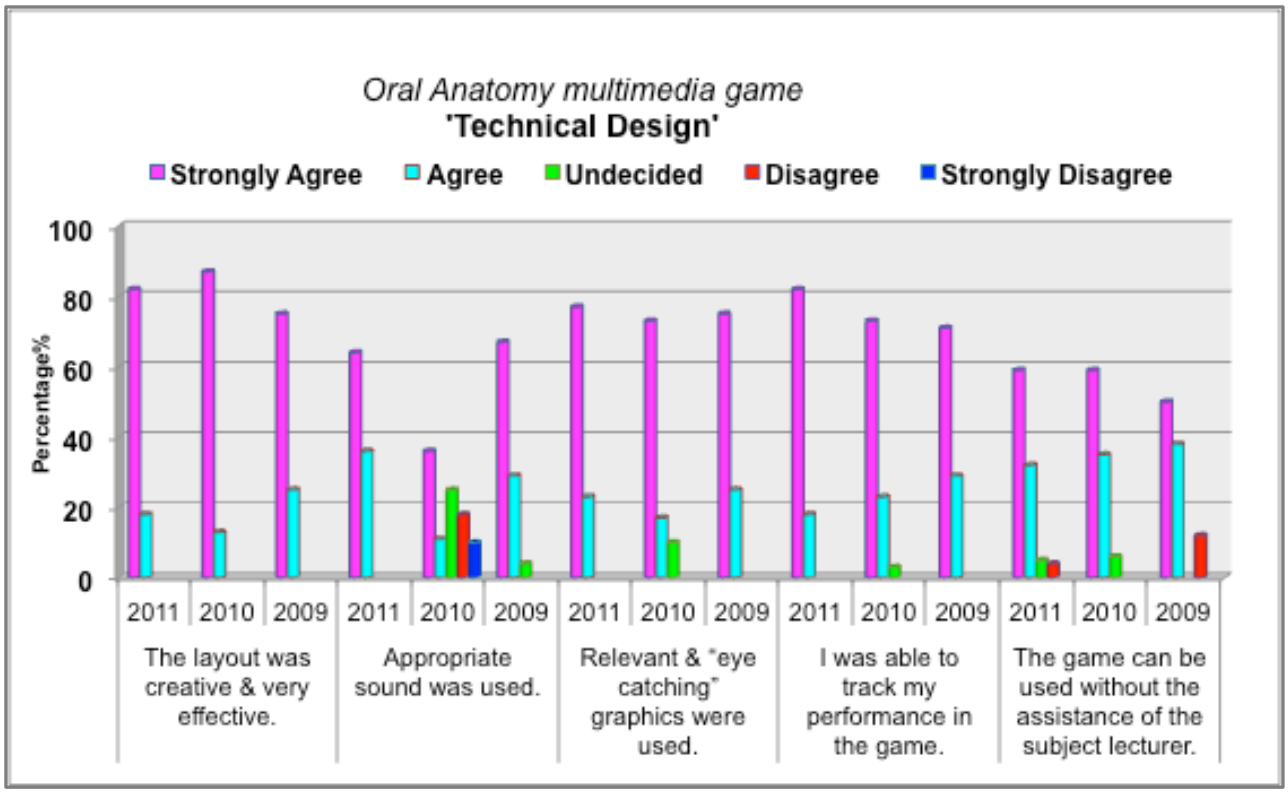
Such interactivity, and as noted by Moreno and Mayer (2005), is likely to activate some of the cognitive processes required for meaningful learning such as activating prior knowledge in long-term memory and trying to find the correct answer. This is also enhanced by guidance from the lecturer who, as the game designer, selected the content and organised and integrated the content with the appropriate design elements of the game. An important implication for learning is that in supporting epistemological access, lecturers must carefully match the design of the game to the students' levels of competency. Zagal (2010) and Pivec (2009) also alluded to this, specifically from the perspective of barriers in learning, that is a significant finding that later emerges in the qualitative analysis section.

In addition, in order to engage meaningfully in learning difficult terminology and anatomical concepts, students reported that they found the *"opportunity to check their notes"* as the *"questions were based on the notes and subject"* thus making it an *"interesting way to learn"*. Overall, it can be gathered that students perceived the OAMG to be a better classroom-based practice than traditional tutorials. Their comments in the open-ended questions revealed that the OAMG was:

> *"A very nice, lovely educational game. It is a lot of fun… An intelligent method of testing one's knowledge on topics discussed".*

It can be inferred from Graph 4-8 and Graph 4-9 that students favoured the instruction and technical designs of the OAMG. To add further support to these findings, Baer (2005) posited that a critical component of maximising the potential of learning is the connection to sound learning pedagogy through the design of the game. In view of her advice, this was considered in terms of whether students perceived the information to be relevant, presented in a clear and logical manner, and if the instructions contained in the manual were easy to understand without necessary assistance from the lecturer. As indicated in Graph 4-8, students found the instructional design was relevant. Nonetheless, about 32% of the students implied that they needed the assistance of the researcher, who is the Oral Anatomy lecturer. Although this result appears to be unfavourable, it could be characteristic of the different learning potentials of

students within a class, where some would require the lecturer's assistance to play the OAMG and others are able to fully engage without such assistance.



Graph 4-9: OAMG - Technical Design

Students also indicated that they favoured the technical design of the OAMG as the layout was*: "effectively creative, relevant graphics were used"; "the hot zone taught me to critically insert muscles in its position.";* and *"tracking of one's own progress was possible in the game."* Consistent with the findings of Moreno (2004) and Moreno and Mayer (2005), it can be garnered that the multimedia materials guided the students in learning and encouraged them to make greater efforts in taking control of their own learning. Perhaps this is a reason for students confidently indicating that they did not necessarily need the assistance of the lecturer. In spite of the positive attributes of using multimedia materials, 22% of the students indicated that the sound used was inappropriate (Graph 4-9). Students therefore recommended, *"improving sound effects for correct and incorrect answers"*. This corroborates with the findings previously reported in Section 4.3.1. Noticeably, the students' accounts from the open-ended questions pointed towards the following game design improvements:

“By adding more levels or stages before getting an award”.

“There should be a time-frame for questions”.

“A do-over function should be included”.

The recommendations above were considered for future improvements of the game.

4.6 Observational and Visual data results

In providing clearer understandings on learning through games, and as outlined in Chapter Three (Section 3.5.5.3), the analysis of the observational and visual (video and digital) data augmented the quantitative results and is viewed in light of the researcher’s knowledge of teaching Tooth Morphology and Oral Anatomy obtained in the past thirteen years. Essentially, the digital images and video recordings are replete with information on the students learning experiences while playing the game. Consequently, and as illustrated in Figure 4-2, a recurring theme exhibited is Game-play. Contrary to the more commonly accepted term ‘game play’, and in line with Gee (2007), here ‘Game-play’ with a capital ‘G’ characterises the social setting in which the game is placed and the interactions around it, especially during play. It was during Game-play that several other trends were identified and coded into sub-themes. This is summarised in the following sections.

Generally, most students played the games more than once. In the first round of playing the game students opted not to use their lecture notes or textbook. In their second and third attempts at playing the game, all students used their lecture notes. After two hours of playing the OAMG, the researcher used a coded computer password and fast-tracked students who had not progressed to the hot zone. The pedagogical purpose for doing this was to allow students to apply their anatomical knowledge by moving the muscles to their correct structural positions on the skull.

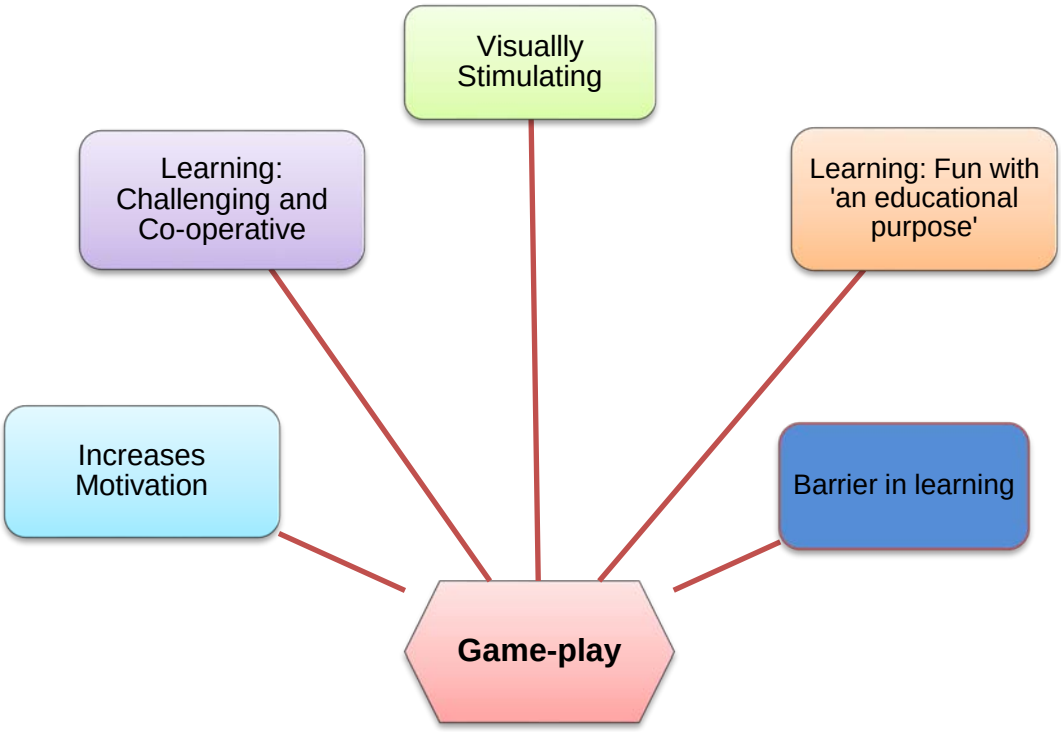


Figure 4-2: Game-play

4.6.1 Game-play: Visually Stimulating

OAMG: The data indicated that the graphics and animations, particularly the movements of the muscles, enhanced the content of the game. Students expressively remarked on its usefulness, particularly in the first fifteen minutes of playing the game. They pointed out that although they found the muscle graphics 'tricky' when placing them on the skull, they mainly enjoyed the challenge. Some articulated that they felt embarrassed when the computer assisted them after their third attempt of failing to correctly place the muscle on the skull. Nonetheless, students conveyed that the experience enriched their understanding of the various muscle positions and helped them to 'recall' knowledge. As previously indicated, this finding is consistent with the multimedia view of cognition according to Mayer, Mautone and Prothero (2002); Moreno (2004) and Moreno and Mayer (2005), that using appropriate multimedia materials could help students to activate some of the cognitive processes required for meaningful learning.

4.6.2 Game-play: Increases Motivation

Many studies have argued (Paras and Bizzocchi 2005; Sandford *et al.* 2006; Gareau and Guo 2009) that well-constructed game design elements provide the motivation necessary for students to persistently re-engage in learning to acquire the much-needed competencies in many disciplines. Motivated students are characteristically enthusiastic, focused and engaged. In this study, some of the motivational activities observed were as follows:

OAMG: Regardless of students reaching the position of the ice age zone in the game, they were determined to re-play the game with the intention of reaching either the position of the twilight or hot zone. Congruently, this motivation also emanated from the students' curiosity of the hot and twilight zones.

TMBG: Teamwork increased motivation as students realised that winning the game was dependent on them working together. This was explicitly exemplified by the discussions, arguments and negotiations that occurred between team members during the playing of the game.

4.6.3 Game-play: Learning is challenging and competitive

For both games, students articulated that the multiple-choice questions (MCQs) were complex as they wholly tested their knowledge. They found that the games were challenging when played without their notes and textbook. Consequently, students used their notes in the second and third attempts of playing the games (Figure 4-3). This is consistent with Garris, Ahlers and Driskell's (2002: 450) finding that games should include progressive levels of difficulty and a certain amount of informational ambiguity to ensure an uncertain outcome. In this way competitive or co-operative motivations can serve to make goals meaningful.

With reference to the:

OAMG: The challenging questions stimulated some students to use their own or a peer's face, to physically locate the muscles of mastication and facial expression. They also used their notes to answer the challenging questions (Figure 4-3, image on the right).

TMBG: The data shows that interaction through dialogue facilitated students to address challenging questions and to engage in learning the morphological content. All teams introduced timers to challenge the opposing team. Generally, the time limit introduced was a minute to answer the MCQ. As the facilitator, the researcher observed that this time limit negated the purpose of learning, as students became less interested in learning the content meaningfully. Instead their primary focus was to complete the game through guesswork. Teams were therefore advised to reconsider the time limit. Subsequently, and to facilitate meaningful learning, teams either appropriately adjusted, or removed, the time frame.

Figure 4-3: Students used their notes during Game-play

Apart from challenging their peers, the purpose of introducing timers was to stimulate competitive learning. This was in line with several medical studies (Beylefeld and Struwig 2007; Meterissan, Liberman and McLeod 2007; Selby, Walker and Diwakar 2007) which found that the competitive element engendered by a gaming approach to learning elicited high levels of student engagement, and more successful learning outcomes in terms of recall and understanding. Similarly, Sorensen and Meyer (2007: 563) and Persky, Stegall-Zanation and Dupuis (2007) noted that in terms of the students' interest in competition, attention to detail, persistence and the will to win are important elements in the learning processes. Hence, rethinking competition in relation to the pedagogical context was a highly relevant challenge that the data indicates had positive educational effects. In corroboration with the aforementioned

authors, it was apparent from the visual data that by competing with each other, students were more focused on seeking the correct answers through discussions and by referring to their notes (Figure 4-3, image on the left). They realised that the design elements of the game depended on them working together to answer correctly and to ultimately win the game.

4.6.4 Game-Play: Learning is fun with 'an educational purpose'

Corroborating the work of Dieleman and Huisingh (2006), the data indicates that the concept of fun learning generated enthusiasm.

OAMG: Students enjoyed the animations, as it was *"funny",* yet educationally *"useful"*, particularly as it helped them to *"recall knowledge"*.

TMBG: Students were extremely expressive (including excited screaming), particularly when they were penalised for answering incorrectly or in defeating the opposing team. It was believed that learning through the game provided a fun and relaxing environment and enabled students to access knowledge co-operatively, collaboratively and competitively.

4.6.5 Game-play: Barrier in learning

Flaws in the technical design of both the games were found in the TMBG and OAMG, which manifested as a barrier in learning. From an epistemological access perspective, the barriers explained below could be positively perceived, as students' were accessing content knowledge.

OAMG: Through play and re-play students identified that the computer answer for the first question of the OAMG was incorrect. This game defect was identified when students competitively aimed to reach the hot zone. Similarly, students found another question where the computer answer was incorrect. They also pointed out a typographical error to the researcher in Question 12 ('noraml' instead of word 'normal') of the game.

TMBG:

Students identified two playing cards with incorrect answers. The questions were:

- Tooth dentine develops from the dental papilla (MCQ option d) and not from the dental sac (MCQ option b) as indicated on the card.
- "The last tooth to erupt is the …… ". The card incorrectly identifies the "mandibular 1st molar". The correct answer is the "maxillary canine" (MCQ option d). The incorrect answer on the card further encouraged students to seek the researcher's attention for clarification.

The aforementioned errors were addressed in future versions of the games.

4.7 Debriefing: Post-game reflections by students

The reflective accounts of the students centered mainly on the content of the game and their suggested improvements. Students unanimously indicated that learning morphology and anatomy through games "*jogged*" their memories. Some even enthusiastically explained that they were surprised at remembering the content learned in earlier modules. In terms of recommendations, students suggested that the OAMG should have the option of going back to the previous question; to introduce more difficult questions; and to provide a printout of results. Students pointed out that a printout of their results would be useful as it would inform them of their weak areas and would even help them to improve in learning Tooth Morphology and Oral Anatomy, and when playing the games again.

Consistent with scholars such as de Freitas and Oliver (2006), Persky, Stegall-Zanation and Dupuis (2007) and Crookall (2010) amongst others, debriefing sessions provided an appraisal of what happened and enabled students to reflect on their experiences. This was evident in this study. For example, students conveyed that playing the game more than once helped them to improve skills such as communication and teamwork. From experience, such skills are helpful in preparing them for industry. It can therefore be gleaned that games link real-world experiences and textbook knowledge to create richer learning experiences. This is pertinent in the context of the vocational nature of Dental Technology at DUT, where knowledge must face both inward to the discipline of the academy and outward to industry.

Overall, the analysis of the preceding section indicated that positive aspects of Game-play and reflective accounts through debriefing support the pedagogical use of the TMBG and OAMG. It can be concluded from this analysis that the intended effects and impacts of games are only realised if they are thoroughly prepared, well-executed and rigorously evaluated. This corroborates with Dieleman and Huisingh's (2006: 842-845) proposal that it is a combination of the contextualisation and preparation of the game, the execution including the explanation of how to play the game, and the debriefing at the end of the game, that critically fosters successful learning outcomes.

4.8 Discussion: Quantitative Analysis

The results indicated that an amalgamated design, that is, a blend of appropriate instructional content and applicable game features, facilitates access to knowledge. This is consistent with previous studies (Sandford *et al.* 2006; Wilson *et al.* 2009; Zagal 2010) which highlighted that sound pedagogical principles in the design of games enable learning of content knowledge. In addition, and in corroboration with other game scholars (de Freitas 2006; Klabbers 2009a; Pivec 2009; Li, Tay and Louis 2012), skills related to teamwork, problem-solving, decision-making and collaboration are among the noted improvements of learning through games. Garris, Ahlers and Driskell (2002: 455) reported that games foster three types of learning outcomes, namely, cognitive, skill-based and affective, which is of significance. Cognitive learning outcomes entail three sub-categories, which are: declarative knowledge (i.e. knowledge about what), procedural knowledge (knowledge about how), and strategic or tacit knowledge (knowledge about which, when, and why). In contrast, affective learning outcomes relate to affective reactions such as feelings of confidence, self-efficacy and attitudes. Skills-based learning outcomes, on the other hand, focus on the development of technical or motor skills. To add further support, Klabbers (2009b: 450) stated that cognitive learning is an "explicit and coded knowledge", whereas non-cognitive learning refers to tacit knowing.

Student test scores revealed that knowledge improved through games. In

conjunction with the results illustrated in the aforementioned graphs, pre-and post-test results further indicate that the students attained declarative knowledge as their performance significantly improved after playing the TMBG and OAMG. This is corroborated by students' accounts that showed strategic learning outcomes were achieved from the games. In the TMBG, for example, successful teamwork was a function of communication and collaborative skills that fostered peer learning between team members. On the other hand, procedural knowledge was intrinsically embedded in the design of the OAMG, as students were required to apply their theory by correctly positioning the muscles of mastication and facial expression on the skull. Students therefore reported that this helped them to recognise muscles and their location more easily as it showed the origin, insertion and action of the different muscles. In spite of the positive results, it is difficult to infer the extent to which declarative, procedural and strategic knowledge is directly leveraged in the TMBG and OAMG. As discussed in the next chapter, theorising the association between games and epistemological access therefore becomes imperative to understand the quantitative results.

The findings of this study also relate to Gee's (2007) concept of situated learning. For example, and as inferred from the results, apart from the graphics and sounds enriching the visual landscape and action sequences in the OAMG, the multimedia materials were directly related to anatomical content. Students could therefore identify and learn the muscles of mastication and facial expression as they were experiencing the anatomical meanings in a situated or discipline specific way. Students were not just seeing muscles in a passive and rote manner, instead the OAMG situated meanings for students to see muscles in an active and critical way (Figure 4-3: picture on the right). Similarly, and together with the game objects (different categories of cards, model, playing tokens and dice) introducing concepts of excitement and challenge, the intended use of the physical tools in the TMBG was to stimulate students to learn collaboratively. The game mechanisms aimed to assist students to proceed with ease, as well as to improve communication, reading and listening skills. It can therefore be gathered that the TMBG and OAMG support the provision of epistemological access to Tooth Morphology and Oral Anatomy,

as students recognised the play (social) and textual (academic) dimensions of the games.

Indeed, the quantitative results suggested that discipline-specific games, if correctly designed, spell out situation-specific terms and knowledge to actual practice. That is, they facilitate epistemological access. If these results are to have any worth, it becomes imperative that a deeper exploration of the underlying knowledge structures of the games is needed to wholly understand how games enable students' access to knowledge. After all, and in support of Allery (2004), the value of the learning (knowledge) experience lies not in the game only, but in the structure that underpins it. This is clarified and discussed in Chapter Five.

Chapter Five – Students' conceptions and beliefs about learning through games: Qualitative Phase Two

5.1 Introduction

The previous chapter analysed the quality of teaching in the subjects Tooth Morphology and Oral Anatomy by evaluating the efficacy of games in the provision of epistemological access. This chapter uses the conceptual frameworks of Bernstein (2000) and Maton (2007) to analyse the focus group data. Specifically, the chapter attempts to describe and characterise students conceptions of learning through games by addressing the first research objective, that is: the quality of teaching and learning in the subjects Tooth Morphology and Oral Anatomy, using the board game and the digital multimedia game. The chapter first introduces the recontextualised field of Dental Technology to provide a clearer context of where the games in this study were positioned. The analysis of the focus group data then follows. The results of the focus group discussions are organised into four sections drawn from the theoretical framing in this study, namely: classification; framing; epistemic relations; and social relations. Subsequently, a discussion summarises the results of these four sections. The chapter concludes by drawing on the literature to provide an overall summary of both the quantitative and qualitative findings.

It is worth noting that the way knowledge is structured in Dental Technology is, in essence, unchartered territory. Hence the brief description in the following section is for the purposes of contextualising the case study in more detail than that provided in Chapter Two. It does not purport to be a complete analysis of Tooth Morphology and Oral Anatomy. Given that the literature discussed in Chapter Two indicated that disciplines and programmes have specific values, knowledge structures and ideal knowers, it is therefore important to begin the analysis of the student data about the games with a description of the knowledge and knower structures of the subjects the two games target. The analysis provides a brief description of the subjects to which the games were intended to provide epistemological access and the programme within which

these two subjects reside.

5.2 The recontextualised field of Dental Technology

As previously noted in Chapter Two (Section 2.6), Dental Technology is typified as a region as it hinges at the interface between disciplinary knowledge and the field of professional practice (Bernstein 2000). This is true for most University of Technology programmes, which have strong links to industry and are focused on providing vocational expertise (Winberg *et al.* 2013). Knowledge in a region is weakly classified[9] as it has been recontextualised at this interface (Barnett 2006). This means that in applied disciplines, traditional subjects or singulars are recontextualised into new forms that take heed of both the academic disciplinary knowledges from which they are formed and from the world of work.

For example, the specific learning outcome for Tooth Morphology is to acquire and apply scientific knowledge of morphological concepts (Dental Sciences Department 2013). This is recontextualised from the singular discipline of human anatomy to only that aspect of dental anatomy pertinent to Dental Technology. Furthermore, and as outlined in the subject guide (Dental Sciences Department 2013), students need to acquire knowledge on the shape and morphology of teeth (the intellectual field of the discipline) in relation to carving practical work (field of external practice). The focus group discussions indicated the importance of morphological concepts in terms of their application to tooth carvings and is illustrated from a student's response below:

> *"If I started carving that is without the knowledge of tooth morphology ... I would have probably made them all the same size, not realising that the mesial lingual cusp is the highest cusp...".*

Similarly, a specific learning outcome for Oral Anatomy is to acquire and apply scientific knowledge of anatomical concepts (Dental Sciences Department 2013). In particular, and as highlighted in the subject guide (Dental Sciences

[9] As discussed in Chapter Three (Section 3.5.5.2), Classification refers to the strength of boundaries between categories of knowledge or contexts. Bernstein, B. 2000. *Pedagogy, Symbolic Control and Identity: Theory, Research, Critique* Revised ed. United States of America: Rowman & Littlefield Publishers, INC.

Department 2013), students need to acquire knowledge on the structural and functional anatomy of muscles of mastication and facial expression (the intellectual field of the discipline) in relation to Dental Technology laboratory practice (field of external practice). Once again, the subject is a recontextualisation in that it is both a selection from singular disciplines (human anatomy and physiology) and directly focused on the manner in which such knowledge is used in the world of work. Student focus groups discussed the theory of muscles in direct relation to its application in laboratory practice. This is evident in the student excerpt below:

> *"Anatomy helped us realise ... helped us to consider, when we're doing a prosthesis … muscles that impact on this and other areas of the mouth … when we are making a prosthesis."*

Equally significant, the South African Dental Technicians Council (SADTC) is clear that in conjunction with delivering an education within a specific framework, UOTs must educate and train students in line with the requirements of the relevant professions (South African Dental Technicians Council 2011). Noticeably, this shows Dental Technology has a strong focus on the profession, as is typical of regions. Furthermore, since there is a set curriculum with no electives, students enter a prescribed progression path. The weakly classified subjects of regions are thus generally strongly framed[10], as the pace and order in which students acquire knowledge is centrally controlled with little room for individual negotiation on the curriculum.

As highlighted in Chapter Three (Section 3.5.5.2), LCT (Specialisation) theorises that every practice or knowledge claim is about or orientated towards something and by someone. Maton (2007) points out that this provides an epistemic relation to an object (ER) and a social relation to a subject (SR). Epistemic relations value the 'what' of knowledge and the specialised methods, procedures and techniques related to the knowledge. In contrast, SR is focused on the knower ('who' is doing the knowing) and their attitudes, habitus and dispositions. As illustrated in Figure 5-1, each relation may be more strongly (+)

[10] As discussed in Chapter Three (Section 3.5.5.1), Framing between subjects refers to the control over selection, sequencing and pacing, and the evaluation criteria of the knowledge to be acquired. Ibid.

or more weakly (-) emphasised within each discipline and these two strengths of emphasis together allow us to plot the four Specialisation codes. In some disciplines ER is more important than SR, as certain concepts and procedures are more valued in terms of being recognised as a legitimate member of the discipline (or profession). In other disciplines SR is more important than ER, and having certain lenses and gazes is more valued, particularly where being a certain kind of knower is needed to be recognised as a legitimate member of the discipline (or profession).

Arguably, the study guide for the entire Dental Technology course indicates a strong epistemic relation as it outlines the concepts and processes of knowledge. It makes little or no reference to the ways of valuing or ways of being that would suggest a strong SR. As illustrated in Figure 5-1, Dental Technology represents a knowledge code. The focus on attributes (or dispositions) of the knower is minor in the course outline and assessments, whereas the focus on knowledge itself is very strong.

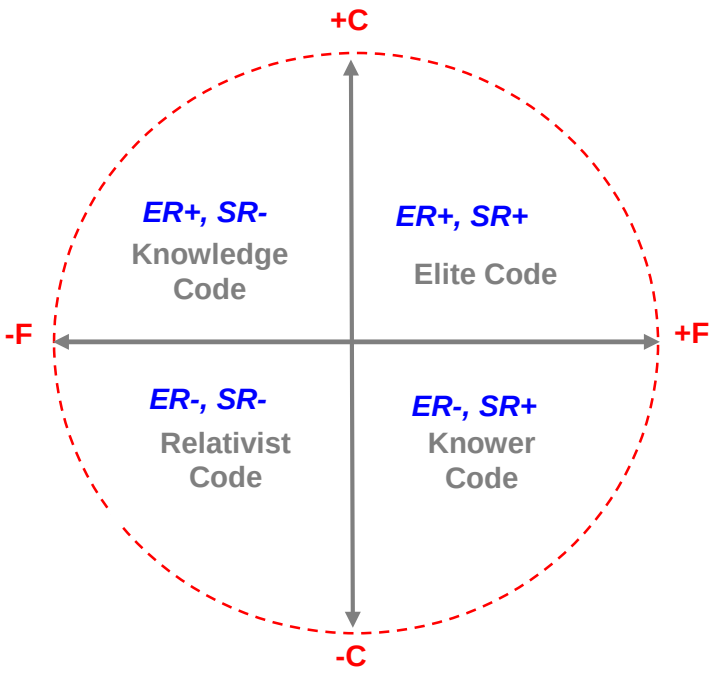


Figure 5-1: Legitimation Code of Dental Technology
(Adapted from Maton (2007: 96))

Chapter Two provided an overview of the site of the study, that is, Dental Technology, and in particular the two subjects where games were administered as part of the pedagogy. This section described the TMBG and OAMG in more detail to further contextualise the data analysis that follows. The next section reports themes identified in the data comprising transcripts of the twelve focus groups. Drawing on Bernstein's (2000) and Maton's (2007) work, the analysis aims to provide an "entrée into the complex worlds people inhabit and suggest a means by which can build a more sophisticated understanding of current phenomena" (Bennett and Maton 2010: 327).

5.3 Analysis of the knowledge structure of the games

Within the brief characterisation of Dental Technology as a region and a knowledge code provided above, this section seeks to understand in-depth the students' experiences of learning through games. As indicated in Chapter Three (Section 3.5.5.2), LCT (Specialisation) subsumes Bernstein's knowledge codes as it uses the concepts of classification and framing and extends these with epistemic relations and social relations. The qualitative analysis will therefore use the concepts of classification and framing first to discuss the data in which students reflect on their use of the games. The analysis then moves on to discuss the extent to which it is relations to knowledge (ER) or relations to knowers (SR) that were foregrounded in the data of the focus groups. As outlined in Chapter Three, the forms these relations take within languages of legitimation may vary independently of each other. Each may be strongly or weakly classified (C) and framed (F). In order to facilitate a clearer understanding of the analytical reporting, an overview of how a language of description of the data was generated in this study will first be presented. An explanation of the data in terms of classification, framing, epistemic relations and social relations then follows.

5.3.1 Overview of the Analysis

This section will begin with two tables to illustrate how the analysis of the focus group discussions was undertaken. In analysing students' use of the games, and as illustrated in Table 5-1, a language of description was generated using

Bernstein's concepts of classification and framing. Illustrative quotes from the empirical data are included in columns 3 and 6 in Table 5-1 to support the claims about the strengths of classification and framing.

Similarly, and using Maton's (2007) LCT of Specialisation, Table 5-2 illustrates the language of description generated from the data collected through focus groups. It comprises of two sections, namely: the epistemic relations (ER) section on the left and the social relations (SR) section on the right. Each ER/SR section is structured so that when read from left to right, it serves as a translator of theory into data, and when read from right to left it is a translator of data into theory. In this study, ER is realised as the degree of emphasis on morphological and anatomical knowledge and procedures (column 2). The manifestation of the SR is the degree of emphasis on the student's attributes and ways of being (column 5). Columns 4 and 7 in Table 5-2 provides student quotes, verbatim, to substantiate the claims about the degree of strength of the epistemic relations and social relations.

As mentioned above, moving from right to left (data to theory) in Table 5-2, it can be seen how data was coded. For example, student comments in the ER section showed that the: "*Curve of Spee*[11]*, I remembered it from the game; ...and what I like about this game is that they both require you to know your theory and your work because if you don't know your work ... at the end that you're not processing the Muscle Mania…*" (Column 4, Row 1). These were coded as exhibiting strong epistemic relations (ER+) as the data suggested an emphasis on access to content knowledge was explicit to students (Column 3, Row 1 - the basis of legitimacy). Moving towards a more theoretical level, it indicated an emphasis on morphological and anatomical knowledge (Column 2, Row 1) in the games (Column 1).

In contrast, moving from left to right (theory to data), it can be seen from Table 5-2 that in relation to Games (Column 1) the epistemic relations refers to the

[11] The anatomical curvature of the occlusal alignment of the posterior teeth commonly referred to as the anteroposterior curve (of Spee). Woelfel, J. 1990. *Dental Anatomy: Its relevance to Dentistry*. 4th ed. Pennsylvania: Lea & Febiger.

degree of emphasis on morphological and anatomical knowledge (Column two). The third column showed that the students indicated strong epistemic relations (ER+), as emphasis on access to content knowledge. This is explicit in the technical design of the game (Column 3, Row 2 – the basis of legitimacy). Column 4 (Row 2) presents student quotes that illustrate data is consistent with the strong degree of strength of the epistemic relations (ER+).

Table 5-1: Language of description for classification and framing

Classification			Framing		
Concept manifested- Strength of boundaries between:	Indicators	Example quotes (in verbatim) from empirical data	Concept manifested- Strength of boundaries between:	Indicators	Example quotes (in verbatim) from empirical data
Theoretical (or know-why) knowledge and **Practical (or know-how)** knowledge of Tooth Morphology and Oral Anatomy.	**-C** Theoretical and Practical knowledge have permeable boundaries.	Tooth morphology... what helped us even more is if you do it practically you understand it better so the prac part of tooth morphology helped us in the theory...if you're carving a tooth, you're actually tying your theory to your prac work, so the prac really helps you. Anatomy helped us realise, helped us to consider, when we're doing prosthesis, muscles that impact on this and other areas of the mouth so it helped us to bring that into consideration when we are making a prosthesis.	**Selecting** the content knowledge of the game. (An alternate pedagogy)	**+F** The discipline lecturer mainly determines content knowledge.	Curve of Spee, I remembered it from the game; ...and what I like about this game is that they both require you to know your theory and your work because if you don't know your work... at the end that you're not processing the Muscle Mania…
			Sequencing of the game. (An alternate pedagogy)	**+F** The sequencing of content knowledge through the game is mainly determined by the lecturer.	Your instructions are virtually on both games... everything that you need to do and the way you need to do it. You know you can play the game or go to read about it; ... in the game the questions are already pre-formed...
			Pacing of the game. (An alternate pedagogy)	**+F** The pacing of content knowledge through the game is mainly determined by the lecturer.	With the tooth morphology game we timed each other, so it really encourages you to think fast; And having those stages where you like you get an ice age, you know that oh no, I don't want to be a failure and you study more…

Table 5-2: An external language of description for epistemic relations and social relations

	Epistemic Relations			Social Relations		
	Concept manifested- Emphasis on:	Indicators	Example quotes (in verbatim) from empirical data	Concept manifested- Emphasis on:	Indicators	Example quotes (in verbatim) from empirical data
GAMES	Morphological and Anatomical Knowledge and procedures.	**ER+** Content knowledge is explicit in the instructional design of the game.	Curve of Spee, I remembered it from the game;...and what I like about this game is that they both require you to know your theory and your work because if you don't know your work …at the end that you're not processing the Muscle Mania; More questions on the games because when I was done with the game I was a bit disappointed; the game to include the whole syllabus, just not muscles.	Student's attributes and ways of being.	**SR-** Identifying social and personal aptitudes that are important to industry is viewed as legitimate educational knowledge.	Interacting with others... like you're going to have to like speak to other lab owners, dentists, like dental technology relies on um, like, how many dentists you know, so if you're going to be an unfriendly person and if you can't interact properly with others it's not going to get you far. Because you need to promote your lab, you need to have the skills in order to introduce your lab and yourself to the dentist so that he will give you his work. You need to create a good impression of yourself to him; Time management because if you're a technician you have to be fast, you have to do things, you have to have good time management so I think that's academic…so managing your time in the game helps to manage your skills in other sections.
		ER+ Content knowledge is explicit in the technical design of the game.	Pictures in the game assisted in the recapping anatomical knowledge; Technical design of the game is perfect...you understand, you know the shape of the muscle, you know exactly where does it fit, you know the position of the muscle; The board game, the card or something, it must be a little bit more brighter; Muscle Mania- the technical design of the game can improve by a voice aid to improve pronunciation of terminology.			

Having briefly illustrated the way in which the analysis was undertaken, this chapter now discusses the findings of this analysis under the theoretically driven headings of classification, framing, epistemic relations and social relations. In the ensuing sections all student quotes from the focus group discussions are given verbatim and are italicised. As the analytical reporting involves two games developed for two different subjects, two data quotes, or more, will be used to describe the characteristics of each game. In addition, and apart from the student quotes that were in relation to the use of the games in general, identifiers such as the TMBG and OAMG are used to link, where applicable, the quote to either the Tooth Morphology board game or Oral Anatomy multimedia game, respectively.

5.3.2 Classification of knowledge in the games

In line with Dental Technology being typified as a region, classification manifested in the study as the strength of boundaries between theoretical (or know-why) knowledge and practical (or know-how) knowledge of Tooth Morphology and Oral Anatomy. Many of the students said that they could see the games: *"help to connect theory to practice"*. Students generally agreed that they could recognise the morphological and anatomical content of the games was relevant to the professional field of Dental Technology:

> *"Every profession requires you to have a certain amount of knowledge and understanding in order for you to get into that profession, so it's important for us to have the knowledge of our teeth and, um, the way you use your knowledge to manufacture the different appliance…".*

To add further support to the games being relevant to Dental Technology, students also pointed out that the games be made available during practical sessions because:

> *"…Practical it's also important to remember morphology and anatomy, so I think the games should still be available to us if we want to remember most of the things in morphology – you can go play the game and remember".*

Another point deserving mention is that some of the students acknowledged that they initially found Oral Anatomy to be a highly theoretical subject: "*Anatomy was the most difficult subject…because of the theory content…I fail*

to find a meaning between the practical....". Playing the OAMG however helped them to see how the theory of muscles connects to their practical work, particularly when fabricating removable dental appliances. This is evident in the following student's extract:

> *"Important that we know all the muscles that are in the oral cavity so that when we're manufacturing an appliance for a patient we won't go beyond the tissues…".*

From the aforementioned, the games can be described as involving relatively weak classification as the boundaries between theoretical knowledge and practical knowledge were fluid and permeable. This is aligned to the characteristic of Dental Technology as a region, where linkages between theoretical and practical knowledge are valued and where only selected aspects of a traditional human anatomy and physiology syllabus are included.

5.3.3 Framing of learning in the games

A consistently recurring theme in the data was the role of the lecturer in framing the game. Students perceived that the lecturer, as the game designer of the TMBG and OAMG, controlled the selection, sequencing and pacing of content knowledge through the design elements of the game. Students clearly and enthusiastically indicated that the lecturer's knowledge strongly framed (selecting and sequencing) the game:

> *"It shows that this game was designed by a very intelligent person, inciting a very generous idea, it's helpful, it's educational and it's well done. I can say I was so amazed and I was shocked that there could be such games in terms of tooth morphology and muscle…".*

> *"The game covers morphology, dentition...basically, the structure of how tooth morphology is brought to us, it's perfect. It is encouraging because…our lecturer knew her work."*

Students positively conveyed that the design of the games enabled the lecturer to arrange and deliver the subject content of Tooth Morphology and Oral Anatomy in a highly structured way:

> *"For your lectures it's more about organisation, the structure, the presentation, your organisation...in the games made learning easier."*

Students also felt that by professionally making the content explicit in the games, the lecturer motivated them to understand the value of the morphological and anatomical content in the context of Dental Technology:

> *"The lecturer...all I can say is tooth morphology was laid in our memories in a professional manner…if it was not for that lecturer I don't think I would have been here...".*

In terms of Bernstein's (2000) concept of realisation rules, framing is therefore strong (+F) as students recognised the role of the lecturer in designing discipline-specific games.

With respect to the pace of learning, which is another aspect of framing, students described being encouraged to get through the game content because of a desire to win the game:

> *"Ja, you've got to play a game to win, otherwise there's no use playing the game."*

They generally agreed that to win the game depended on their knowledge of Tooth Morphology and Oral Anatomy. The pace was set by the game itself, as each person or team had a turn and they had to proceed according to this structure. Furthermore, the competitive element ensured that such progression was undertaken at speed. Students took cognisance of this in terms of how their answers influenced specific actions built (as is the case of the TMBG) or programmed (as is the case of the OAMG) into the game:

> **TMBG***: "I can say the cards, the card can be a disadvantage and an advantage as well because if you go back, you're going to start again, maybe you're going to come across the questions that you didn't come to…".*

> **OAMG:** *"The anatomy game also became like a competition…we wanted to try and get the jingle all the time, tried to see who was getting more jingles."*

In contrast to traditional teaching methods, and as exemplified from the aforementioned student excerpts, the design elements of the game were regarded by many students to be an effective means of controlling the pace of learning. As indicated above, all the issues related to framing that is selection,

sequencing and pacing were strong in the study data, however, it is important to note the fun aspect of the games. The extent to which framing was in the hands of the lecturer did not restrict students' engagement in the Game-playing process. The data from both the focus groups and from observations of students playing the games suggested that the light-hearted, competitive and untraditional nature of the Game-playing added to their engagement. Another common theme which emerged from the data was the concept of fun:

> *"Educational games helped make learning fun and helped you to perform better in tests"*.

The majority of the students described the games as:

> *"A fun way of learning…most of us are not English first language … so it not easy to pick up some words, so in the game you can repeat the word, it's easy to understand".*

Consequently, learning is: *"active as you recall your theories"*. It can be argued that playing the games helped English second-language students to learn the specialist language of Tooth Morphology and Oral Anatomy. The specialist language of the games suggests that knowledge is strongly framed (+F). It is worth noting that the above student extracts aligned to the Dental Technology industry's expectations. Students prominently emphasised that they learned the anatomical and morphological words (terminology) and how to work collaboratively in teams.

In addition, three other key factors emerged from the data in relation to 'fun learning' namely: learning is challenging, active and competitive. Students positively commented as follows: that the challenging content of the games made learning *"fun, interesting, make you think more…to get the answer right."* This, in turn, encouraged students to compete with each other: *"…the games were a bit challenging…you have competition with your friends it makes it a lot more fun."* Students repeatedly claimed that the competitive element engendered by the games elicited an: *"active way of learning that is more fun*." It can be gathered that while learning through games is fun, the questions in the game challenged the students to think more about the morphological and anatomical content.

From a technical design perspective, students pointed out that the different levels of the games facilitated fun learning:

> **TMBG:** *"…Like meeting stages and then when everyone has reached the top stage and you're starting something fun."*

> **OAMG:** *"…Muscle Mania does give me stages, so while you're playing the game you want to reach the second stage, the fun stage, so it makes it more interesting and more like important for you to like know your work and then go in the further – third stage."*

5.3.4 Epistemic Relations

The aforementioned analysis indicated that the games were experienced as weakly classified and strongly framed. The analysis now turns to the LCT concept of epistemic relations. Student focus group discussions were replete with comments on the focus of knowledge acquired through playing the games, both in terms of key disciplinary concepts and in terms of professional procedures. Connected to and in support of the analytical results of the quantitative phase, students prominently emphasised that the morphological and anatomical knowledge derived from the games was explicit through its instructional and technical designs. Students highlighted that they not only recalled morphology concepts but that they could see the connection of the morphological knowledge to laboratory practice. This is exemplified in the following student excerpts.

> **TMBG:** *"I remembered it from the game – I thought of it Curve Wilson, uh, Spee, and then from the game it came back…".*

> **OAMG:** *"When a muscle popped out, I could identify that this was a masseter and I could tell that it was a muscle, so when it came to the Orbicularis Oris muscle, I go to see the interior portion of the person's face other than seeing the skin. The games helped me a lot…helps to connect theory to practicals."*

> *"Technical design of the game is perfect...you understand, you know the shape of the muscle, you know exactly where does it fit, you know the position of the muscle."*

From the students' descriptions, it can be gathered that the contents of the games can be understood as being grounded in the epistemic relations of

knowledge to its object (ER+). It is perhaps for this reason that students advised that the games be formalised into the curriculum, and is evident from the comments below:

> *"…the game must be officially, like promoted, in dental. It must be like a subject that's added on the subject, like tooth morphology...game contributes 20% on your final year mark."*

> *"Last week we do an assignment and they said 10% of the year mark contributed on the assignment, maybe like 5% of the year mark contributed on the game...it's like a DP for entering the games. In other words, introduce it as part of formal assessment."*

In addition, and in support of the quantitative findings in Chapter 4 (Section 4.5.5), students conceded that design flaws in the games positively assisted them to seek knowledge. This is highlighted below:

> *"You know, that was actually – it had a positive outcome because it was the first question that I made a mistake, on the programme, the first question that the answer should have been correct, but they said in the programme that it was incorrect, so it made me check and re-check and re-check in my notes and then finally when I wasn't sure I asked the lecturer."*

The paradox highlighted above is that the errors in the games, which have been corrected in subsequent versions of the games, inadvertently enabled students' access to knowledge, as they were encouraged to use their notes to crosscheck the game answers and to discuss the answer with the lecturer. It can be argued that students identified errors in the games because the content is so deeply embedded in the knowledge domain of Tooth Morphology and Oral Anatomy. In this process, and as students commented, they felt empowered knowing that they outsmarted the game. Apart from students critically pointing out the improvements needed, it can be gathered that games have strong epistemic relations (ER+).

Lastly, and a consistently recurring theme that emerged in the data, was that the lecturer served as an enablement to the epistemic relations of knowledge. As the game designer, the lecturer explicitly had control over the Framing of the content including knowing the difference between the subject matter and

the language of the field of the subject. Essentially, the lecturer selected what should be included in the games, and specifically how concepts fitted together to communicate a distinctive type of morphological and anatomical knowledge within the game. For the students, the lecturer is also an object – a guiding source of legitimate knowledge when accessing morphological and anatomical knowledge through games.

5.3.5 Social Relations

Having discussed the factors that indicated games have strong epistemic relations, the discussion now moves to the data related to social relations. This is about the knower and the extent to which a particular kind of knower, with specific attributes, is required by the games.

Students generally agreed that another benefit of playing the games is to improve certain skills, such as listening and communication. They regarded this as a secondary purpose of the games, however, particularly as some skills were viewed as part of one's personal characteristics such as having computer skills and being patient. Noticeably, the focus groups included very little data related to social relations. Instead, the data valorised knowledge over knowers as students predominantly reported that:

> *"You have to have an idea of a background of anatomy and morphology…to be able to play the game and enjoy the game."*

In spite of this, some of the students critically pointed out the value of some skills leading them to become a certain kind of person who is able to communicate in professional ways. The most prominent personal skills reported in relation to the games were: interacting with others, communication skills, and time management skills, each of which is highlighted in the student extracts below:

> *"Interacting with others...like you're going to have to like speak to other lab owners, dentists…you need to promote your lab, you need to have the skills in order to introduce your lab and yourself to the dentist so that he will give you his work. You need to create a good impression of yourself to him."*

> *"We have to use the proper language…speaking in the correct terms…anatomy…I mean you're not going to go to your lab owner and say, hey you know what, I need to fix the right hand side of this when you could have said no I want to fix the mesial corner or whatever it is. You sound more professional."*
>
> *"Time management…you make sure that whatever work you're working on needs to be given or delivered by the time stipulated.*

Thus while there was some mentions of the games developing certain personal skills, there were few references to having to take on particular attributes. The social aspects of knowers, such as students' personal and social aptitudes in relation to industry, were rarely addressed and manifested in relatively weaker social relations (SR-). It can therefore be concluded that the games were regarded as weaker SR, since the data made very little reference to the valuing of specific attributes or dispositions of the knowers.

Although beyond the scope of this research, another point worth mentioning is an institutional move to increase the SR of all the programmes at DUT. Presently, and in line with the vision of DUT (Durban Univerisity of Technology 2012b), an emphasis on graduate attributes and especially critical citizenship is being promulgated through a curriculum renewal project (Durban Univerisity of Technology 2012a). One way in which this move is planned to be implemented is through the introduction of 'General Education' both within existing subjects and through the introduction of a core curriculum across the institution in 2015. This will have numerous pedagogical implications for programmes such as Dental Technology, that are knowledge codes, where the legitimation of the programme is through the epistemic relations to knowledge rather than the social relations to the knower. Such implications are outside of the scope of this thesis but it is sufficient to point out that such institutional shifts are likely to impact on the context in which the games will be played. In light of the central argument of this thesis that games and other pedagogies need to take the target knowledge and knower structures into account, any significant shifts in the educational context, such as those being mooted at DUT, will need to be carefully considered.

5.4 Discussion

Based on the results presented, it can be gathered from the LCT analysis that stronger epistemic relations and weaker social relations, that is a knowledge code (ER+/SR-), was reflected in how the students described their engagement with the games. Three overarching themes emerged, namely: (1) the games promoted access to morphological and anatomical knowledge; (2) the guidance of the lecturer was crucial in person and through the design of the games; and (3) the learning was fun and challenging.

With regards to the first two themes above, students accessing knowledge through games emerged in terms of them: following a pre-determined sequence of learning; keeping pace by aiming to win; and seeking to correctly understand content knowledge. In addition, and as declared by the students, having prior content knowledge and the lecturer's instructional guidance were considered to be valuable resources in the facilitation of legitimate knowledge. Students concluded that by designing the games the lecturer engaged them to learn discipline-specific content. This further suggests that students experienced a hierarchy (strong framing) in the pedagogical relationship that was augmented by the strong selection and sequencing of the content, as noted above.

Moreover, the design of the games also critically enabled students to access discipline-specific knowledge. This was apparent when students positively recommended that games be formalised into the curriculum. Students also expressed that regardless of the errors in the games they were encouraged to use their notes while playing the games. These descriptions of accessing discipline-specific knowledge and using their notes to learn indicate that students experienced successful learning through games as they accessed legitimate knowledge.

The various types of learning experienced by the students exemplify the third theme, a focus on the concept of fun learning. Students characterised fun learning in terms of the challenging questions that made them *"think more"* and

ultimately engaging in a state of competition with their friends. Consequently, this stimulated them to actively learn the discipline-specific content. Students also recounted that in spite of the technical design of the games challenging their knowledge, it was fun in terms of advancing through the various stages of the game. The challenge and competitive elements underlining the concept of fun learning made the students feel they were accessing valued knowledge.

Although the students valued the social nature of learning by using games, they did not strongly perceive the games as developing any particular dispositions or set of lenses or gazes (Maton 2007). The games were therefore regarded as exhibiting a relatively weak SR to the knower. It can be argued that the secondary focus of the social relations is steered by the design of the game which foregrounds the object (knowledge) and backgrounds the subject (knower). This downplaying of the attributes of the knower points to an educational experience that embodies relatively weaker social relations (SR-). Crucially, this is aligned to the nature of the target subjects and to Dental Technology as a whole, which is a knowledge code with stronger ER and weaker SR as argued in Chapter Two and in section 5.2 of this chapter.

Overall, students' experiences of learning through games indicate specialist knowledge and skills were relatively more important to legitimate participation in the games than the possession of personal attributes and dispositions. This is appropriate, because for Dental Technology the basis of specialisation is to have an extensive grasp of morphological and anatomical knowledge that is appropriately presented in professional practices.

5.5 Games and Epistemological Access: A connected summary

To synthesise the quantitative and qualitative results, this section begins with the following quote from a student that captures the pedagogical value of games in supporting the provision of epistemological access.

> *"There's this Chinese proverb that I once learned that says 'Teach me and I'll forget, show me and I might remember, involve me and I will understand' so now with these games you are more involved in these games, you get an understanding of what you've learnt. You are not just sitting and reading and answering questions about you, you're applying your knowledge, so that in that way you're understanding what you are doing, all right."*

The recurring themes in this study, such as fun, collaborative, competitive, co-operative and active learning, adds further support to the growing body of scholarship (Sandford *et al.* 2006; Coiro *et al.* 2008; Wilson *et al.* 2009; Zagal 2010) that posits learning through games is not a debate of teacher-centered versus student-centered learning. Instead, it is about finding the right mix between teacher-centered and student-centered activities that are achievable through pedagogical tools such as the games in this study. Equally significant, and tying to Gee's (2007: 112-128) concept of situated learning, students positively described that the technical design of the games (for example: sounds, images, questions on the cards, playing tokens, tooth model) situated morphological and anatomical meanings in the games. Indeed this, according to the data, enriched the learning of Tooth Morphology and Oral Anatomy through games. To a lesser extent, the games also provided students with an opportunity to improve their social skills. This last point is important and needs some clarification from the perspective of literature on affinity groups.

Although the concepts of affinity groups prominently feature in the debates of learning through video games (Gee 2007; Jenkins *et al.* 2009; Gee and Hayes 2012), aspects of this work are relevant to the findings of this study. As outlined in Chapter Two, Gee (2007; 2010) pointed out that affinity groups are ways in which students socio-culturally organise themselves to engage in activities. Essentially, affinity groups offer powerful opportunities for learning because they are sustained by common endeavours irrespective of age, class, race,

gender and educational level. The students positively conveyed that they developed an affinity to learning Tooth Morphology and Oral Anatomy through teamwork and peer-to-peer learning. They emphasised that regardless of the games being played within a formal learning environment (such as the classroom) their social skills of learning improved through Game-play. In some ways, this is characteristic of an affinity group (Gee and Hayes 2012) but not necessarily an 'ideal' affinity space, which is more focused on students learning how to create content in video games and massive multiplayer online games. A significant implication is that this opens a different area of research where lecturers and students co-design educational games in higher education. Perhaps, this teaching approach brought about by new technology will help lecturers to prepare students for broader roles in the development of a South African society.

A key result of this study indicates that learning through games exemplifies a visible pedagogy (Bernstein 2000). Students' accounts revealed that the games enriched their teaching and learning interactions as the games enabled them to engage with disciplinary knowledge in meaningful and enjoyable ways. At the same time, learning through games enabled the students to make connections to the codified situated knowledge of laboratory practice. In line with the research of Squire and Jenkins (2003), the results of this study suggest that games are micro-worlds that enable students to develop a much firmer sense of how different bodies of knowledge are interwoven with each other. Indeed, learning through games may have little to do with increasing factual recall or the ability to choose correct answers. Instead, and as exemplified by the students' explanations, games potentially made complex knowledge accessible to all the students, most of whom were English second-language speakers, and it assisted them to participate in discipline discourses. This will more likely increase their understanding that morphological and anatomical concepts are a pre-condition to fabricating intraoral dental appliances, particularly in view of Beere's (2012) oft-cited phrase that the "bone sets the tone and the soft tissue is the issue".

As illustrated in Figure 5-2, the three consistently recurring themes emerging

from the data that overlap both the quantitative and qualitative phases are: (1) access to knowledge; (2) instructional design of the games; and (3) technical design of the games. It is worth noting that implicit in the instructional design of the games is the lecturer as guide to the learning process. This point deserves some clarification. Given the lack of awareness of Dental Technology knowledge among first-year students, it appears sensible that the teaching of a domain should be associated with some explicit instruction of the knowledge structure of that domain. If students do not understand what kind of knowledge is valued, other areas of work will be harder to understand because they do not know how to think about or learn the material. This indicates that in conjunction with the design of the game, strong Framing is a function of the lecturer making the game part of a larger coherent teaching and learning system. Only then are students likely to be provided with epistemological access.

Figure 5-2: Themes common to both research phases

Equally significant, literature illustrated that weakly framed knowledge is often problematic as students are unable to acquire epistemological access without

support in terms of pace, selection and sequencing (Morais *et al.* 2001; Young and Gamble 2006; Case 2011). For example, and in her review of the competency-based training model in the vocational education and training sector in Australia, Wheelahan (2009) argued that strongly framed knowledge is likely to be strongly sequenced, paced and evaluated. This provides students, especially English second-language speakers, better access to higher levels of knowledge. By contrast, weakly classified and framed knowledge is problematic as it denies students access to powerful knowledge. Consequently, students will be unable to participate in debates within their occupational fields of practice, which is a core underpinning of vocational qualifications and programmes. The guidance of the lecturer, a strong recurring theme in this study, is central to making content accessible to students (+F). Hence, the lecturer is at the core of Figure 5-2.

In summary, and in meeting the research objectives, this study has analysed the extent to which the games provided epistemological access. In particular, it considered the extent to which the discipline-specific content in the games was relevant and beneficial in the context of what is generally valued in Tooth Morphology and Oral Anatomy. Legitimation Code Theory (Specialisation) shows how all disciplines have their own values and have particular knowledge structures. In this case, the structure of Dental Technology knowledge represents a knowledge code with stronger ER and weaker SR. The students' experience of the games was analysed using this theoretical frame. It was established that the games had a main focus on concepts and specialised practices (ER+) with less concern for particular dispositions (SR-). The specialisation of the games was thus aligned to that of the target subjects and therefore could provide enhanced epistemological access to that target discipline.

The stronger ER and weaker SR of the two games analysed here should emphatically not be the goal of all game design. The knowledge code nature of the games in this study would be entirely inappropriate, especially, and as pointed out by Chen, Maton and Bennett (2011), in a discipline where a particular gaze or lens needs to be cultivated. Legitimation Code Theory

(Specialisation) allows us to understand that epistemological access is access to knowledge-knower structures of that particular discipline. The aim of any pedagogical intervention is thus to provide access to the code of that discipline, be it a knower code; an elite code; a relativist code; or, as in the case of this study, a knowledge code. In summary, the games in this study were found to provide nuanced ways of enabling students' access to content knowledge that is grounded in the form of knowledge valued by morphological and anatomical principles.

The next chapter concludes the thesis by drawing these discussions together to develop a framework that will provide guidelines for the development of games applicable to higher education.

Chapter Six – Conclusions and Recommendations

This research study set out to investigate the pedagogical value of games in providing epistemological access to Tooth Morphology and Oral Anatomy. A mixed methods sequential explanatory research design was adopted to provide an in-depth analysis. The study comprised data from surveys, pre- and post-tests, observational data, debriefing sessions (Quantitative phase 1) and student focus groups (Qualitative phase 2). The thesis used the sociological lenses of knowledge structures (Bernstein 2000) and Legitimation Code Theory of Specialisation (Maton 2007) to comprehensively analyse the underlying knowledge structures of the games. The purpose of this final chapter is to draw the discussions of Chapter Four and Chapter Five together to develop a framework that can support the design of games for quality teaching and learning. A summary of improvements and current developments of the TMBG and OAMG follows. The chapter concludes by highlighting some directions for future research.

6.1 A proposed framework for using games in higher education

The preceding chapter indicated that game design is a critical component in their potential to enhance epistemological access, particularly in terms of the underlying structuring principles of knowledge and coherent theories of learning through games. Various skills such as collaboration through teamwork, communication, reading and problem solving skills were also reinforced when using games to learn. Educational game design is therefore a form of what Squire and Jenkins (2003: 30) call “social engineering”, as it enables lecturers and students to develop a sense of how specific social processes and practices are interwoven, and how different bodies of knowledge relate to each other. As the findings of this study revealed, it is critical that there is alignment between knowledge-knower structure of the target discipline/subject/programme and the game. The developing framework takes this into consideration by providing guidelines to develop games that can create richer and more supportive learning environments in higher education. Significantly, and as advocated by Dondi and Moretti (2007: 503), it will create a culture of ‘quality’ learning through

games. This is pertinent from the perspectives of quality in higher education, specifically the concepts of quality as 'fitness for purpose' and 'transformation'.

Harvey and Green (1993) pointed out that quality can be understood in various ways in higher education. South Africa has drawn on two of these ways to conceptualise quality at a national level (Council on Higher Education 2004b) that is, quality as 'fitness for purpose' and quality as 'transformation'. Quality as fitness for purpose is usually based on the ability of an institution to fulfil its mission or of a programme to fulfil its aims. It relates to the extent to which a product or service fits its purpose. The question asked is whether the institution or department has ensured that all of its policies, practices, structures and approaches enable the fulfilment of its stated purpose. The discipline of quality management also refers to fitness for purpose. According to Foster (2001: 5), the quality of a product in terms of performance is the efficiency with which a product achieves its intended purpose.

In contrast, quality as transformation is about the empowerment of students in higher education. Transformation does not necessarily apply to physical transformation but to the cognitive reshaping of students as a consequence of the learning process. The question asked is whether the graduate has been transformed in meaningful and appropriate ways as a result of their education. In South Africa, it is argued that Harvey and Green's (1993) conception of transformation has been extended to also refer to transformation at a broader level of society expressed by the works of Quinn and Boughey (2009) and McKenna and Quin (2012). These conceptions of quality have been important throughout this study and both relate to notions of epistemological access. They also drew this study to its third objective, which is the development of a framework to support the use of games in higher education.

As illustrated in Figure 6-1, the principles of de Freitas and Oliver's (2006) four-dimensional framework, together with Gee's (2007) G/game concepts guided the initial ideas of the proposed framework in this study. The four-dimensional framework focuses on four generic principles, namely the context of the game, mode of representation, pedagogic approach used and the specifics of a

student. A brief explanation of each principle is demonstrated in Figure 6-1 and is presented in the context of this study. de Freitas and Oliver (2006: 262), report that the four-dimensional framework is more suitable for educational advisors or educational software designers, hence it may need to be refined if used by a teacher. In agreement with them, and as indicated by the dotted circle in Figure 6-1, other concepts emerging from this study namely, the underlying principles of knowledge, epistemological access, game literacy and quality of learning, have influenced the development of a different structural and analytical framework. As this study attempted to emphasise, and of significance, these concepts point to a conceptual gap in the current literature on games in terms of how higher education lecturers can harness the use of games in the provision of epistemological access. This is consistent with the argument of Scott, Yeld and Hendry (2007) that a key investment in higher education is to provide conceptual and analytical tools that will help enhance the quality of teaching and learning of non-traditional practices.

Table 6-1 demonstrates the guiding principles (most of which are presented as questions) of the proposed framework as illustrated in Figure 6-2, that need to be considered when developing games in higher education. These principles emerge from the findings discussed in Chapters Four and Five. The framework critically highlights the alignment between the knowledge - knower structure of the target discipline/subject/programme in terms of three main frames, namely knowledge/instructional, technical and educational. Consequently, the proposed framework name 'KITE' (**K**nowledge/**I**nstructional, **T**echnical and **E**ducational) was formed. The game design frame, that is the 'kit' of the KITE, refers to the underlying interconnecting design principles. The educational aspect, by contrast, focuses on the quality of the game from two perspectives namely: (1) Teaching, learning and assessment; and (2) Research. Importantly, the knowledge/instructional design frame is a precondition to the technical design frame, and the 'KIT' frame is a pre-requisite to the educational research frame. While the guiding principles in Table 6-1 are clear, there are aspects that require some clarification and these are explained below.

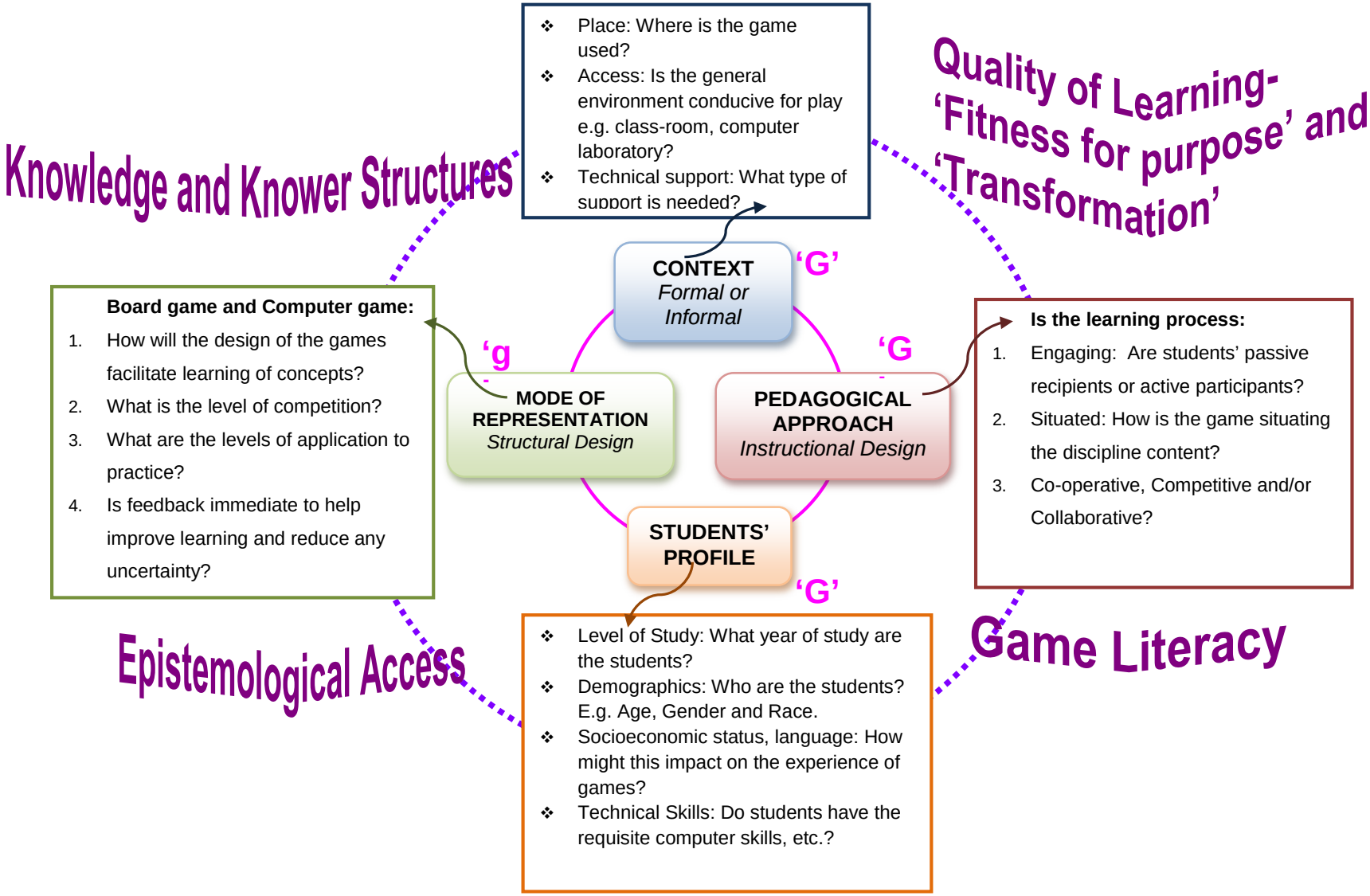


Figure 6-1: Elementary ideas for proposed framework
(Adapted from de Freitas and Oliver (2006: 23) four-dimensional framework)

Table 6-1: Guiding principles of the proposed KITE framework

KIT E		
Knowledge/Instructional Design Frame ***(Lecturer)***	**Technical Design Frame** ***(Game Designer)***	**Educational Research Frame** ***(Lecturer/Researcher/ Game designer)***
Lecturer guiding principles: ***University: Formal Access*** 1. What type of training is offered in the University? *(Traditional versus Vocationally-Orientated qualifications)* 2. What are the profiles of the students? *(Level of study, socio-cultural, socio-economic and socio-technological backgrounds)*. ***Knowledge to support the provision of Epistemological Access:*** 3. What are the knowledge and knower structures underpinning the discipline/subject? What is valued in the discipline in terms of epistemic relations and social relations? ***Curricula to align to learning objectives in the provision of Epistemological Access, hence to consider:*** 4. Which game literacy theories will be used to support learning? 5. What theory of learning underpins the curriculum?	Game Designer guiding principles: ***Game Genre to support Epistemological Access:*** 1. Which game delivery platform most appropriately aligns to the knowledge/instructional frame? 1.1 Non-digital 1.2 Digital 1.3 Video 1.4 Mobile 1.5 Massive Multiplayer online 1.6 Blend of the above 2. Roles and responsibilities of the various design experts must be explicit to achieve target goals through engaging teamwork. 3. Together with the lecturer, the game designer to determine the rules of the game. 4. Intellectual Property - Copyright, Trademark and Patents. 5. Debriefing: Lecturer and Game designer/s.	*Quality-fitness for purpose and transformation*: Game Prototype **Lecturer: Pedagogy** 1. Which teaching and learning strategies will be used to support the learning outcomes embedded in the games? 2. How will the game be assessed to determine the efficacy of learning? 3. What kind of debriefing process is to be used? *Quality-of a product*: Game Prototype **Researcher:** 1. Advocate mixed-methods research. 2. Debriefing integral to the research process. 3. Publication. **Game Designer:** Technical support, track and monitor technical aspects of the teaching and research processes. **Overall Debriefing and Evaluation*:*** Lecturer, Researcher and Game designer.
		

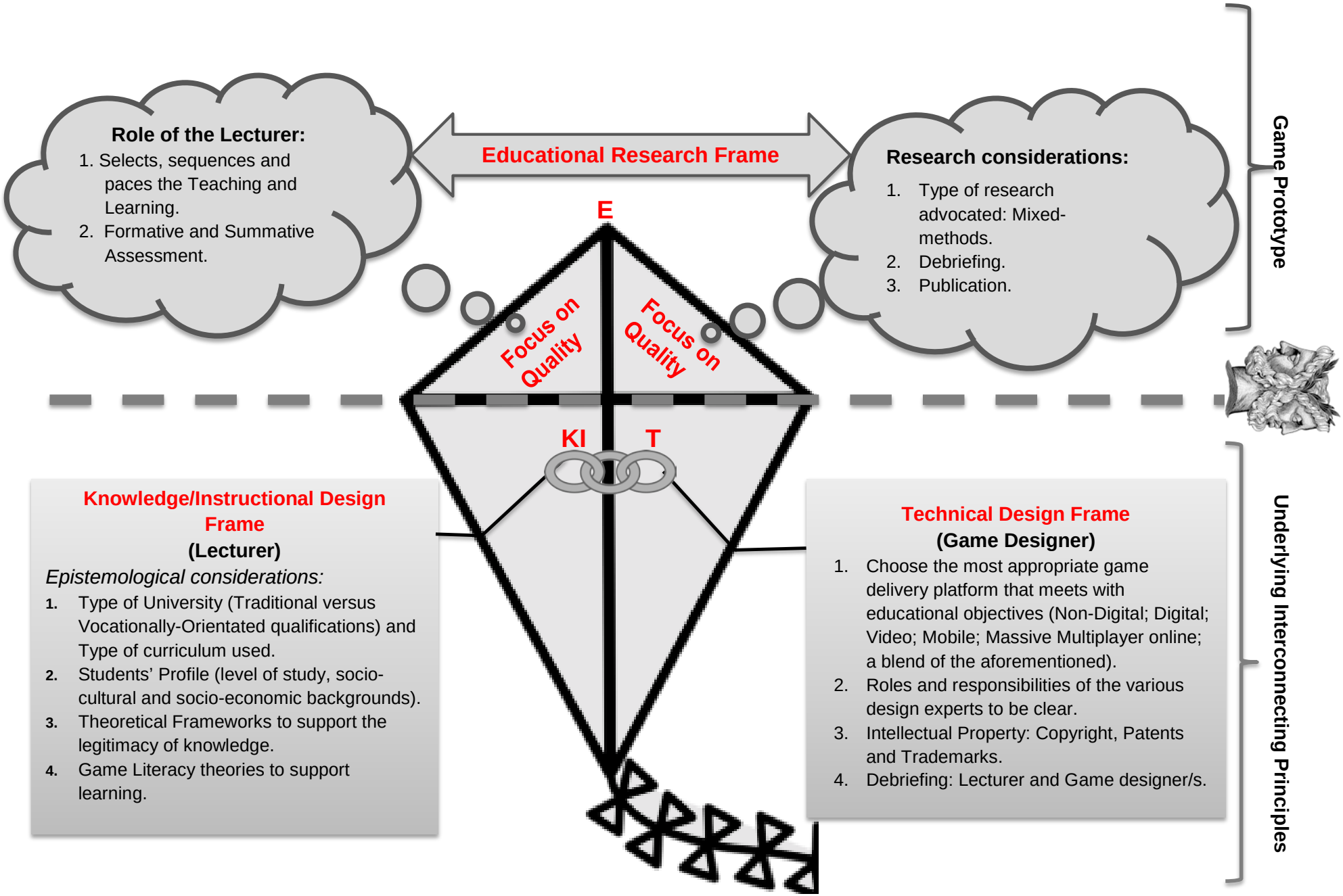


Figure 6-2: KITE Framework

From the outset, it was found that the game architecture needs to be embedded in the curriculum by building it into the game's underlying engine (or technology). The type of game chosen must systematically align with the learning objectives of the game and the purposes it will serve. As the results of this study indicated, facilitating the amalgamation of the KIT frame, as well as to assure that students are exposed to appropriate and realistic learning environments, requires that the lecturer understands the structure of the knowledge underpinning the curriculum (Table 6-1: left-hand column). From a higher education perspective, and resonating with Wheelahan (2007: 648), the lecturer, in turn, helps the students to understand the knowledge-structuring processes and how complex bodies of knowledge fit together in deciding what knowledge is relevant for a particular purpose. It is suggested that the KITE framework may need to be refined if students are the instructional designers of the games, as they may not necessarily have sufficient knowledge of the underlying knowledge principles of the curriculum. Under such circumstances it is advisable for the students to be co-instructional designers.

From a technical layout perspective, and as garnered from this study, game designers depend on clearly defined conceptual briefs given by the lecturer to successfully and technologically synthesise the learning objectives, outcomes and assessment criteria with the relevant game mechanisms. Good game design can leverage a deeper approach to learning in terms of enabling students to understand complex concepts and linking it to the field of professional practice. It is therefore important, and in corroboration with Whitton and Hollins (2011), that to develop educationally sound games with relevant graphics and other multi-media materials depends largely on the concerted effort of a team that shares the same vision, goals and cultural norms.

In addition, this study explicitly indicated the value of debriefing as a sharing platform of ideas between lecturers and students. It provided a legitimate source of learning. Debriefing is included in the technical design frame for the lecturer and game designer to discuss and to gain clarity and deeper insight at the various stages of game development. If an online game is being developed, debriefing needs to be built in as an integral part of both the software and procedures of running a game. In this way, and as Crookall (2010: 908) believes, students can debrief in a richer and more

accurate way. Therefore, debriefing has been included in the educational frame to further turn the game experience into a valuable part of learning.

With reference to intellectual property, and from a legal perspective, lecturers need to be knowledgeable of their university's intellectual property policy to guide the protection of the game innovation. This is an integral component of the game design frame particularly from the perspectives of introducing the game, or in legal terms the intellectual property, to the business world. This is significant in moving educational games to quality levels of pedagogical validation beyond perceptions that they are purely for entertainment or livelier lessons. Games must be valid for the full range of purposes for which they are intended. For example, and is the case in this study, a coherent research approach revealed intangible aspects of the game design elements that presented barriers in learning. On a positive note, rigorous and recognisable research can also attract funding for further developments of the game. Such published research becomes the strength of a discipline and will ultimately bolster the profession and the university's image, overall.

One key argument underpinning the guiding principles of KITE is the extensive linking of academic discipline-specific content and the field of professional practice. This was crucial in the case of Dental Technology but may be less so for other disciplines. The KITE framework argues that careful consideration of such issues is fundamental to the design of quality educational games.

Equally important, the framework aims to be a stepping-stone toward a much larger and deeper conversation about the enhancement of epistemological access to legitimate knowledge through games. It is noteworthy that the design and development of educational games is an iterative process as it allows the design process to be revised, particularly as the initial blueprints will evolve with advancing technology. Arguably, limitations of technology in the game could negatively impact on its pedagogical value in the classroom. This point will be expanded on in the section below by outlining the future directions of the design of the games in this study.

6.2 Summary of improvements and current developments

Table 6-2 summarises the improvements needed to enhance the pedagogical value of the Dental Technology games, as gathered from the students' feedback and focus group discussions.

Table 6-2: Recommended improvements of the Dental Technology games

Tooth Morphology board game	Oral Anatomy multimedia game
1. Convert the TMBG into a computer game or use a combination of digital and non-digital game design.	1. Convert the game into an online game for students to access it at any time and at any place.
2. The full mouth stone model to be replaced with a more durable material such as a hard plastic model.	2. Introduce other sounds.
3. Review the questions, particularly the rewards and penalty category, by reconsidering the penalties that could demotivate and frustrate students during game play. To also introduce additional higher order cognitive questions.	3. Correct the errors identified in the questions.
4. Correct the errors identified on the cards.	4. Introduce a voice aid to assist students in the pronunciation of anatomical terminology.
5. Instructional manual to be more specific as to which direction the team is to move and to provide guidelines on reasonable time frames that will encourage student learning. Note that if the game is to be computerised then these specifications will be built into the software of the game.	5. Introduce 3-D interactive multimedia materials, particularly an interactive skull.
6. Refine the structural layout of the game in terms of using more vibrant colours.	6. Multiplayer option - to encourage co-operative, competitive and collaborative learning.
	7. Students to receive a printout of their game results.
	8. Introduce other anatomical content such as Dental Histology and Border Movements.
	9. Introduce higher levels of challenge and to reveal the correct answer during game play.

With the exception of point 1 in Table 6-2 (left-hand column) it is worth noting that all of the recommendations given by the students were addressed in the latest version of the TMBG. Appendix 13 illustrates the new game prototype, 'Bite-phology™'. In

addition, the researcher has initiated an M-Learning project to convert the OAMG into a mobile game. Part of the design is to include other mini sub-games that particularly address points 6, 8 and 9 in Table 6-2 (right-hand column). In terms of the KITE framework, the game is currently in the early stages of the technical design frame as it seeks the expertise of:

- A computer programmer who through coding and debugging will determine how game play is to be designed/converted.
- A graphic designer will be tasked with the brief to design realistic graphical content that facilitates interaction by the users. This includes the artwork, game effects and user interface design.
- Dental Technology lecturers to test the game and to report any problems to the project leader (the researcher). This feedback will in turn be given to the computer programmer and graphic designer. Through subsequent iterations of the game it is anticipated that an acceptable mobile game prototype will emerge and will be used in the teaching, learning and assessment of Oral Anatomy (educational frame of KITE).

Furthermore, students unanimously agreed that the Dental Technology games should be formalised into the curriculum. To give this consideration means changing the 'game' of assessment so that performing well in major tests is not the only objective. The current timetabling will also need to change, as there is likely to be a shift in the teaching and learning of Tooth Morphology and Oral Anatomy. The researcher is to further explore this area of inquiry.

6.3 Future directions of the Dental Technology games

Recently, and using the TMBG as an exemplar, Connolly *et al.* (2012: 666) acknowledged the high quality of the empirical reporting of the pilot study. They highlighted that consideration of how non-digital games support learning can provide additional support to the analysis of digital games. In particular, the mixed methods of this extended study helped to document the shift away from a novice understanding (as reported in the pilot study) to a more robust analysis of understanding the knowledge-knower structure in the games. This study revealed how deeper insights on the students' learning experiences through games is acquired in a way that is not

always possible when data is collected and analysed using only a quantitative, or qualitative, design. Other critical information gained included: role of the lecturer, the instructional frame in which the game is presented, and the game-related pedagogical support and learning opportunities provided through debriefing sessions.

In addition, this study made methodological and theoretical contributions in terms of using Bernstein's (2000) concepts of educational knowledge codes and Maton's (2007) LCT (Specialisation). The conceptual framework facilitated the rigorous analysis and robust reporting on the nuances of the students' understandings, reflections and reactions of how games support the provision of epistemological access. The study demonstrated how the conceptual framework revealed that specialist knowledge and skills are relatively more important to legitimate participation and learning achievement in the target subjects than the personal attributes and dispositions of students. The games in this study embedded a knowledge code and in this way enabled students to acquire epistemological access to discipline-specific knowledge. A significant implication of this finding is that further research is required on the underlying structuring principles of knowledge of the Dental Technology curriculum, overall. Such research is likely to reinforce the argument for developing games in other Dental Technology subjects. Equally important, it could add further support to formalising games into a structured curriculum. To advance future research in this area, a number of directions are provided below. These are based on the limitations and findings of this study.

From a Bernsteinian perspective, a theoretical contribution made by this study is providing an initial description of Dental Technology as a region. A significant implication is that further research is required to understand the double re-contextualisation process of the entire Dental Technology curriculum, particularly through the conceptual framework proposed by Winberg *et al.* (2013). Herein lies an area wide open for research. From a fitness for purpose quality perspective, researching the Dental Technology curriculum and its constituent forms of knowledge will help lecturers to objectively assess their teaching, learning and assessment practices, and whether such practices enable students to acquire epistemological access to both disciplinary and situated knowledge. This analysis is likely to

contribute to the ongoing debate on whether graduates are equipped to understand and resolve the critical issues of the work place.

While LCT has been shown to serve as an analytical tool for this study, its use was only focused on the dimension of Specialisation. There may be other aspects of the educational experience that are worth exploring, some of which can be conceptualised using other dimensions of LCT or appropriate game theories. For instance, to completely understand the affective dimensions of students experiences of using games warrants attention in future research.

In terms of methodological issues, one limitation of the research was that only Dental Technology students at DUT played the games. This was expected, as the researcher is the Tooth Morphology and Oral Anatomy lecturer at DUT and for practical reasons was able to plan her teaching, learning and assessment of the games more effectively. Nonetheless, objective assessments from dental technology lecturers and students from other universities, namely Cape Peninsula University of Technology and Tshwane University of Technology, would be of value for further research and development of the games.

Lastly, the structural and functional anatomy of the muscles of mastication and facial expression is content that is common to other Health Sciences programmes in DUT, for example Chiropractic, Homeopathy and Somatology. Using the OAMG in these programmes will provide valuable insights, particularly in terms of promoting the adoption of games in higher education. Similarly, using the OAMG in the teaching, learning and assessment of dentistry could promote collaborative game projects between UoTs and traditional universities. From a marketing perspective, the interdisciplinary use is likely to promote the OAMG both nationally and internationally.

6.4 Conclusion

This research explored the pedagogical value of games in providing students with epistemological access. The study used the concepts of knowledge and knower structures to find that the games provided students with epistemological access. This nuanced understanding of games is different from the empirical descriptions generally

found in the literature, as it involved more than just assuming games will motivate and engage students in learning. Instead, this study revealed that it is about assessing the appropriateness of content knowledge embedded in the game and how game design mechanisms make it possible for students to access that knowledge. This study also foregrounded that regardless of the game design used, the lecturer strongly frames the sequence and pace at which students learn through non-traditional practices. A framework is therefore proposed to guide higher education lecturers to develop games that connect discipline specific knowledge to the professional field of practice. Arguably, the usefulness of the KITE framework in guiding the design of games to analyse the epistemic relations and social relations of the target knowledge and the knowledge enabled through the games, is an area for further research.

Importantly, the study suggests that the pedagogical value of games is strengthened when conditions amenable to this form of teaching is accepted. These conditions include students having some knowledge of the content prior to playing the game and their approval of the technology used in the game. If the purpose of an educational game is to provide students access to content knowledge, how critical is it then for students to have any such knowledge prior to playing a game? This is an area for further research. Finally, the findings of this study could potentially enable the researcher to market the games both nationally and internationally. It could also attract external funders to support the development of other and more advanced games in Dental Technology.

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Appendix 1: The Tooth Morphology board game

"You must make games to study them, and you must study games to make them"
Bogost et al. (2005: 60).

1.1 Preliminary Study: Tooth Morphology board game

The study population consisted of first-year Dental Technology students for the years 2003, 2004, 2005 and 2006. The total sample size, as outlined in Table 1, is one hundred and twenty-eight students. Census sampling was used. Pre- and post-surveys were used to evaluate the usefulness of the game in view of further developments. Academic experts such as a Dental Technology lecturer and an Academic Literacy lecturer, who taught first-year Dental Technology students, validated the study by reviewing the contents of the game. The shortcomings in the technical design of the board game (Figure 1) influenced the development of the second version (Figure 3) of the game. Through action research, the shortcomings in the instructional and technical designs of the second version of the Tooth Morphology board game (TMBG) persuaded the development of the third form (Figure 3). This form of the board game was deemed to be acceptable for the pilot study.

Table 1: Total Sample Size: Preliminary Study

Year	Version of the Tooth Morphology board game	Number of Students
2003	First	29
2004	Second	31
2005	Second	32
2006	Third	36
	N=128	

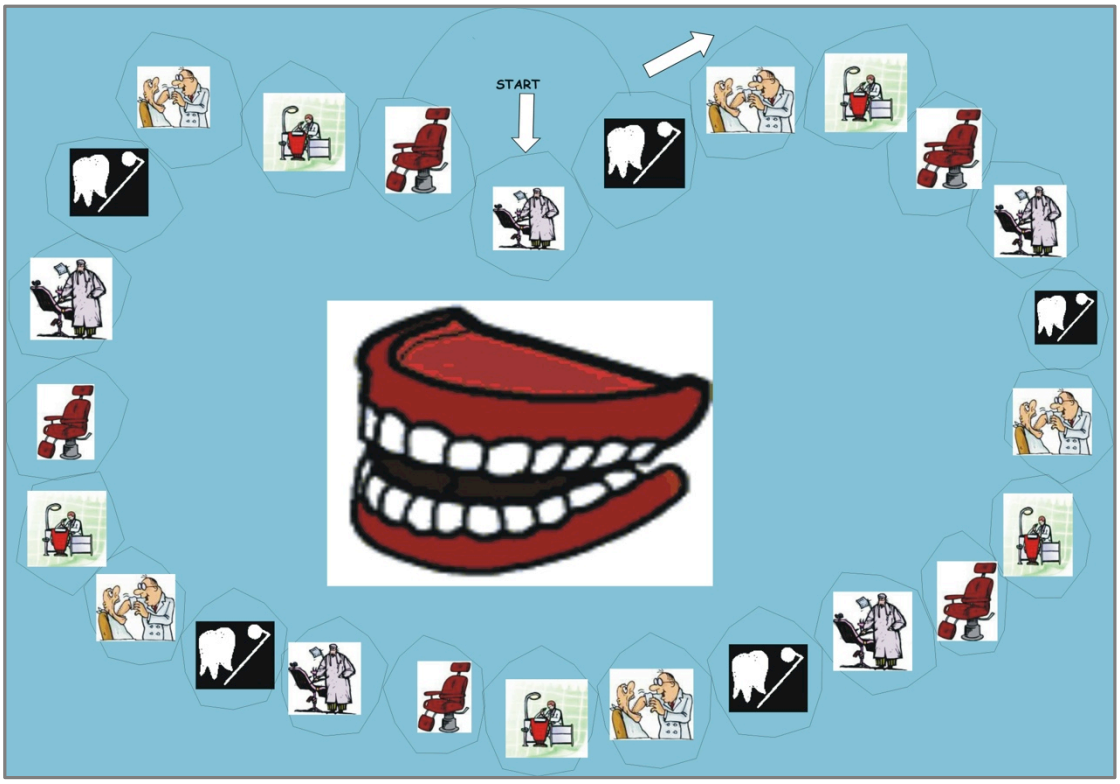

Figure 1: **Version One:** Tooth Morphology board game

Figure 2: **Version Two:** Tooth Morphology board game

Figure 3: **Final Version:** Tooth Morphology board game©

1.2 Components of the Tooth Morphology board game

The physical components of the game comprise of a board (Figure 3) that uses graphically depicted square blocks corresponding to the playing cards (Figure 4). The graphics represent the three categories, namely, high cognitive multiple-choice questions, low cognitive multiple-choice questions, and rewards and penalties. Multiple-choice questions are presented on the playing cards vis-à-vis the Tooth Morphology content of the structural and functional morphology of molars, different types of malocclusion, chewing process, general description of primary teeth, and various dental anomalies. A full mouth maxillary model (Figure 5), dice and acrylic molar teeth with correct morphological detail (Figure 4) made suitable playing tokens.

Figure 4: Tooth Morphology playing cards and tokens

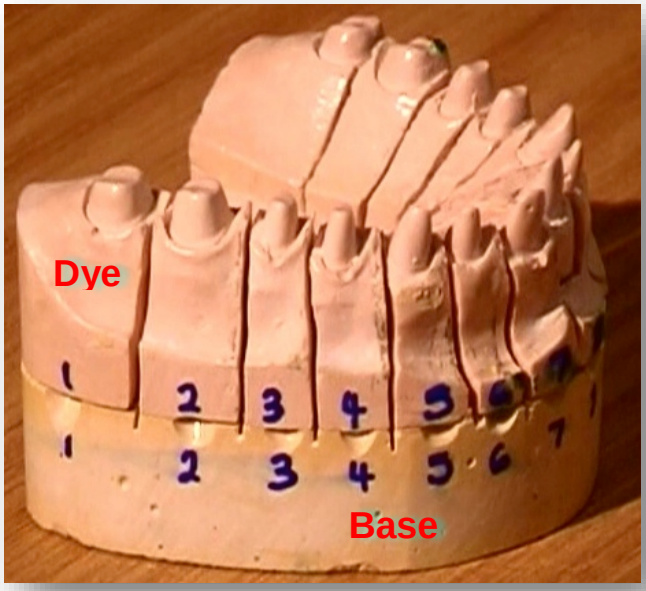

Figure 5: Full Mouth Maxillary Model

1.2.1 Rules of the TMBG

- There are two teams per board game. Each team should have between two to three players.

It must be noted that teams were randomly selected in order to accommodate male/female mix as well as ECP/mainstream student combinations. This was

principally done to encourage dialogue and break social and cultural boundaries between students. It must be emphasised that at the time of developing the TMBG, the researcher anticipated that placing students into teams would encourage fun, yet effective learning of the abstract content, and would promote healthy discussions through collaboration and competition.

- Each team is presented with a full mouth maxillary model that is made up of a base and fourteen dyes. Each dye is numbered and corresponds to the number on the base. Each team is to remove all dyes from the base prior to commencement of the TMBG. Note that:
  - For every correct answer the team is to return a numbered dye to its corresponding numbered base.
  - For every incorrect answer the team is to remove a dye from the base.
  - The team that returns all the dyes correctly to its corresponding numbered base and completes the full maxillary model is the WINNER.
- Students within a team are to discuss their choices with each other before answering. The answer given will be taken as **FINAL**. Students can refer to notes and textbooks. The cards that have been played should be placed at the bottom of the pack.

1.2.2 How to play the TMBG

- Both teams place their tokens on the figure of the tooth that is marked **START**.
- Each team has a turn to roll the dice.
- The first team to roll **SIX** on the dice will be called **Team 1** and they will start the game.
- **Team 1** rolls the dice and moves left on each figure the number of spaces as indicated by the dice.

- **Team 2** picks up the card that corresponds to the picture on the board where Team 1 has landed and then questions them.
- If Team 1 answers correctly they are to return a dye to the model base and proceed to roll the dice again.
- If Team 1 answers incorrectly, then it is the turn of the opposing team (Team 2) to roll the dice.
- The game continues in this manner until all dyes are returned to the base and the maxillary model is completed.

1.3 TMBG: Background to Preliminary study

The objective of the preliminary study was to closely understand and evaluate the pedagogical practice of using games. Hence an action research strategy was adopted. Action research combines diagnostic action and reflection (McNiff 2002: 15) to help bridge the gap between theory and practice (Noffke and Somekh 2011: 94). The practical inquiry of the preliminary work used concepts of action research to trace the invention and re-invention of the games. For the researcher, the dual aim was to improve her pedagogical practice as well as to develop new knowledge about her practice of teaching through games. Hence, action research initiated the innovative change in pedagogy and this, together with the pilot study, is expanded on in the sections below.

1.4 TMBG: Preliminary Findings

As illustrated in Figure 6, data from the surveys used to elicit students' perceptions of this classroom-based practice was reported in terms of two categories, namely technical design and instructional design.

1.5 TMBG: Pilot study

Reflecting on how students behaved in the preliminary study it could be inferred that pedagogy through a game assists students to learn academically and stimulates social interactions with peers. This finding is consistent with other board and card game studies (Eckert *et al.* 2004; Ogershok and Cottrell 2004; da Rosa *et al.* 2006; Bochennek *et al.* 2007).

The study population consisted of first-year Dental Technology students registered for the subject Tooth Morphology for the years 2007 (n = 30) and 2008 (n = 32). After the game tutorial session, students completed a 14-question anonymous survey detailing several demographic variables. Four closed-ended questions measured by a four-point Likert scale (the forced choice response scale) were used to assess students' opinions of the board game as a pedagogical tool (Appendix 8). The responses from the Likert scale questions were coded from 1 to 4, with "Strongly Agree" labelled 4 and "Strongly Disagree" labelled 1. In addition, three open-ended questions were also included to allow students to further elaborate on their opinions of the board game. A debriefing session then followed.

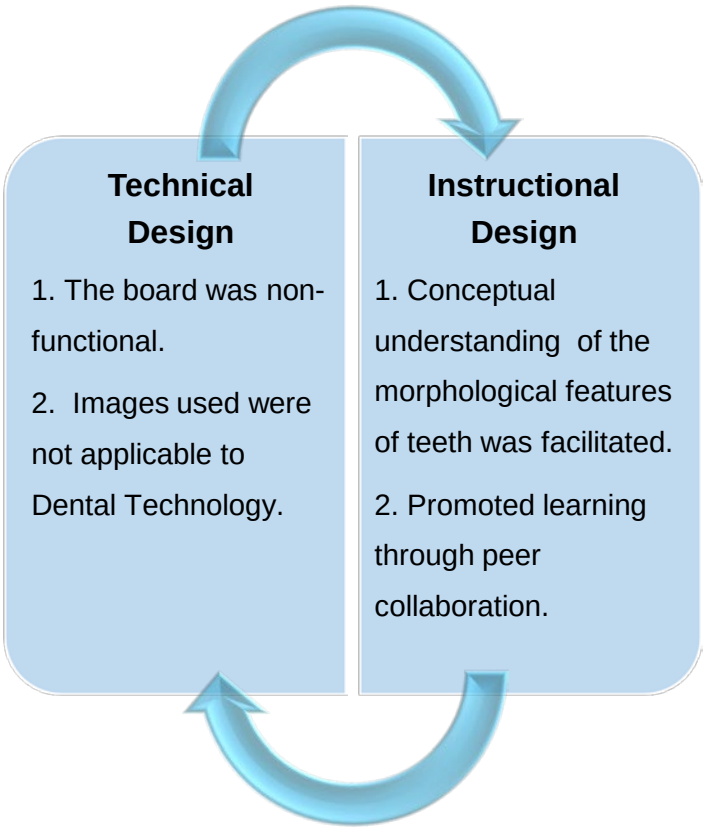

Figure 6: Tooth Morphology board game – Preliminary findings

1.6 TMBG: Data Analysis – Pilot study

Both descriptive and inferential statistics (SPSS Version 20®) were used to analyse the closed-ended questions. A rotated varimax factor analysis was performed for the data obtained from the Likert scale in order to identify items that loaded together, as well as for each of the variables under study. Eigen values closer to 1 (generally above 0.5) were chosen to determine which factor the statement belonged to. One

item of the Likert Scale in Question 12 (Appendix 3) was excluded due to negative covariance in the results.

Cronbach's alpha index was used to assess the reliability of the survey post testing. Nvivo 9 (QSR International Pty Ltd, 2009) was used to organise and analyse data from the open-ended questions by searching for factors and clustering these into specific themes to search for trends. Coding thematically included phrasing or paraphrasing the words of the students so that themes could be identified.

1.7 TMBG: Pilot Results

Overall, 41 (2007 = 20; 2008 = 21) students responded to the survey, which constituted a 66% response rate. With reference to the Likert scale questions in Appendix 3, namely questions 5, 7, 8 and 12, the Cronbach's alpha index revealed a reliability (alpha) coefficient of: $\alpha=0.453$; $\alpha=0.344$; $\alpha=0.451$ and $\alpha=0.394$, respectively. The low alpha scores indicate that the underlying construct was scored in an inconsistent manner. Perhaps the weak correlation of items is due to the insufficient number of variables or, alternately, students found the statements were ambiguous. The validity of the survey items, operationalisation of the constructs and ambiguities or difficulties in the wording were revised for the main study.

In general, the questionnaire elicited students' perceptions of the TMBG in terms of two main themes, namely: instructional design of the TMBG and technical design of the TMBG. The instructional design has three sub-themes and the technical design has four sub-themes. These are explained below.

Figure 7 illustrates that in spite of the lecturer providing guidance, the instructional design of the game is clear as students could play the board game on their own. Equally significant, and as inferred from Figure 8 and Figure 9, the instructional design also stimulated students in learning the morphological content. Students were actively learning, as they had to engage with the other readings (Figure 8). Some students felt that they were challenged as the questions, together with the language, were difficult (Figure 9). The negative responses received (Figure 9) could be attributed to different learning potentials among students, where some are stronger learners whilst others find learning challenging. Hence, students make reference to additional learning

materials. Furthermore, it can be gleaned the TMBG enabled students' access to morphological knowledge as learning was situated in context and active stimulated them.

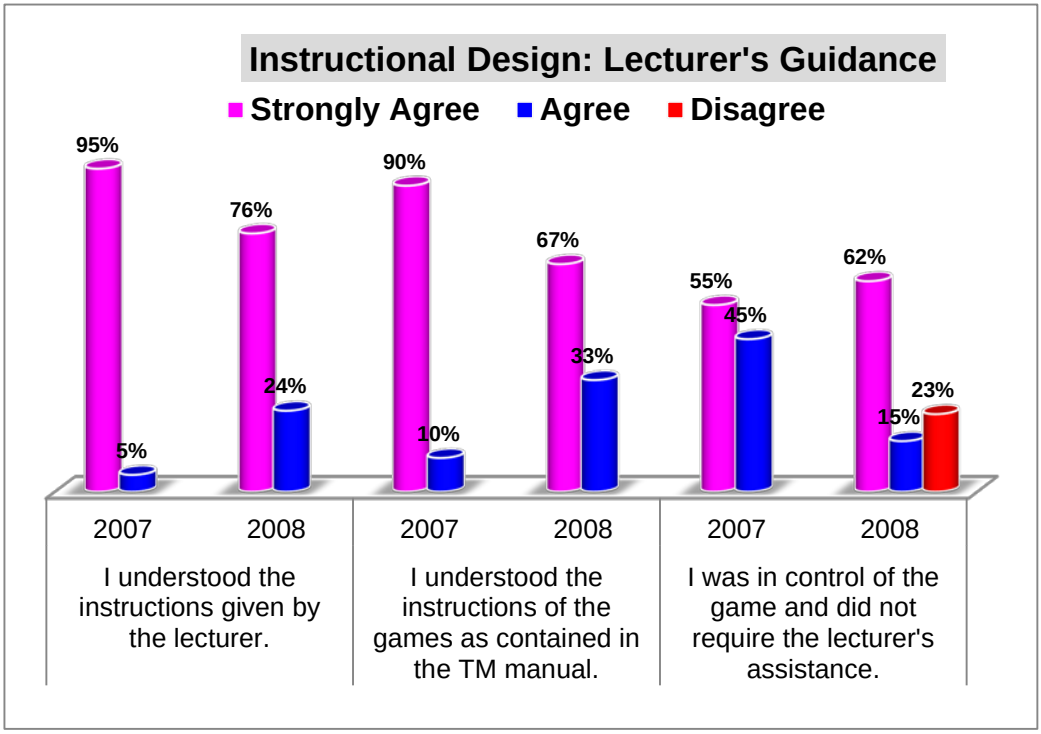

Figure 7: Instructional design: Lecturer's guidance

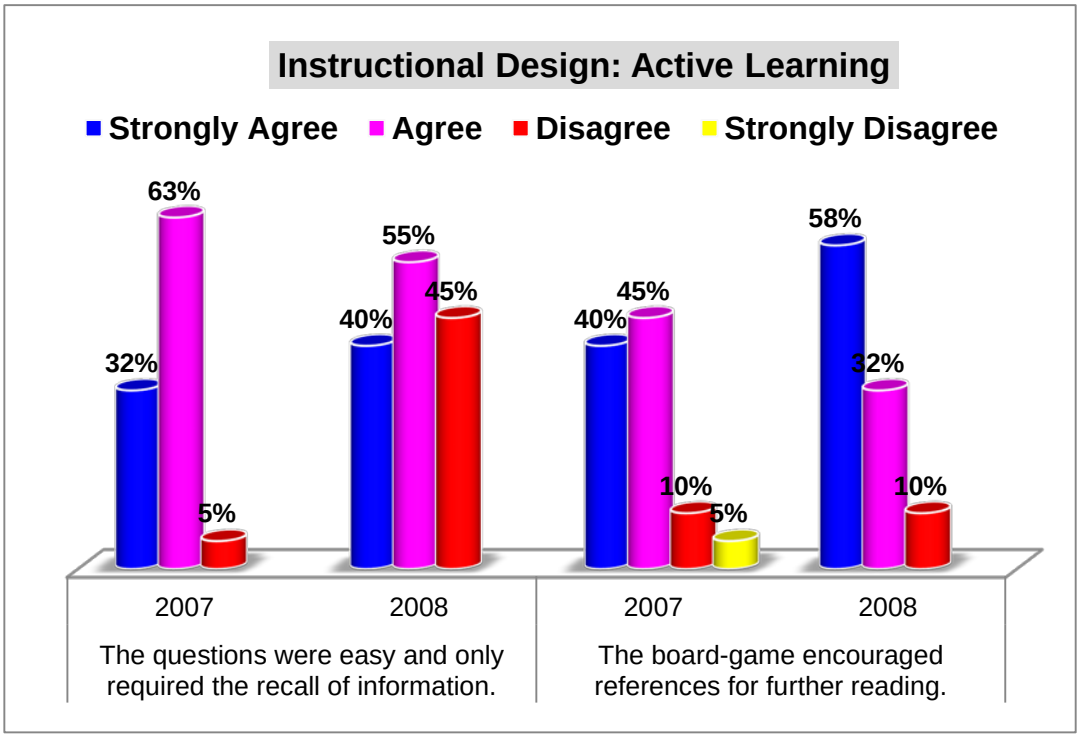

Figure 8: Instructional design: Active learning

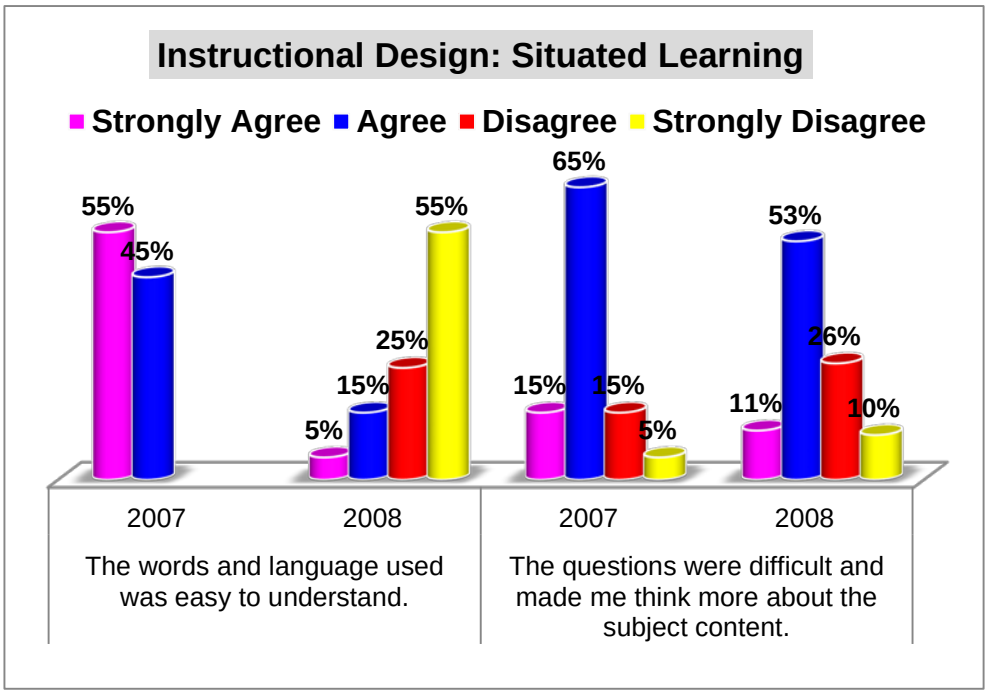

Figure 9: Instructional design: Situated learning

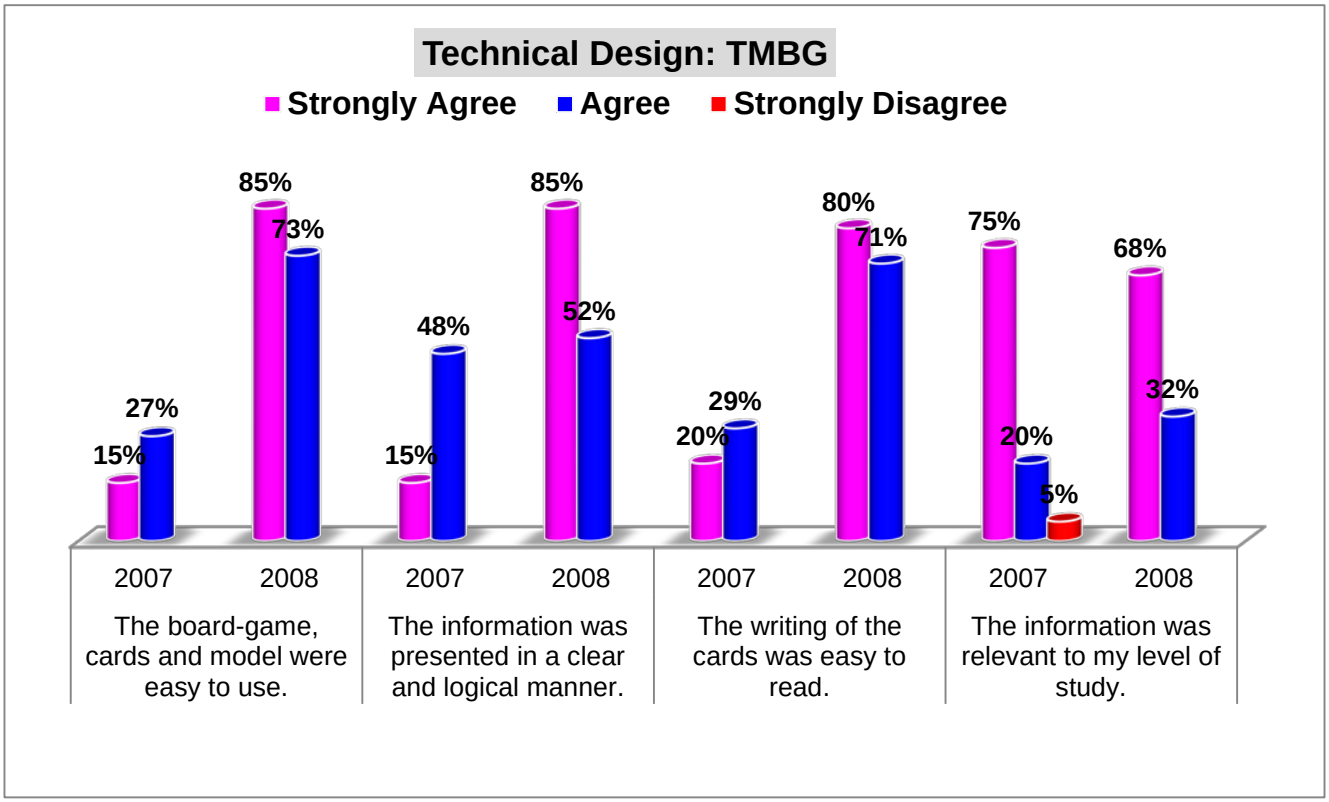

Figure 10: Technical Design: TMBG

From Figure 10, it can be inferred that students were amenable to the technical design of the game, particularly the colours and pictures used in the game (Figure 11). Consequently, learning of the morphological knowledge was fun and motivating (Figure 12). In the process, students were also encouraged to collaborate with their peers (Figure 13).

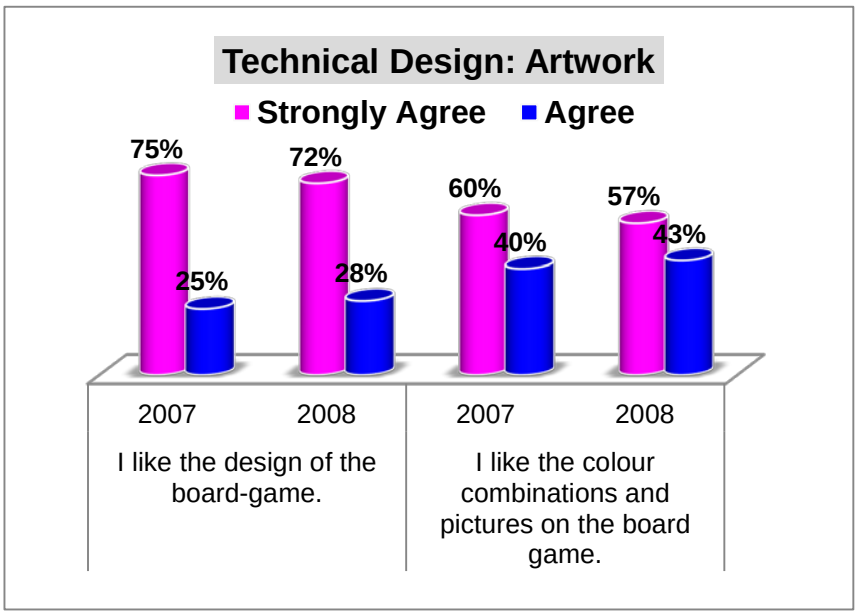

Figure 11: Technical Design: Artwork

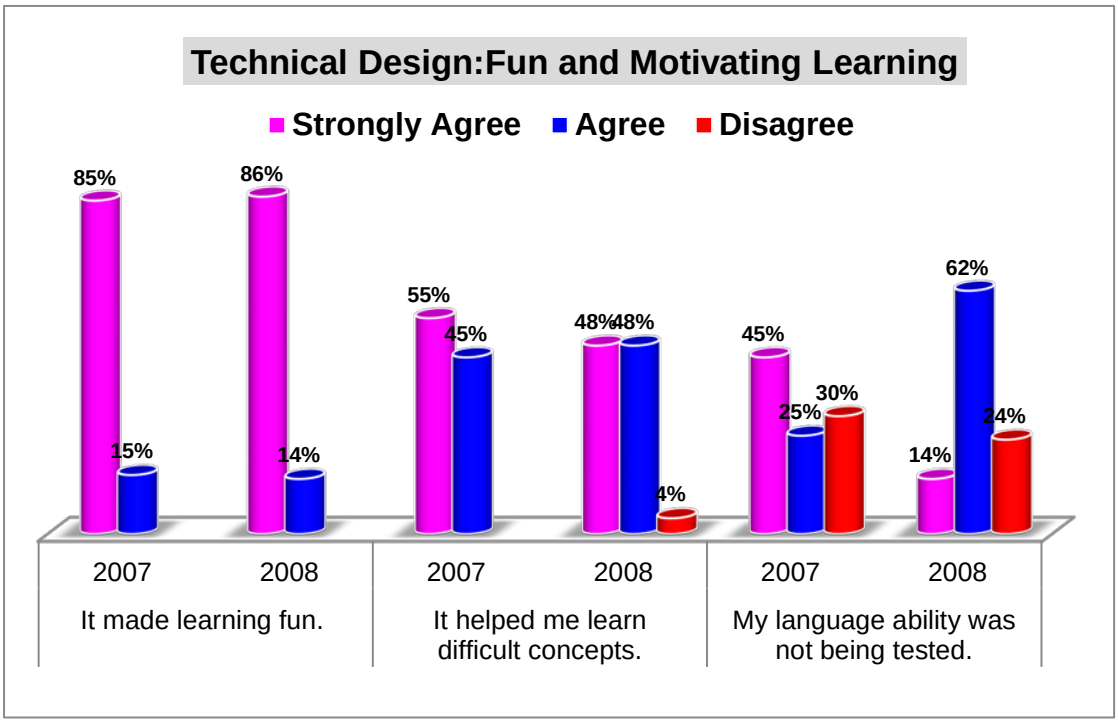

Figure 12: Technical Design: Fun and Motivating

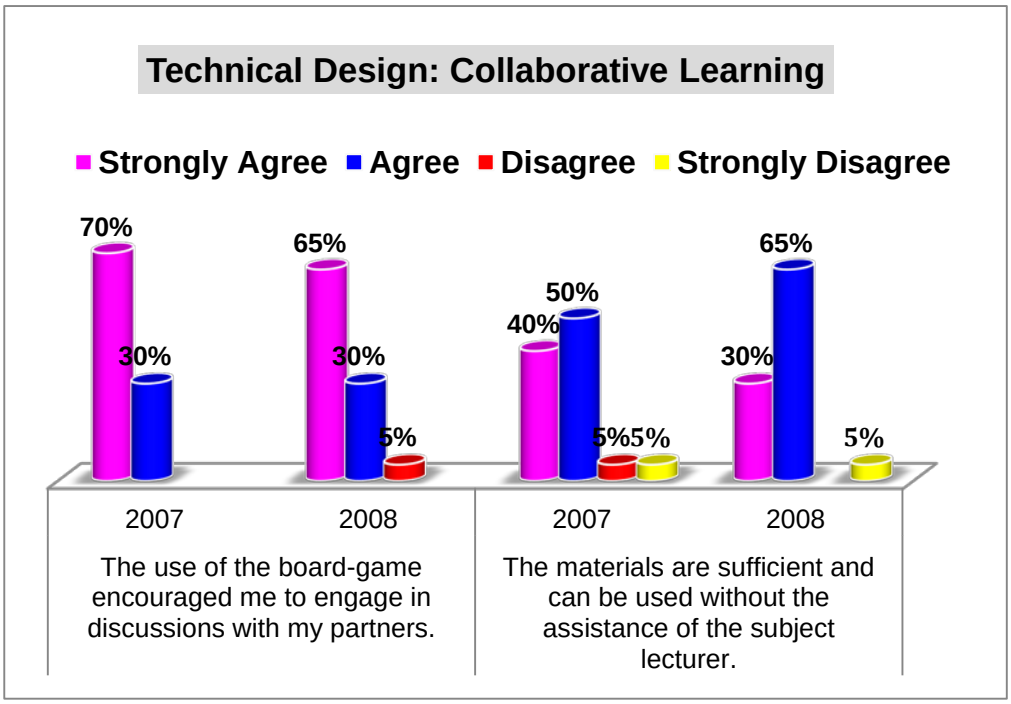

Figure 13: Technical Design: Collaborative learning

Student responses from the open-ended questions centered on the novelty of the classroom-based practice. Students reported that games transform the classroom into a community of interactive learning where teamwork encouraged the development of interpersonal skills. In addition, and during game play, the researcher observed that students behaved collaboratively (negotiation and decision making) with their partners. This is supported by Figure 14, which shows that collaborative behaviour promoted healthy competition between teams.

Students' negative feedback focused on the technical aspect of introducing time limits when answering questions. Figure 14 clearly illustrates this. Some of the students responses, given verbatim, were: *'Include a timer, it would make the game more exciting'.; "Give a time limit e.g. 2 minutes…".; "Must be time limit to finish a question".; 'A time limit for answering the questions will help i.e. the eager participants would know and understand the questions and answers rather than a guestimation'.*

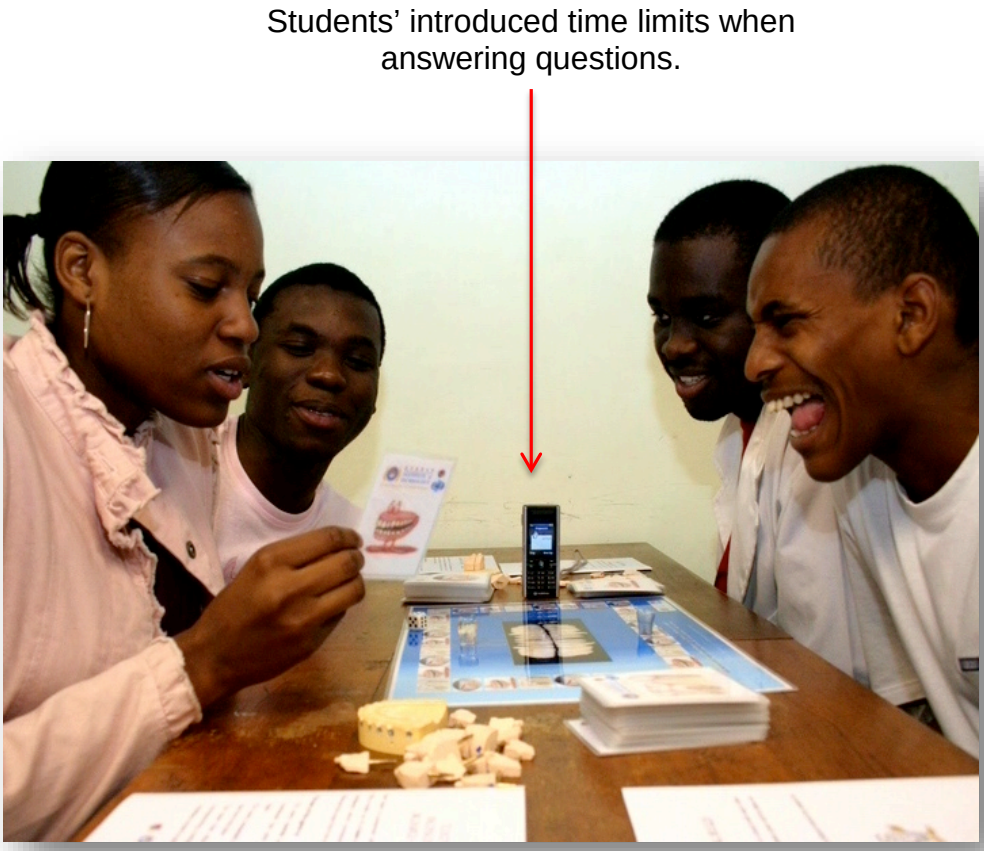

Figure 14: Teamwork and collaboration during game play.

Appendix 2: The Oral Anatomy multimedia game

"You must make games to study them, and you must study games to make them"
Bogost et al. (2005: 60).

2.1 Design and development of the Oral Anatomy multimedia game

To encourage students to learn the abstract structural and functional anatomy of the muscles of mastication and facial expression, a computer application was conceived to provide an intrinsically motivating environment as it provides a mix of fantasy, curiosity and challenge (Ebner and Holzinger 2005). Reportedly, computer-based applications also encourage students to self-regulate and to take responsibility for their own learning (Rieber 1996: 47). It is therefore reasonable to assume that students are more likely to find a computer application intrinsically motivating, as it allows them to monitor and evaluate their own learning. For the Oral Anatomy game (Muscle Mania©), a multimedia software, specifically Macromedia® Flash™ technology (Figure 15), provided a delivery platform for the artwork. This software maintained the high-quality animations and delivery of flash objects across different screen resolutions. Macromedia® Flash™ technology also provided realistic ways of delivering complex muscle concepts in one computer application. To facilitate game speed and automatic allocation of marks, the game is designed around multiple-choice questions.

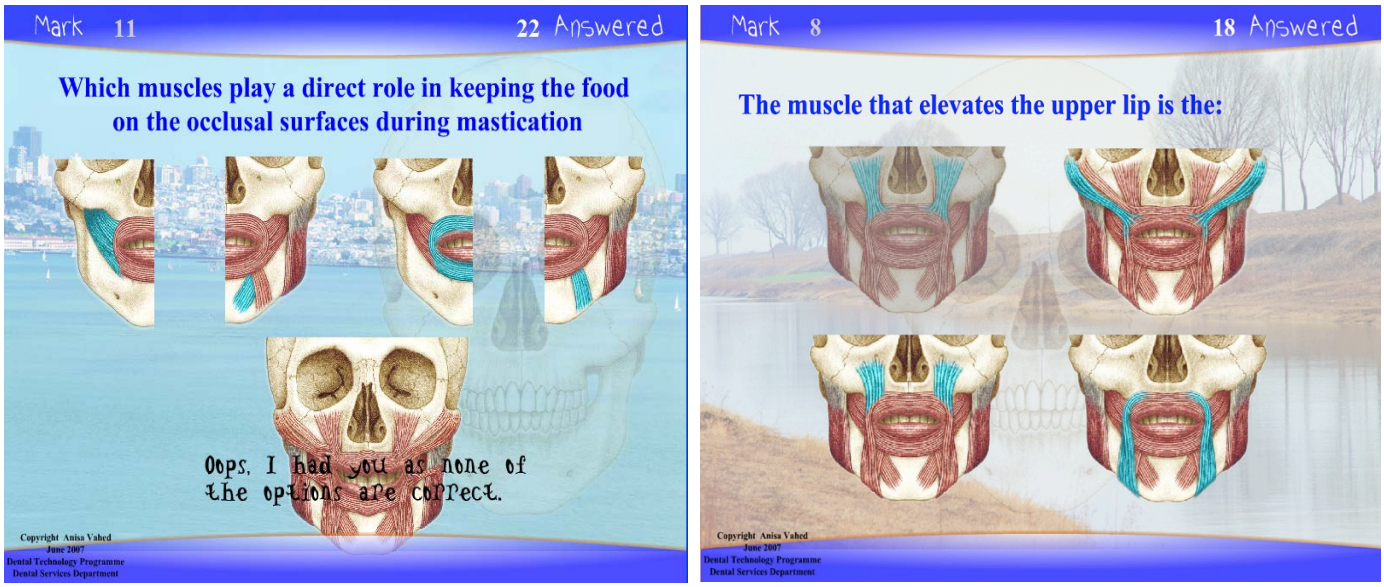

Figure 15: Macromedia® Flash™ technology

With reference to Figure 15, it is worth noting that a student's score and the number of questions answered are displayed. The game is run as a stand-alone Windows application. The screen design, presentation style, the type and quantum of visuals, sound effects, etc. were selected to raise the student's curiosity during play. The questions in this game centered on the structural and functional anatomy of muscles of mastication and facial expression. The student's progress in the game is measured in terms of achieving the following objectives.

1. If you score a mark of **100%**, you will enter the **HOT** zone.
2. If you score a mark of **80% or more**, you will enter the **TWILIGHT** zone.
3. If you score a mark **less than 80%**, you will enter the **ICE AGE** zone.

As described by Ruggill *et al.* (2005: 24), including sound in the game enriches and vivifies the visual landscapes and action sequences they accompany. Hence two different action sounds were used, where a cheerful jingle or long drone trumpet informed the student when he/she correctly or incorrectly answered, respectively.

The main aim of the game is to enter the Hot Zone (Figure 16), where three different skull images are displayed. The objective is for the student to move the various muscles to its rightful place on the skull. Consequently, this reinforces the anatomical knowledge learnt during game play. It was also anticipated that the aforementioned rule would in turn motivate the weaker student to repeat play in order to reap the benefits. As documented in the literature, repeat play indirectly leads to more in-depth learning and can empower students to:

- Become independent thinkers (not passive absorbers of facts);
- Interactively challenge their thinking;
- Engage in self-directed study; and
- To return to the lecturer for further reflection of the knowledge gained.

The Twilight zone (Figure 17) offers movement of the muscles in the frontal view of the skull only. The Ice Age zone (Figure 18) offers no rewards to the student. The game is available on CD-ROM, which also contains the Flash™ software to reduce the problem of inaccessibility in viewing the Flash learning objects. There is also a student manual containing instructions on how to install Flash™, objectives and rules of the game.

Figure 16: Screen Snapshot of Hot Zone-Muscle Mania©

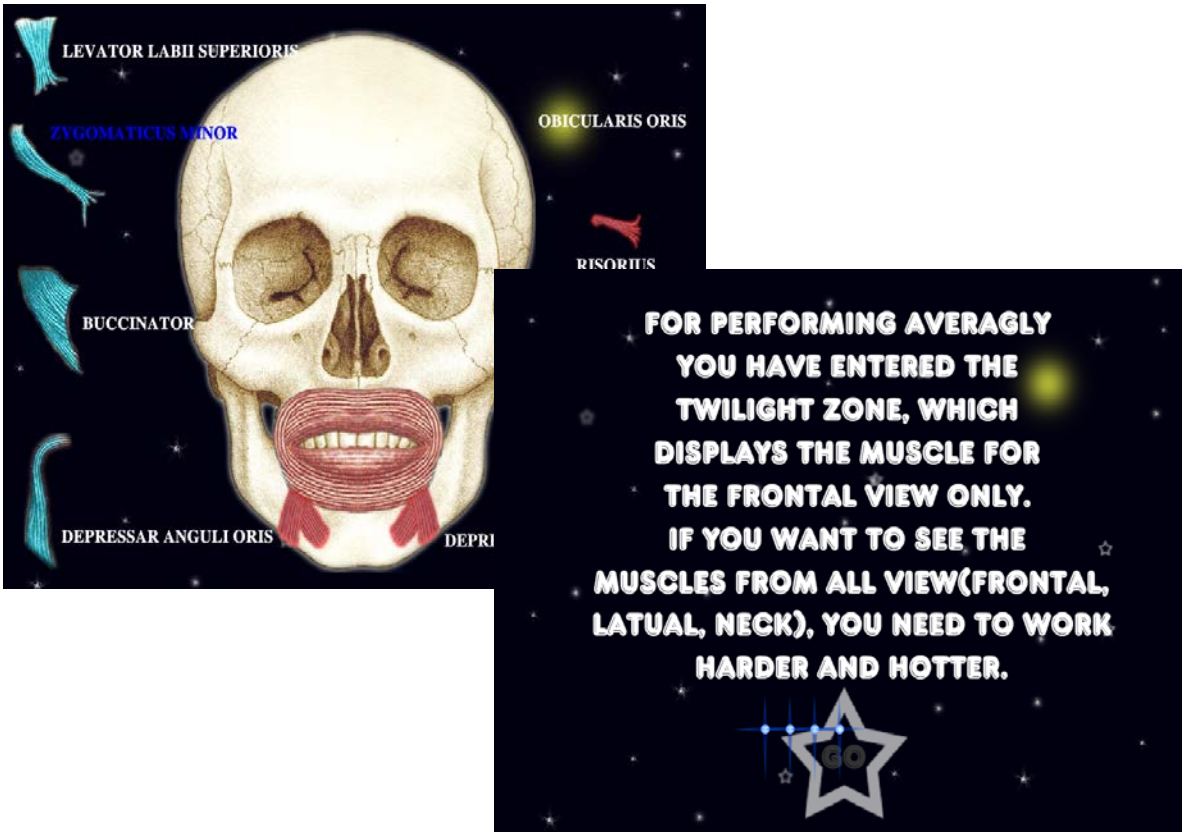

Figure 17: Screen Snapshot of Twilight Zone-Muscle Mania©

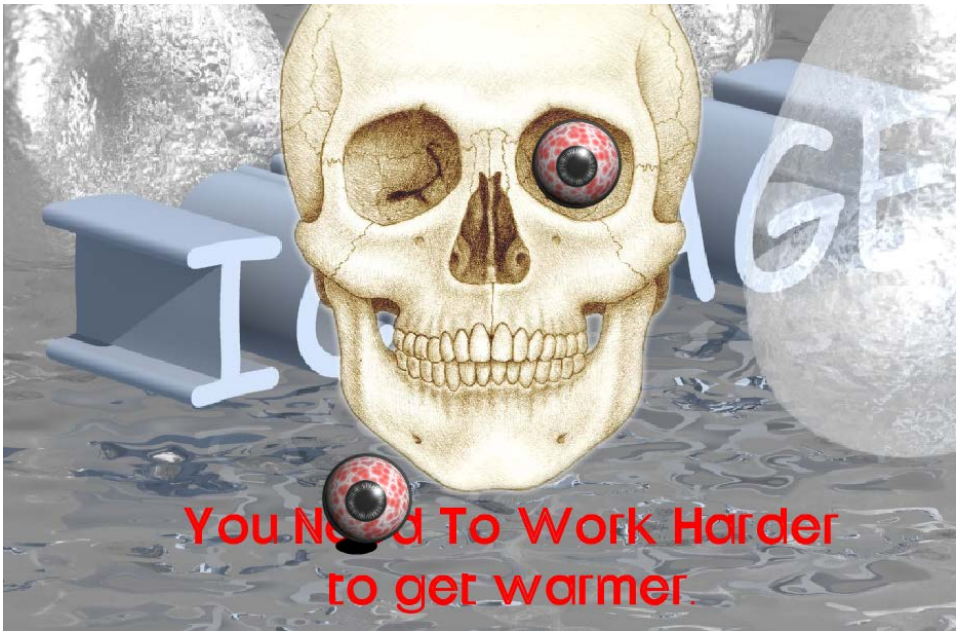

Figure 18: Screen Snapshot of Ice Age Zone-Muscle Mania©

2.2 OAMG: Preliminary Study

The study population consisted of the 2007 first-year Dental Technology students (n=30), who had attended lectures on the structural and functional anatomy of the muscles of mastication and facial expression. An anatomy professor validated the study by assessing the contents of the games. To explore the usefulness of the multimedia game in the teaching and learning environment, and to corroborate the researcher's observations, video recordings and digital images were captured. A staff member from DUT's audio-visual unit recorded the video and images. After the game tutorial session, students completed a 14-question anonymous survey (Appendix 4) detailing several demographic variables and four closed-ended questions measured by a four-point Likert scale (the forced choice response scale) to assess their opinions of the multimedia game as a pedagogical tool. The responses from the Likert scale questions were coded from 1 to 4 with "Strongly Agree" labelled 4 and "Strongly Disagree" labelled 1. In addition, three open-ended questions were also included to allow students to further elaborate on their opinions of the multimedia game.

2.3 OAMG: Preliminary Findings

As illustrated in Figure 19, data from the post-game surveys used to elicit students' perceptions of this classroom-based practice was reported in terms of two categories, namely the technical design and instructional design of the game.

2.4 OAMG: Pilot study

Reflecting on how students behaved in the preliminary study, it could be inferred that learning through a multimedia game stimulates students to engage actively with the anatomical content. This finding is consistent with other multimedia game studies (Garris, Ahlers and Driskell 2002; Aarseth 2005; Prensky 2005). Dental technology experts validated the study by reviewing the contents of the both of the games. The methodology for the pilot work was conducted in the same way as outlined in the preliminary study. The differences were that the study population for 2008 was N = 32[12] and a debriefing session was introduced after the student completed the surveys.

[12] In the year 2008, the number of students registered for the subjects Tooth Morphology and Oral Anatomy was 32. Hence, the sample size for both the board and multimedia games were the same.

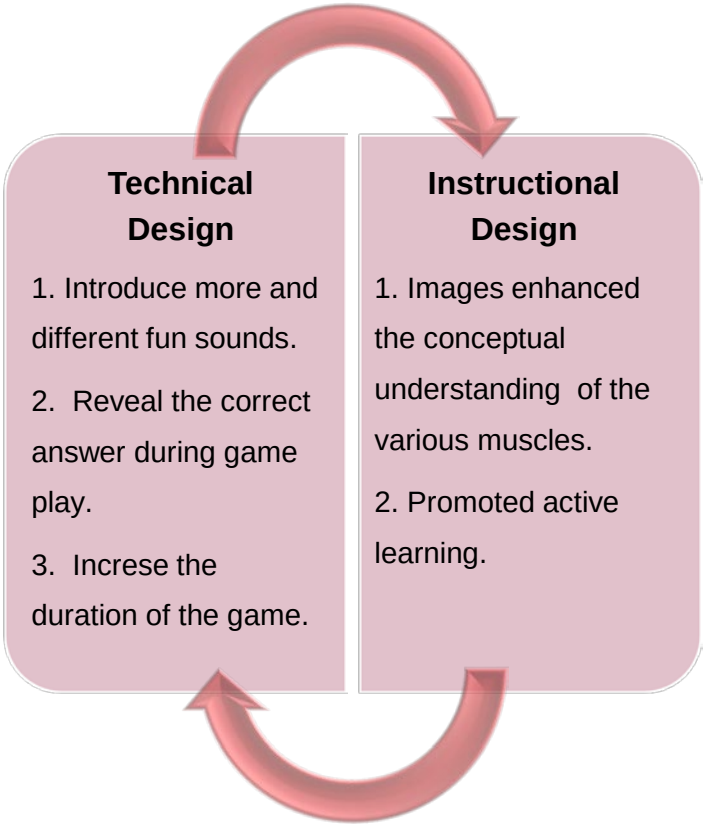

Figure 19: Oral Anatomy multimedia game – Preliminary findings

2.5 OAMG: Data Analysis – Pilot study

The data was analysed using SPSS (Version 20®). Both descriptive and inferential statistics were used for the closed-ended questions. A rotated varimax factor analysis was performed for the data obtained from the Likert scale, in order to identify items that loaded together as well as for each of the variables under study. Eigen values > 0.5 were chosen to determine which factor the statement belonged to. Cronbach's alpha index was used to assess the reliability of the survey post-testing.

Nvivo 9 (QSR International Pty Ltd, 2009) was used to organise and analyse data from the open-ended questions by searching for factors and clustering these into specific themes to search for trends. Coding thematically included phrasing or paraphrasing the words of the students into either positive and negative clusters that referred to broader topical areas.

2.6 OAMG: Pilot Results

Overall, 22 students responded to the survey, which constituted a 69% response rate. With reference to the Likert scale questions in Appendix 4, namely questions 5, 6, 7 and 11, the Cronbach's alpha index revealed a reliability (alpha) coefficient of: α=0.757; α=0.474; α=0.750 and α=0.810, respectively. With the exception of question 6, the underlying constructs of the survey items for the rest of the questions had an acceptable to high internal consistency. Perhaps the weak interrelation of items for question 6 is due to insufficient variables or students' misinterpreting the statements. The validity of the survey items, operationalisation of the constructs and ambiguities or difficulties in the wording need to be further developed for the main study.

In general, the questionnaire elicited students' perceptions of the OAMG in terms of three main themes, namely: instructional design, technical design and independent learning. There are three sub-themes to the instructional design and two sub-themes for technical design. These are explained below.

While acknowledging the lecturer's assistance (Figure 20) in playing the game, students clearly indicated that the game enabled them to access knowledge that is relevant to the muscles of mastication and facial expression (Figure 21). In turn, and as inferred from Figure 22, this encouraged them to actively engage in learning the anatomical content.

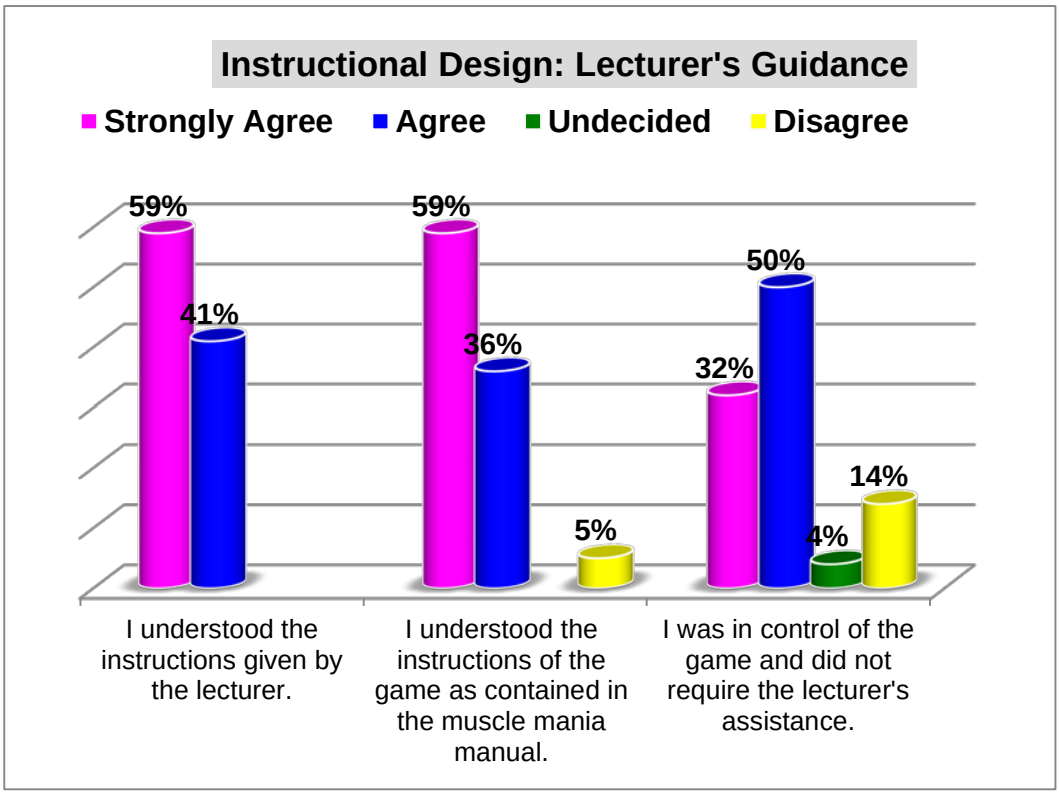

Figure 20: Instructional Design: Lecturer's guidance

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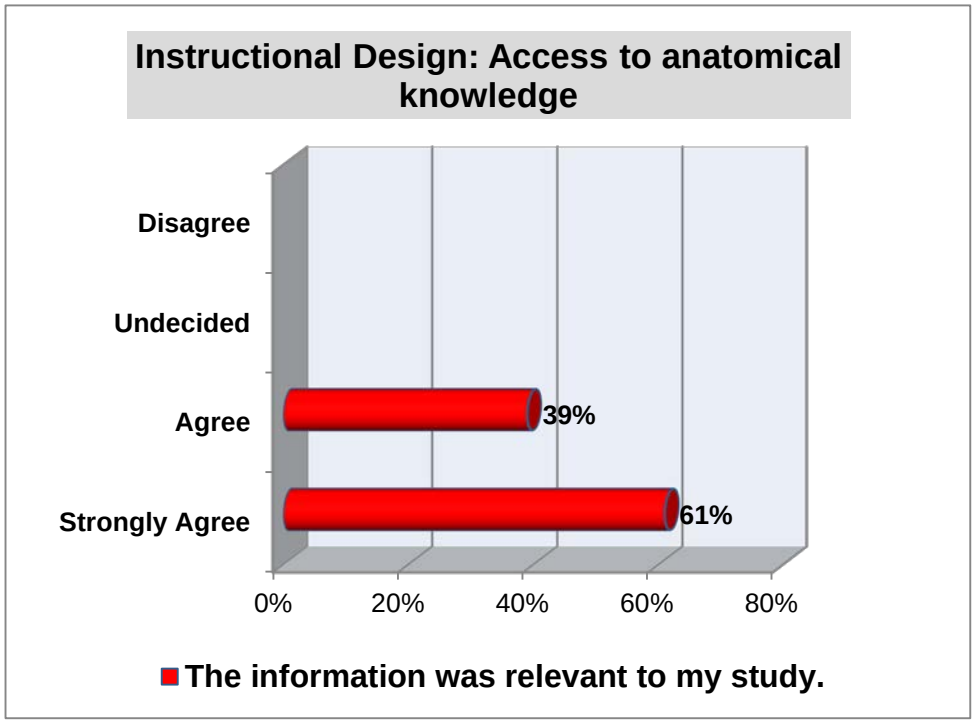


Figure 21: Instructional Design: Access to anatomical knowledge

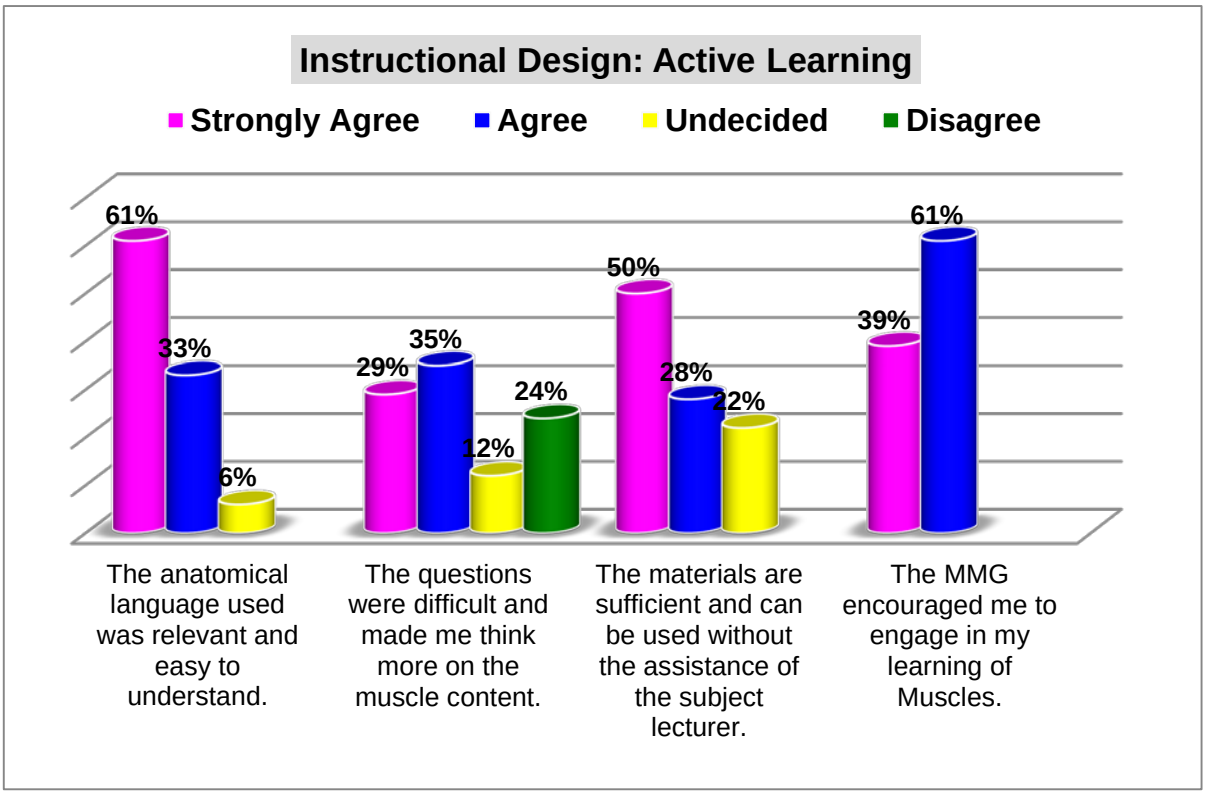


Figure 22: Instructional Design: Active Learning

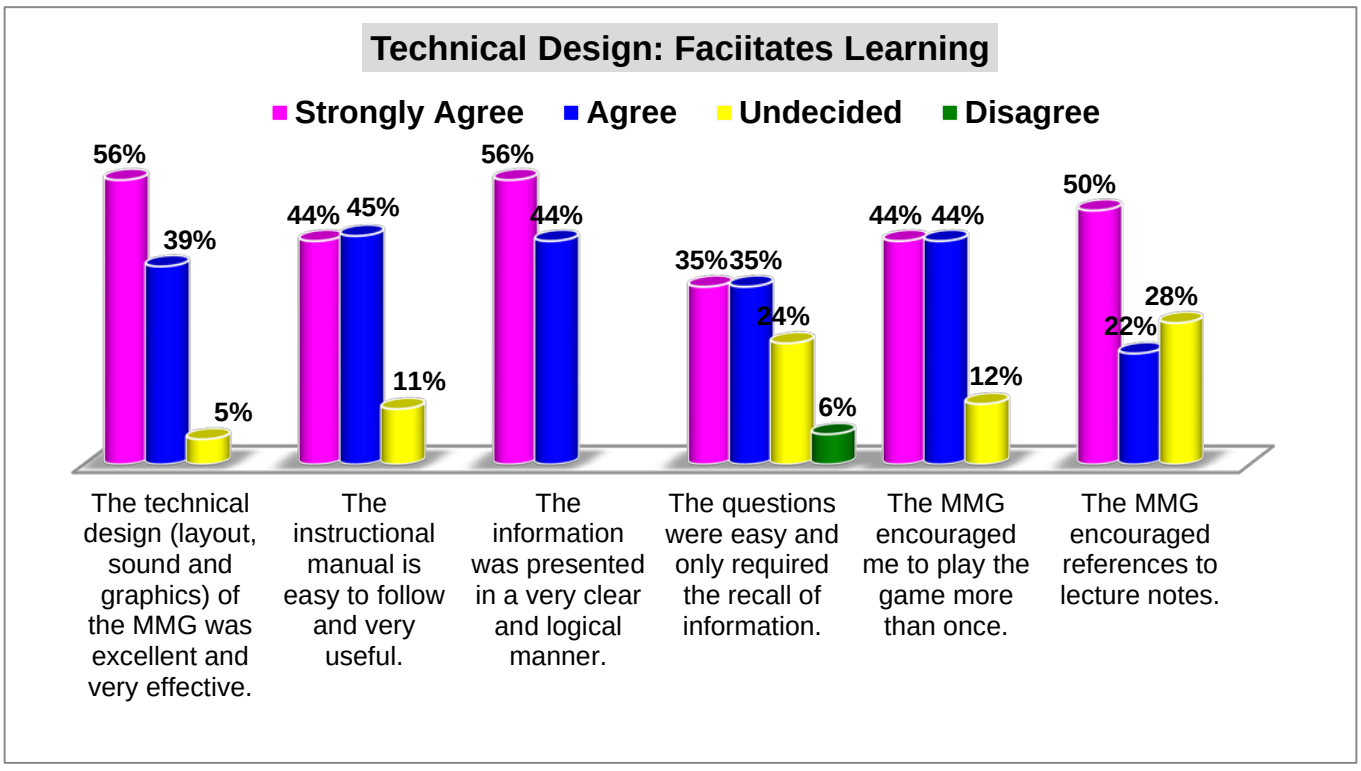


Figure 23: Technical Design: Facilitates Learning

It can be inferred from Figure 23 that the technical design of the game facilitates learning. Equally significant, the technical design enriches learning as it made it fun and enjoyable for the students (Figure 24).

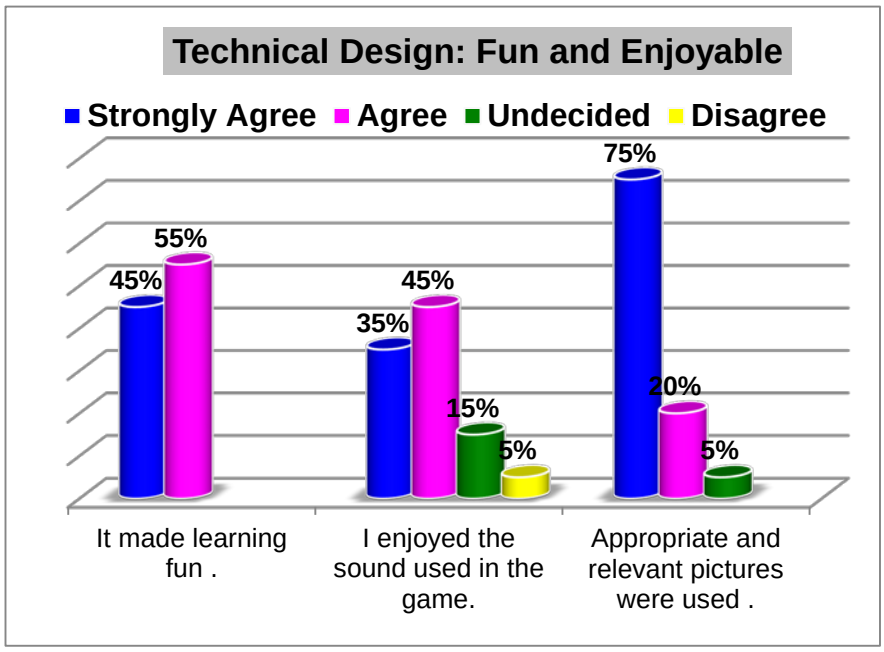


Figure 24: Technical Design-Fun and Enjoyable

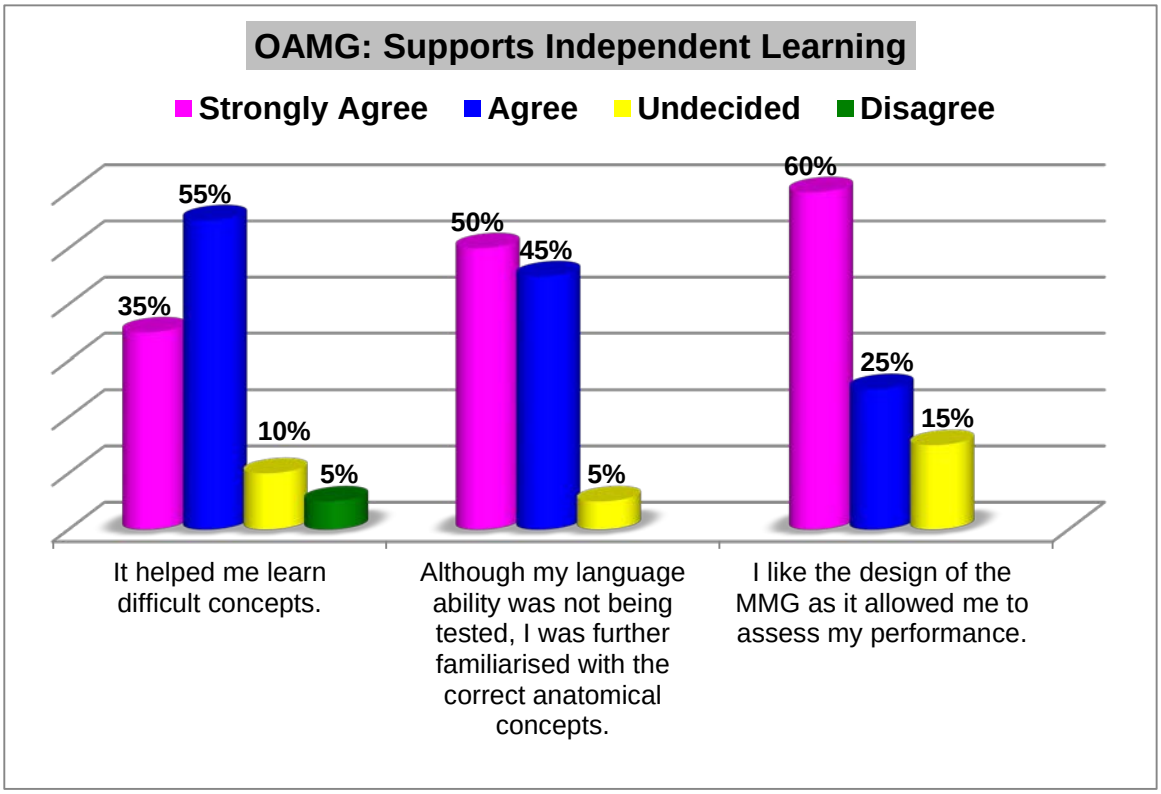


Figure 25: Support Independent learning

As Figure 25 illustrates, the OAMG encouraged students to learn independently by allowing them to assess their own learning, and in the process enable them to learn the difficult anatomical concepts correctly (Figure 25). This is further supported by Figure 26, which shows students engaging with their notes while learning through the OAMG. In summary, Figure 21 and Figure 25 strongly indicated that the OAMG provides students access to anatomical knowledge.

Themes emerging from the open-ended questions indicated improvements to the technical design of the game in terms of including different fun sounds; reveal the correct answer during game play; and to increase the duration of the game. These were some of the students' responses, given verbatim: *"add more fun sounds".; "show the correct answer after an incorrect answer".; "If the right answer is displayed at the end of the questions".; "make the game longer".*

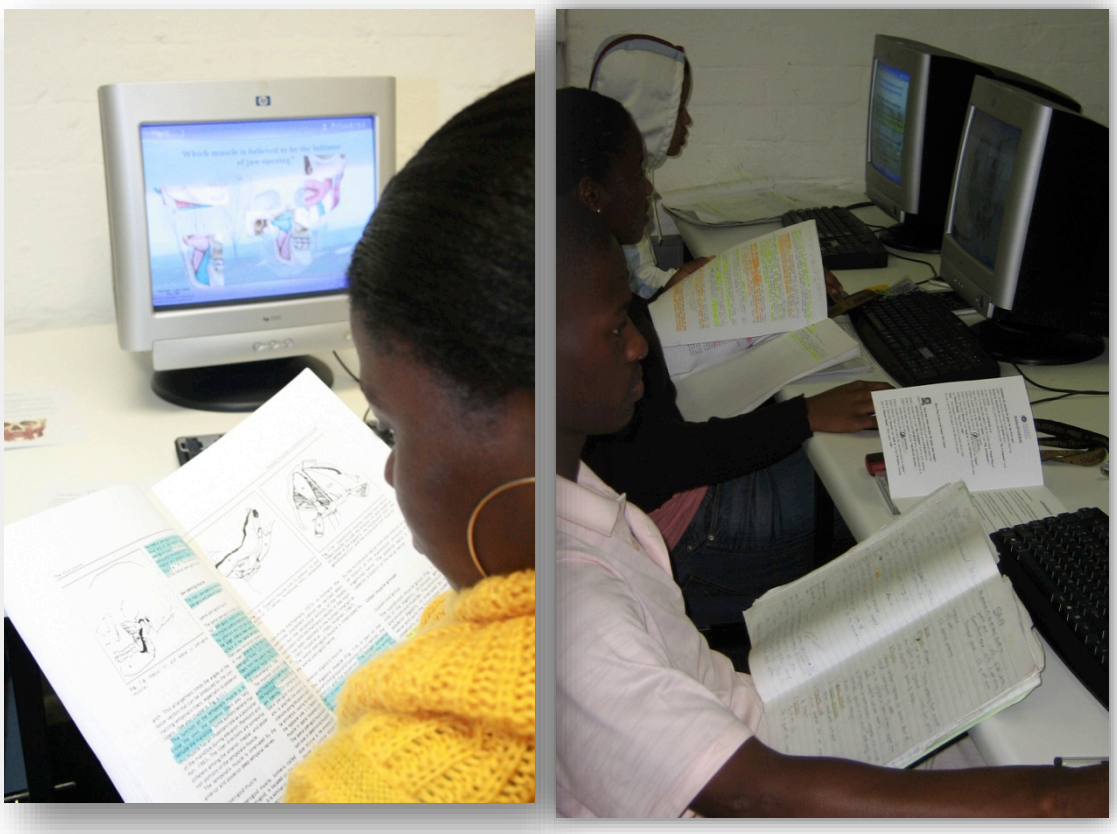


Figure 26: Students engaging with their notes during game play

Appendix 3: Tooth Morphology-Pilot Survey (example)

The aim of the Tooth Morphology board game **[TMBG]** is to improve your learning experience. Your feedback on the TMBG is important for the development of future learning materials in the department. The data collected therefore requests your frank and honest opinions.

Please "tick" the appropriate box:

1. I am in the age group
   - 1.1 17 – 20 [ ] 1
   - 1.2 21 – 23 [ ] 2
   - 1.3 24 – 27 [ ] 3
   - 1.4 Other [ ] 4

2. I am
   - 2.1 Male [ ] 1
   - 2.2 Female [ ] 2

3. This is the first time I am enrolled for this subject.
   - 3.1 Yes [ ] 1
   - 3.2 No [ ] 2

4. I have played multi-media-games previously?

YES _____	NO ____

(Please tick the appropriate box)

If 'Yes', Please Specify:

4.1……..

4.2……..

4.3……..

5. How would you evaluate the **Tooth Morphology** subject:
Please indicate by placing a **"tick"** in the appropriate block.

	ALWAYS	VERY FREQUENTLY	OCCASIONALLY	RARELY	VERY RARELY	NEVER
5.1 I can consult with the subject lecturer.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
5.2 I see the relationship and relevance of this subject to Dental Technology	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
5.3 I contribute actively to the lecture.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
5.4 I remember the information after the lecture.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
5.5 I am able to use the knowledge from lectures in the practical.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

The following questions are related to the Tooth Monopoly board game:

6. I can play the game.

6.1 Yes [ ] 1

6.2 No [ ] 2

7. I can play the board-game because:
(Please indicate by placing a "tick" in the appropriate block)

	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE
7.1 I understood the instructions given by the lecturer.	[ ]	[ ]	[ ]	[ ]
7.2 I understood the **"rules"** of the game.	[ ]	[ ]	[ ]	[ ]
7.3 I was able to get assistance from the lecturer whilst playing the game.	[ ]	[ ]	[ ]	[ ]
7.4 Provide any other reason as to why you can play the game.				

8. I like the board-game because:
(Please indicate by placing a "tick" in the appropriate block)

	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE
8.1 It made learning fun.	[ ]	[ ]	[ ]	[ ]
8.2 It helped me learn the difficult concepts.	[ ]	[ ]	[ ]	[ ]
8.3 My language ability was not being tested.	[ ]	[ ]	[ ]	[ ]
8.4 I like the design of the board-game.	[ ]	[ ]	[ ]	[ ]
8.5 I like the colour combinations and pictures on the board-game.	[ ]	[ ]	[ ]	[ ]
8.6 Provide any other reason as to why you like the game.				

9. The board-game helped me to understand the content in Tooth Morphology because:

……

……

……

10. The board-game did not help me understand the content in Tooth Morphology because:

……

……

11. How do you think we can improve on the board-game? Please list your suggestions in point form.

……

……

……

Tooth Monopoly Board Game: Learning Material Assessment

12. Please **READ** the following statements and enter your response by placing a **"tick"** in the appropriate column.

You are only allowed to choose one answer.

	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE	OTHER COMMENTS
1. The information was presented in a clear and logical manner.	[ ]	[ ]	[ ]	[ ]	
2. The information was relevant to my level of study.	[ ]	[ ]	[ ]	[ ]	
3. The board-game, cards and model were easy to use.	[ ]	[ ]	[ ]	[ ]	
4. The writing of the cards was easy to read.	[ ]	[ ]	[ ]	[ ]	
5. There was too much information on the card, which made reading difficult.	[ ]	[ ]	[ ]	[ ]	
6. The words and language used was easy to understand.	[ ]	[ ]	[ ]	[ ]	
7. The questions were easy and only required the recall of information.	[ ]	[ ]	[ ]	[ ]	
8. The questions were difficult and made me think more about the subject content.	[ ]	[ ]	[ ]	[ ]	
9. The board-game encouraged references for further reading.	[ ]	[ ]	[ ]	[ ]	
10. The use of the board-game encouraged me to engage in discussions with my partner/s.	[ ]	[ ]	[ ]	[ ]	
11. The materials are sufficient and can be used without the assistance of the subject lecturer.	[ ]	[ ]	[ ]	[ ]	

Thank You for your time and co–operation.

Appendix 4: Oral Anatomy-Pilot Survey (example)

Muscle mania - multimedia game (MMG)

The aim of the Muscle Mania MMG is to improve your learning experience. You can help us achieve our aim by completing this questionnaire. Your response is important for the development of future learning materials. We thank you for your co-operation.

Please "tick" the appropriate box:

1. I am in the age group
   - 1.1 17 – 20 [ ] 1
   - 1.2 21 – 23 [ ] 2
   - 1.3 24 – 27 [ ] 3
   - 1.4 Other [ ] 4

2. I am
   - 2.1 Male [ ] 1
   - 2.2 Female [ ] 2

3. This is the first time I am enrolled for this subject.
   - 3.1 Yes [ ] 1
   - 3.2 No [ ] 2

4. I have played multi-media-games previously?

YES _____	NO ____

(Please tick the appropriate box)

If 'Yes', Please Specify:

4.1……..

4.2……..

4.3……..

5. How would you evaluate the **Oral Anatomy** subject:
Please indicate by placing a **"tick"** in the appropriate block.

	ALWAYS	SOMETIMES	SELDOM	NEVER
5.1 I can consult with the subject lecturer.	[ ]	[ ]	[ ]	[ ]
5.2 I see the relationship and relevance of this subject to Dental Technology	[ ]	[ ]	[ ]	[ ]
5.3 I contribute actively to the lecture.	[ ]	[ ]	[ ]	[ ]
5.4 I remember the information after the lecture.	[ ]	[ ]	[ ]	[ ]
5.5 I am able to use the knowledge from lectures in the practical.	[ ]	[ ]	[ ]	[ ]

The following questions are related to the "Muscle Mania MMG"

6. I can play the multimedia game because:
(Please indicate by placing a "tick" in the appropriate block)

	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE
6.1 I understood the instructions given by the lecturer.	[ ]	[ ]	[ ]	[ ]
6.2 I understood the **"instructions"** of the game as contained in the **"muscle mania"** manual.	[ ]	[ ]	[ ]	[ ]
6.3 I was in control of the game and did not require the lecturer's assistance.	[ ]	[ ]	[ ]	[ ]
6.4 Provide any other reason as to why you can play the game.				

7. I like the multimedia game because:
(Please indicate by placing a "tick" in the appropriate block)

	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE
7.1 It made learning fun.	[ ]	[ ]	[ ]	[ ]
7.2 It helped me learn difficult concepts.	[ ]	[ ]	[ ]	[ ]
7.3 Although my language ability was not being tested, I was further familiarised with the correct anatomical concepts.	[ ]	[ ]	[ ]	[ ]
7.4 I like the design of the MMG as it allowed me to assess my performance.	[ ]	[ ]	[ ]	[ ]
7.5 I enjoyed the "sound" used in this game.	[ ]	[ ]	[ ]	[ ]
7.6 Appropriate and relevant pictures were used.	[ ]	[ ]	[ ]	[ ]
7.7 Provide any other reason as to why you like the game.				

8. The MMG helped me understand the Muscle content in Oral Anatomy because:

……

……

……

9. The MMG did not help me understand the Muscle content in Oral Anatomy because:

……

……

10. How do you think we can improve on the game?
(**Please list your suggestions in point form)**

……

……

……

"Muscle Mania" Multimedia Game**: Learning Material Assessment**

11. Please **READ** the following statements and enter your response by placing a **"tick"** in the appropriate column.

You are only allowed to choose one answer.

	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE	OTHER COMMENTs
1. The technical design (layout, sound, and graphics) of the MMG was excellent and very effective.	[ ]	[ ]	[ ]	[ ]	
2. The instructional manual is easy to follow and very useful.	[ ]	[ ]	[ ]	[ ]	
3. The information was presented in a clear and logical manner.	[ ]	[ ]	[ ]	[ ]	
4. The information was relevant to my level of study.	[ ]	[ ]	[ ]	[ ]	
5. The anatomical language used was relevant and easy to understand.	[ ]	[ ]	[ ]	[ ]	
6. The questions were easy and only required the recall of information.	[ ]	[ ]	[ ]	[ ]	
7. The questions were difficult and made me think more about the subject content.	[ ]	[ ]	[ ]	[ ]	
8. The MMG encouraged references to lecture notes.	[ ]	[ ]	[ ]	[ ]	
9. The MMG encouraged me to engage in my learning of Muscles.	[ ]	[ ]	[ ]	[ ]	
10. The MMG encouraged me to play the game more than once.	[ ]	[ ]	[ ]	[ ]	
11. The materials are sufficient and can be used without the assistance of the subject lecturer.	[ ]	[ ]	[ ]	[ ]	

Thank You for your time and co–operation.

Appendix 5: Consent Form (example)

Date: _____

Dear Student

Research Questionnaire

I am currently conducting research as part of my doctoral studies on “critiquing the use of Dental Technology education games as pedagogical tools”.

I would appreciate it if you would kindly complete the questionnaire. The questionnaire will take approximately 10 minutes to complete. I will be present to clarify any problems you may experience during this session. You have the opportunity to request a summary of results of the study, if desired.

Kindly note that your participation in completing the survey is voluntary. Anonymity and Confidentiality of the information will be respected.

Thank you for your co-operation.

Yours sincerely,

Anisa Vahed
Lecturer: Dental Technology
Tel.: 031 373 2848

Appendix 6: Video Tape Consent Form (example)

Dental Sciences: Dental Technology

Informed consent by students to be video'd in a lecture tutorial the "TOOTH MORPHOLOGY BOARD GAME"

Introduction

The university and those conducting this tutorial subscribe to the ethical conduct of academia and research and to the protection at all times of the interests, comfort, and safety of participants. This form and the information that it contains are given to you for your own protection and full understanding of the procedures. Your signature on this form will signify that you have been informed about the video procedures and the benefits of this tutorial, that you have had adequate opportunity to consider the information communicated to you, and that you voluntarily agree to be video'd. Any information that is obtained during this lecture tutorial will be used as per the agreement, viz. that it will be documented for scholarly purposes, and for public information, where relevant and applicable, and only with this prior consent.

****

Consent Form

I have been asked by Anisa Vahed, Dental Technology lecturer at the Durban University of Technology to be video'd in a lecture tutorial, focused at helping students learn Tooth Morphology.

I ……..... understand that I am participating in this lecture tutorial that will be video'd for teaching and learning purposes, and have consented to this. I understand the procedures that will take place.

I also understand that I may register any concerns that I may have with Anisa Vahed (work number: 031 373 2848.) I understand that the information gathered for this study is intended for public access.

By signing this form, I am acknowledging that I understand the contents of this document.

Name : ……..

Address: ……..

Signature: ……..

Witness: ……

Date: ……

Appendix 7: Tooth Morphology - Main Study Survey (example)

DUT DURBAN UNIVERSITY OF TECHNOLOGY

EVALUATIVE QUESTIONNAIRE: The Tooth Morphology board game

Dental Sciences Department: Dental Technology Programme

Please tick "√" the appropriate box:

Section A: Demographic Profile

1. I am:

	African	[ ] 1
	Indian	[ ] 2
	Coloured	[ ] 3
	White	[ ] 4
	Other: Please Specify_____	[ ] 5

2. I am in the age group

2.1 17 – 20	[ ] 1
2.2 21 – 23	[ ] 2
2.3 24 – 27	[ ] 3
2.4 Other	[ ] 4

3. I am

3.1 Male	[ ] 1
3.2 Female	[ ] 2

4. This is the first time I am enrolled for this subject.

4.1 Yes	[ ] 1
4.2 No	[ ] 2

5. I have played educational board games previously?

YES _____	**NO ____**

(Please tick "√" the appropriate box)

If 'Yes', Please Specify:

5.1……..

5.2……..

5.3……..

Section B: Views on the subject Tooth Morphology

Please note that **Question 6** is asking your opinion on the Tooth Morphology subject **BEFORE** your experience of playing the board game. **Please tick "√" the appropriate box:**

6. Generally, how would you evaluate the **Tooth Morphology** subject:

	STRONGLY AGREE	AGREE	UNDECIDED	DISAGREE	STRONGLY DISAGREE
6.1 The subject encourages me to consult with the lecturer for assistance when I do not understand the lecture.	[ ]	[ ]	[ ]	[ ]	[ ]
6.2 I remember the information after the lecture.	[ ]	[ ]	[ ]	[ ]	[ ]
6.3 I am able to use the knowledge from lectures and apply it practically.	[ ]	[ ]	[ ]	[ ]	[ ]
6.4 I consider multiple choice quiz games as effective tutorials.	[ ]	[ ]	[ ]	[ ]	[ ]

Please note that the following sections are asking your opinion AFTER your experience of playing the game.

Section C:

- **Instructional Design of the board game**

7. I can play the board game.

7.1 Yes [ ] 1

7.2 No [ ] 2

If your answer to question 7 is **"No"**, please explain:

……

……

……

Please tick "√" the appropriate box:

8. I could play the board game because:

	STRONGLY AGREE	AGREE	UNDECIDED	DISAGREE	STRONGLY DISAGREE
8.1 I understood the "instructions" of the game as contained in the game instructional manual.	[ ]	[ ]	[ ]	[ ]	[ ]
8.2 I did not need the help of the instructor to start the game.	[ ]	[ ]	[ ]	[ ]	[ ]
8.3 I was able to get assistance from the lecturer whilst playing the game.	[ ]	[ ]	[ ]	[ ]	[ ]
8.4 The instruction of the board game was presented in a clear and logical manner.	[ ]	[ ]	[ ]	[ ]	[ ]
8.5 The instruction was relevant to my level of study.	[ ]	[ ]	[ ]	[ ]	[ ]
8.6 My language ability was not being tested.	[ ]	[ ]	[ ]	[ ]	[ ]
8.7 Provide any other reason as to why you could play the game.					

❖ **Technical Design of the board game**

Please tick "√" the appropriate box:

9. I liked the board game because:

	STRONGLY AGREE	AGREE	UNDECIDED	DISAGREE	STRONGLY DISAGREE
9.1 Of the colour combinations and pictures used.	[ ]	[ ]	[ ]	[ ]	[ ]
9.2 The cards, models & game board were easy to use and were applicable to the subject.	[ ]	[ ]	[ ]	[ ]	[ ]
9.3 I understood the questions.	[ ]	[ ]	[ ]	[ ]	[ ]
9.4 The materials were sufficient and can be used without the assistance of the lecturer.	[ ]	[ ]	[ ]	[ ]	[ ]
9.5 Provide any other reason as to why you liked the board game.					

10. How do you think the board game can be improved? .

……

……

……

……

❖ **Learning via the board game**

Please tick "√" the appropriate box:

11. The board game:

	STRONGLY AGREE	AGREE	UNDECIDED	DISAGREE	STRONGLY DISAGREE
11.1 Made learning fun.	[ ]	[ ]	[ ]	[ ]	[ ]
11.2 Helped me to learn difficult morphological concepts.	[ ]	[ ]	[ ]	[ ]	[ ]
11.3 Had questions that helped recall information easily.	[ ]	[ ]	[ ]	[ ]	[ ]
11.4 Had questions that helped me to understand the Tooth Morphology content related to molars, occlusion, dental anomalies, primary dentition, tissues of the pulp cavity & forensic dentistry.	[ ]	[ ]	[ ]	[ ]	[ ]
11.5 Encouraged and motivated me to engage in discussions with my partner/partners when I did not understand the design of the board game.	[ ]	[ ]	[ ]	[ ]	[ ]
11.6 Encouraged and motivated me to engage in discussions with my partner/partners when I did not understand the content of Tooth Morphology.	[ ]	[ ]	[ ]	[ ]	[ ]
11.7 Allowed references to lecture notes & text books when I had doubts on the content of Tooth Morphology.	[ ]	[ ]	[ ]	[ ]	[ ]
11.8 Provides a better tutorial alternative than the regular "old fashion" Tutorial class.	[ ]	[ ]	[ ]	[ ]	[ ]

12. The board game helped me to understand the content in Tooth Morphology because:

……

……

……

……

13. The board game did not help me understand the content in Tooth Morphology because:

……

……

……

14. Do you think you acquired any skills while playing the game? Please explain.

……

……

……

……

Thank You for your time and co–operation.

Appendix 8: Oral Anatomy-Main Study Survey (example)

EVALUATIVE QUESTIONNAIRE: "Muscle Mania" Multi Media game

Please tick "√" the appropriate box:

Section A: Demographic Profile

1. I am:

1.1 African	[ ] 1
1.2 Indian	[ ] 2
1.3 Coloured	[ ] 3
1.4 White	[ ] 4
1.5 Other: Please Specify	[ ] 5

_____

2. I am in the age group

2.1 17 – 20	[ ] 1
2.2 21 – 23	[ ] 2
2.3 24 – 27	[ ] 3
2.4 Other	[ ] 4

3. I am

3.1 Male	[ ] 1
3.2 Female	[ ] 2

4. This is the first time I am enrolled for this subject.

4.1 Yes	[ ] 1
4.2 No	[ ] 2

5. I have played multimedia games previously?

YES _____	**NO ____**

Please tick "√" the appropriate box:

If 'Yes', Please Specify:

5.1……..

5.2……..

5.3……..

Section B: Views on the subject Oral Anatomy

Please note that **Question 6** is asking your opinion on the Oral Anatomy subject **BEFORE** your experience of playing the multimedia game. **Please tick "√" the appropriate box:**

6. Generally, how would you evaluate the **Oral Anatomy** subject:

	STRONGLY AGREE	AGREE	UNDECIDED	DISAGREE	STRONGLY DISAGREE
6.1 The subject encourages me to consult with the lecturer for assistance when I do not understand the lecture.	[ ]	[ ]	[ ]	[ ]	[ ]
6.2 I remember the information after the lecture.	[ ]	[ ]	[ ]	[ ]	[ ]
6.3 I am able to use the knowledge from lectures and apply it practically.	[ ]	[ ]	[ ]	[ ]	[ ]
6.4 I consider multiple choice quiz games as effective tutorials.	[ ]	[ ]	[ ]	[ ]	[ ]

Please note that the following sections are asking your opinion AFTER your experience of playing the game.

Section C:

- **Instructional Design of the multimedia game**

7. I can play the multimedia game.

7.1 Yes [ ] 1

7.2 No [ ] 2

If your answer to question 7 is **"No"**, please explain:

……

……

Please tick "√" the appropriate box:

8. I could play the multimedia game because:

	STRONGLY AGREE	AGREE	UNDECIDED	DISAGREE	STRONGLY DISAGREE
8.1 I understood the "instructions" of the game as contained in the game instructional manual.	[ ]	[ ]	[ ]	[ ]	[ ]
8.2 I did not need the help of the instructor to start the game.	[ ]	[ ]	[ ]	[ ]	[ ]
8.3 I was able to get assistance from the lecturer while playing the game.	[ ]	[ ]	[ ]	[ ]	[ ]
8.4 The instruction was presented in a clear and logical manner.	[ ]	[ ]	[ ]	[ ]	[ ]
8.5 The instruction was relevant to my level of study.	[ ]	[ ]	[ ]	[ ]	[ ]
8.6 The anatomical language used was relevant and easy to understand.	[ ]	[ ]	[ ]	[ ]	[ ]
8.7 Provide any other reason as to why you could play the game.					

❖ **Technical Design of the multimedia game**

Please tick "√" the appropriate box:

9. I liked the multimedia game because:

	STRONGLY AGREE	AGREE	UNDECIDED	DISAGREE	STRONGLY DISAGREE
9.1 The layout was creative & very effective.	[ ]	[ ]	[ ]	[ ]	[ ]
9.2 Appropriate sound was used.	[ ]	[ ]	[ ]	[ ]	[ ]
9.3 Relevant & "eye catching" graphics were used.	[ ]	[ ]	[ ]	[ ]	[ ]
9.4 I was able to track my performance in the game.	[ ]	[ ]	[ ]	[ ]	[ ]
9.5 The game can be used without the assistance of the subject lecturer.	[ ]	[ ]	[ ]	[ ]	[ ]
9.6 Provide any other reason as to why you liked the game.					

10. How do you think the Muscle Mania multimedia game can be improved?

……

……

……

❖ **Learning via the multimedia game**

Please tick "√" the appropriate box:

11. The Muscle Mania multimedia game:

	STRONGLY AGREE	AGREE	UNDECIDED	DISAGREE	STRONGLY DISAGREE
11.1 Made learning fun.	[ ]	[ ]	[ ]	[ ]	[ ]
11.2 Helped me to learn difficult anatomical concepts related to the muscles of mastication and facial expression.	[ ]	[ ]	[ ]	[ ]	[ ]
11.3 Improved my terminology while learning the anatomical concepts related to the muscles of mastication and facial expression.	[ ]	[ ]	[ ]	[ ]	[ ]
11.4 Had questions that helped me to recall information easily.	[ ]	[ ]	[ ]	[ ]	[ ]
11.5 Had questions that improved my understanding of the structural anatomy of muscles of mastication and facial expression.	[ ]	[ ]	[ ]	[ ]	[ ]
11.6 Had questions that improved my understanding of the functional anatomy of muscles of mastication and facial expression.	[ ]	[ ]	[ ]	[ ]	[ ]
11.7 Encouraged me to consult my lecture notes to clarify my understanding of the structure of the muscles of mastication and facial expression.	[ ]	[ ]	[ ]	[ ]	[ ]
11.8 Motivated me to refer to my lecture notes to clarify my understanding of the function of the muscles of mastication and facial expression.	[ ]	[ ]	[ ]	[ ]	[ ]
11.9 Provides a better tutorial alternative than the regular "old fashion" Tutorial class.	[ ]	[ ]	[ ]	[ ]	[ ]

12. The Muscle Mania multimedia game helped me understand the Muscle content in Oral Anatomy because:

    ……

    ……

    ……

13. The Muscle Mania multimedia game did not help me understand the muscle content in Oral Anatomy because:

    ……

    ……

    ……

    ……

14. Do you think you acquired any skills while playing the game? Please explain.

    ……

    ……

    ……

Thank you for your time and co-operation.

Appendix 9: Student Interview (example)

STUDENT INTERVIEW: INTRODUCTION

WELCOME: Thanks for agreeing to be part of this interview. I appreciate your willingness to participate.

Title of Research Thesis: Ensuring the quality of pedagogy through games in Dental Technology**.**

Purpose: This interview session focuses on teaching and learning through games, and will be facilitated by Miss Anisa Vahed. As part of the scholarly requirement for the research, Ms Gillian Cruickshank is the selected peer observer who will only be observing the interview session. In addition, the interview session will be tape recorded for the purpose of capturing accurate feedback.

Participation in this session is voluntary and involves ***±60 – 90 minutes*** input to and discussion of the ***potential value of using games to learn Tooth Morphology and Oral Anatomy***. There are no known or anticipated risks to your participation in this session. You may decline answering any questions that you may feel you do not wish to answer, and you may decline contributing to the session in other ways if you so wish. All information you provide will be considered confidential and grouped with responses from other participants. Your name will not be identified with the input you give to this session, so you will be anonymous within the transcripts and write-up. The information collected from this session will be kept for a period of seven years in ***the Department of Dental Sciences (DUT).***

There are no right or wrong answers to the interview questions. Each person's experiences and opinions are important. I would therefore like to hear many different viewpoints and would like to hear from everyone. If you have been silent for a while during the interview, they I may directly ask you an individual question for your to respond. There may be occasions when your thoughts and responses may not be in agreement with the rest of the group. In which case, your honestly in responding will be greatly valued. With regard to all participants, I would request that only one individual speak at a time in the group and that **responses made by all participants be kept confidential.**

I can confirm that this study is supported and has received ethics clearance by the Research Ethics Committee of the Faculty of Management Sciences and through the Head of Department (Dental Sciences, DUT). However, the final decision about participation is yours.

Thank you for your assistance with this research project.

Yours sincerely,
Miss Anisa Vahed (*Lecturer/Student: Dental Technology)*

Interview Consent Form

By signing this consent form, you are not waiving your legal rights or releasing the investigator or involved institution from their legal and professional responsibilities.

I have read the information presented in the information letter about the session being facilitated by *Miss Anisa Vahed*, and peer observed by *Ms Gillian Cruickshank* from the Faculty of Health Sciences, DUT. I have had the opportunity to ask the facilitator any questions related to this session, to receive satisfactory answers to my questions, and any additional details I required. This project has been reviewed and received ethics clearance by the Research Ethics Committee of the Faculty of Management Sciences and through the Head of Department (Dental Sciences, DUT).

I understand that

2. Taking part in this study is entirely voluntary.
3. It is my right to decline to answer any question that I am asked.
4. I may withdraw from the session without penalty at any time by advising the facilitator of my decision.
5. The interview session will be tape recorded for scholarly purposes.
6. The information gathered for this study is intended for public access.
7. My name and identity will remain confidential in any publications or discussions.
8. My name will not appear on any tapes or transcripts from the interview.

I have read this consent form. I have had a chance to ask questions concerning anything that I did not understand, or any areas of concern that I may have had.

With full knowledge of the above mentioned, I agree, of my own free will, to participate in this session and to keep in confidence information that could identify specific participants and/or the information they provided.

Name (Please Print):
……

Date:……. ***Signature:***……..

Witness (Print Name & Sign): …….

Appendix 10: Summary of Correlation Testing-Spearman's Rho

Note: For Table 2 and Table 3, variables are colour coded to highlight correlation. Only significant linear correlations above r=0.4 at the significant level of 0.01 were considered.

Table 2: Spearman Rank Correlation Results: TMBG

	TMBG-Variables	Spearman Correlations Coefficient (r)
1	The subject encourages me to consult with the lecturer for assistance when I do not understand the lecture. Had questions that helped recall information easily.	**0.403**
2	The subject encourages me to consult with the lecturer for assistance when I do not understand the lecture. Had questions that helped me to understand the Tooth Morphology content related to molars, occlusion, dental anomalies, primary dentition, tissues of the pulp cavity & forensic dentistry.	**0.511**
3	I remember the information after the lecture. I am able to use the knowledge from lectures and apply it practically.	**0.424**
4	I consider multiple choice quiz games as effective tutorials. Helped me to learn difficult morphological concepts.	**0.496**
5	I understood the "instructions" of the game as contained in the game instructional manual. The instruction of the board game was presented in a clear and logical manner.	**0.496**
6	I understood the "instructions" of the game as contained in the game instructional manual. Encouraged and motivated me to engage in discussions with my partner/partners when I did not understand the design of the board game.	**0.496**
7	I understood the "instructions" of the game as contained in the game instructional manual. Encouraged and motivated me to engage in discussions with my partner/partners when I did not understand the content of Tooth Morphology.	**0.570**
8	I understood the "instructions" of the game as contained in the game instructional manual. Allowed references to lecture notes & textbooks when I had doubts on the content of Tooth Morphology.	**0.652**
9	I did not need the help of the instructor to start the game. The instruction of the board game was presented in a clear and logical manner	**0.354**
10	The instruction of the board game was presented in a clear and logical manner. The instruction was relevant to my level of study.	**0.635**
11	The instruction of the board game was presented in a clear and logical manner. The materials were sufficient and can be used without the assistance of the lecturer.	
12	The instruction of the board game was presented in a clear and logical manner. Allowed references to lecture notes & textbooks when I had doubts on the content of Tooth Morphology.	**0.443**
13	The instruction was relevant to my level of study. The materials were sufficient and can be used without the assistance of the lecturer.	**0.402**
14	The cards, models & game board were easy to use and were applicable to the subject. Provides a better tutorial alternative than the regular "old fashion" Tutorial class.	**0.420**
15	Made learning fun. Had questions that helped recall information easily.	**0.401**
16	Made learning fun. Had questions that helped me to understand the Tooth Morphology content related to molars, occlusion, dental anomalies, primary dentition, tissues of the pulp cavity & forensic dentistry.	**0.415**

17	Made learning fun. Provides a better tutorial alternative than the regular "old fashion" Tutorial class.	**0.484**
18	Helped me to learn difficult morphological concepts. Had questions that helped recall information easily.	**0.518**
19	Helped me to learn difficult morphological concepts. Had questions that helped me to understand the Tooth Morphology content related to molars, occlusion, dental anomalies, primary dentition, tissues of the pulp cavity and forensic dentistry.	**0.502**
20	Had questions that helped recall information easily. Had questions that helped me to understand the Tooth Morphology content related to molars, occlusion, dental anomalies, primary dentition, tissues of the pulp cavity and forensic dentistry.	**0.510**
21	Had questions that helped recall information easily. Encouraged and motivated me to engage in discussions with my partner/partners when I did not understand the content of Tooth Morphology.	**0.467**
22	Encouraged and motivated me to engage in discussions with my partner/partners when I did not understand the design of the board game. Encouraged and motivated me to engage in discussions with my partner/partners when I did not understand the content of Tooth Morphology.	**0.648**
23	Encouraged and motivated me to engage in discussions with my partner/partners when I did not understand the content of Tooth Morphology. Allowed references to lecture notes & textbooks when I had doubts on the content of Tooth Morphology.	**0.595**

Table 3: Spearman Rank Correlation Results: OAMG

OAMG -Variables		Spearman Correlations Coefficient (*r*)
1	I was able to get assistance from the lecturer while playing the game. The instruction was presented in a clear and logical manner.	**0.434**
2	I was able to get assistance from the lecturer while playing the game. Improved my terminology while learning the anatomical concepts related to the muscles of mastication and facial expression.	**0.437**
3	I was able to get assistance from the lecturer while playing the game. Had questions that helped me to recall information easily.	**0.412**
4	The instruction was presented in a clear and logical manner. The instruction was relevant to my level of study.	**0.686**
5	The instruction was presented in a clear and logical manner. The anatomical language used was relevant and easy to understand.	**0.567**
6	The instruction was presented in a clear and logical manner. I was able to track my performance in the game.	**0.427**
7	The instruction was presented in a clear and logical manner. Had questions that helped me to recall information easily.	**0.488**
8	The instruction was presented in a clear and logical manner. Provides a better tutorial alternative than the regular "old fashion" Tutorial class.	**0.402**
9	The instruction was relevant to my level of study. The anatomical language used was relevant and easy to understand.	**0.567**
10	The instruction was relevant to my level of study. Had questions that helped me to recall information easily	**0.535**
11	The anatomical language used was relevant and easy to understand. I was able to track my performance in the game.	**0.400**
12	The anatomical language used was relevant and easy to understand. Had questions that helped me to recall information easily	**0.587**
13	The anatomical language used was relevant and easy to understand. Had questions that	**0.583**

	improved my understanding on the structural anatomy of muscles of mastication and facial expression.	
14	The anatomical language used was relevant and easy to understand. Had questions that improved my understanding on the functional anatomy of muscles of mastication and facial expression.	**0.430**
15	The anatomical language used was relevant and easy to understand. Provides a better tutorial alternative than the regular “old fashion” Tutorial class.	**0.459**
16	The anatomical language used was relevant and easy to understand. Made learning fun.	**0.415**
17	The anatomical language used was relevant and easy to understand. Relevant & “eye catching” graphics were used.	**0.440**
18	The anatomical language used was relevant and easy to understand. Provides a better tutorial alternative than the regular “old fashion” Tutorial class.	**0.462**
19	Appropriate sound was used. Relevant & “eye catching” graphics were used.	**0.410**
20	Appropriate sound was used. I was able to track my performance in the game.	**0.518**
21	Appropriate sound was used. Provides a better tutorial alternative than the regular “old fashion” Tutorial class.	**0.456**
22	Relevant & “eye catching” graphics were used. Provides a better tutorial alternative than the regular “old fashion” Tutorial class.	**0.409**
23	I was able to track my performance in the game. I consulted my lecture notes to clarify my understanding on the structure of the muscles of mastication and facial expression.	**0.444**
24	I was able to track my performance in the game. Provides a better tutorial alternative than the regular “old fashion” Tutorial class.	**0.476**
25	Made learning fun. Improved my terminology while learning the anatomical concepts related to the muscles of mastication and facial expression.	**0.410**
26	Made learning fun. Had questions that improved my understanding on the structural anatomy of muscles of mastication and facial expression.	**0.545**
27	Made learning fun. I consulted my lecture notes to clarify my understanding on the structure of the muscles of mastication and facial expression.	**0.435**
28	Made learning fun. Provides a better tutorial alternative than the regular “old fashion” Tutorial class.	**0.445**
29	Helped me to learn difficult anatomical concepts related to the muscles of mastication and facial expression. Improved my terminology while learning the anatomical concepts related to the muscles of mastication and facial expression.	**0.708**
30	Helped me to learn difficult anatomical concepts related to the muscles of mastication and facial expression. Improved my terminology while learning the anatomical concepts related to the muscles of mastication and facial expression.	**0.531**
31	Helped me to learn difficult anatomical concepts related to the muscles of mastication and facial expression. Had questions that improved my understanding on the structural anatomy of muscles of mastication and facial expression.	**0.438**
32	Helped me to learn difficult anatomical concepts related to the muscles of mastication and facial expression. Had questions that improved my understanding on the functional anatomy of muscles of mastication and facial expression.	**0.591**
33	Helped me to learn difficult anatomical concepts related to the muscles of mastication and facial expression. I consulted my lecture notes to clarify my understanding on the structure of the muscles of mastication and facial expression.	**0.568**
34	Helped me to learn difficult anatomical concepts related to the muscles of mastication and facial expression. I consulted my lecture notes to clarify my understanding on the function of the muscles of mastication and facial expression.	**0.405**
35	Helped me to learn difficult anatomical concepts related to the muscles of mastication and facial expression. Provides a better tutorial alternative than the regular “old fashion” Tutorial class.	**0.481**

36	Improved my terminology while learning the anatomical concepts related to the muscles of mastication and facial expression. Had questions that helped me to recall information easily.	**0.462**
37	Improved my terminology while learning the anatomical concepts related to the muscles of mastication and facial expression. Had questions that improved my understanding on the structural anatomy of muscles of mastication and facial expression.	**0.490**
38	Improved my terminology while learning the anatomical concepts related to the muscles of mastication and facial expression. Had questions that improved my understanding on the functional anatomy of muscles of mastication and facial expression	**0.479**
39	Improved my terminology while learning the anatomical concepts related to the muscles of mastication and facial expression. I consulted my lecture notes to clarify my understanding on the structure of the muscles of mastication and facial expression.	**0.553**
40	Improved my terminology while learning the anatomical concepts related to the muscles of mastication and facial expression. I consulted my lecture notes to clarify my understanding on the function of the muscles of mastication and facial expression.	**0.420**
41	Had questions that helped me to recall information easily. Had questions that improved my understanding on the functional anatomy of muscles of mastication and facial expression.	**0.593**
42	Had questions that helped me to recall information easily. I consulted my lecture notes to clarify my understanding on the structure of the muscles of mastication and facial expression.	**0.405**
43	Had questions that helped me to recall information easily. Provides a better tutorial alternative than the regular “old fashion” Tutorial class.	**0.528**
44	Had questions that improved my understanding on the structural anatomy of muscles of mastication and facial expression. Had questions that improved my understanding on the functional anatomy of muscles of mastication and facial expression.	**0.572**
45	Had questions that improved my understanding on the structural anatomy of muscles of mastication and facial expression. I consulted my lecture notes to clarify my understanding on the function of the muscles of mastication and facial expression.	**0.529**
46	Had questions that improved my understanding on the functional anatomy of muscles of mastication and facial expression. I consulted my lecture notes to clarify my understanding on the structure of the muscles of mastication and facial expression.	**0.458**
47	Had questions that improved my understanding on the functional anatomy of muscles of mastication and facial expression. I consulted my lecture notes to clarify my understanding on the function of the muscles of mastication and facial expression.	**0.448**
48	Had questions that improved my understanding on the functional anatomy of muscles of mastication and facial expression. Provides a better tutorial alternative than the regular “old fashion” Tutorial class.	**0.500**
49	I consulted my lecture notes to clarify my understanding on the structure of the muscles of mastication and facial expression. I consulted my lecture notes to clarify my understanding on the function of the muscles of mastication and facial expression.	**0.641**

Appendix 11: Chi-Square Test Results

TMBG: As all values are above 0.05 (the level of significance), there was no significant difference in the results by years.

Table 4: TMBG: Summary of Chi square test results

TMBG: Summary of Chi square test results	Level of Significance by Years
The subject encourages me to consult with the lecturer for assistance when I do not understand the lecture.	0.589
I remember the information after the lecture.	0.140
I am able to use the knowledge from lectures and apply it practically.	0.204
I consider multiple choice quiz games as effective tutorials.	0.747
I understood the “instructions” of the game as contained in the game instructional manual.	0.612
I did not need the help of the instructor to start the game.	0.395
I was able to get assistance from the lecturer whilst playing the game.	0.882
The instruction of the board game was presented in a clear and logical manner.	0.894
The instruction was relevant to my level of study.	0.143
My language ability was not being tested.	0.608
Of the colour combinations and pictures used.	0.131
The cards, models & game board were easy to use and were applicable to the subject.	0.516
I understood the questions.	0.642
The materials were sufficient & can be used without the assistance of the lecturer.	0.530
Made learning fun.	0.904
Helped me to learn difficult morphological concepts.	0.617
Had questions that helped recall information easily.	0.915
Had questions that helped me to understand the Tooth Morphology content related to molars, occlusion, dental anomalies, primary dentition, tissues of the pulp cavity & forensic dentistry.	0.321
Encouraged and motivated me to engage in discussions with my partner/partners when I did not understand the design of the board game.	0.699
Encouraged and motivated me to engage in discussions with my partner/partners when I did not understand the content of Tooth Morphology.	0.671
Allowed references to lecture notes & text books when I had doubts on the content of Tooth Morphology.	0.560
Provides a better tutorial alternative than the regular “old fashion” Tutorial class.	0.259

OAMG: Highlighted values (in yellow) show statistically significant difference in the results by years (the level of significance is below 0.05).

Table 5: OAMG: Summary of Chi square test results

OAMG: Summary of Chi square test results	Level of Significance by Years
The subject encourages me to consult with the lecturer for assistance when I do not understand the lecture.	0.742
I remember the information after the lecture.	0.346
I am able to use the knowledge from lectures and apply it practicall.y	0.296
I consider multiple choice quiz games as effective tutorials.	0.504
I understood the “instructions” of the game as contained in the game instructional manual.	0.162
I did not need the help of the instructor to start the game.	0.671
I was able to get assistance from the lecturer while playing the game.	0.661
The instruction was presented in a clear and logical manner.	0.476
The instruction was relevant to my level of study.	0.141
The anatomical language used was relevant and easy to understand.	0.378
Provide any other reason as to why you could play the game.	.030*
The layout was creative & very effective.	0.546
Appropriate sound was used.	.000*
Relevant & “eye catching” graphics were used.	0.276
I was able to track my performance in the game.	0.676
The game can be used without the assistance of the subject lecturer.	0.446
Provide any other reason as to why you liked the game.	0.756
How do you think the Muscle Mania multimedia game can be improved?	0.421
Made learning fun.	0.44
Helped me to learn difficult anatomical concepts related to the muscles of mastication and facial expression.	0.062
Improved my terminology while learning the anatomical concepts related to the muscles of mastication and facial expression.	0.46
Had questions that helped me to recall information easily.	0.202
Had questions that improved my understanding on the structural anatomy of muscles of mastication and facial expression.	0.567
Had questions that improved my understanding on the functional anatomy of muscles of mastication and facial expression.	0.92
I consulted my lecture notes to clarify my understanding on the structure of the muscles of mastication and facial expression.	0.732
I consulted my lecture notes to clarify my understanding on the function of the muscles of mastication and facial expression.	0.102
Provides a better tutorial alternative than the regular “old fashion” Tutorial class.	0.317

Appendix 12: Frequency of Students Responses

8.1 I understood the "instructions" of the game as contained in the game instructional manual,

	Year			Total
	2011	2010	2009	
Undecided	4,2%	0,0%	0,0%	1,2%
Agree	29,2%	34,3%	29,2%	31,3%
Strongly Agree	66,7%	65,7%	70,8%	67,5%

8.2 I did not need the help of the instructor to start the game.

	Year			Total
	2011	2010	2009	
Strongly Disagree	4,2%	2,9%	0,0%	2,4%
Disagree	12,5%	17,1%	16,7%	15,7%
Undecided	4,2%	14,3%	0,0%	7,2%
Agree	41,7%	20,0%	37,5%	31,3%
Strongly Agree	37,5%	45,7%	45,8%	43,4%

8.3 I was able to get assistance from the lecturer whilst playing the game.

	Year			Total
	2011	2010	2009	
Disagree	0,0%	2,9%	0,0%	1,2%
Undecided	8,3%	5,7%	12,5%	8,4%
Agree	33,3%	37,1%	37,5%	36,1%
Strongly Agree	58,3%	54,3%	50,0%	54,2%

8.4 The instruction of the board game was presented in a clear and logical manner.

	Year			Total
	2011	2010	2009	
Agree	25,0%	20,0%	20,8%	21,7%
Strongly Agree	75,0%	80,0%	79,2%	78,3%

8.5 The instruction was relevant to my level of study.

	Year			Total
	2011	2010	2009	
Agree	33,3%	14,3%	33,3%	25,3%
Strongly Agree	66,7%	85,7%	66,7%	74,7%

8.6 My language ability was not being tested.

	Year			Total
	2011	2010	2009	
Strongly Disagree	8,3%	2,9%	8,3%	6,0%
Disagree	8,3%	8,6%	8,3%	8,4%
Undecided	8,3%	8,6%	12,5%	9,6%
Agree	41,7%	20,0%	33,3%	30,1%
Strongly Agree	33.3%	60.0%	37.5%	45.8%

9.1 Of the colour combinations and pictures used.

	Year			Total
	2011	2010	2009	
Disagree	5,0%	3,0%	12,5%	6,5%
Undecided	10,0%	9,1%	8,3%	9,1%
Agree	45,0%	63,6%	25,0%	46,8%
Strongly Agree	40,0%	24,2%	54,2%	37,7%

9.2 The cards, models & game board were easy to use and were applicable to the subject.

	Year			Total
	2011	2010	2009	
Undecided	5,0%	3,0%	0,0%	2,6%
Agree	25,0%	27,3%	12,5%	22,1%
Strongly Agree	70,0%	69,7%	87,5%	75,3%

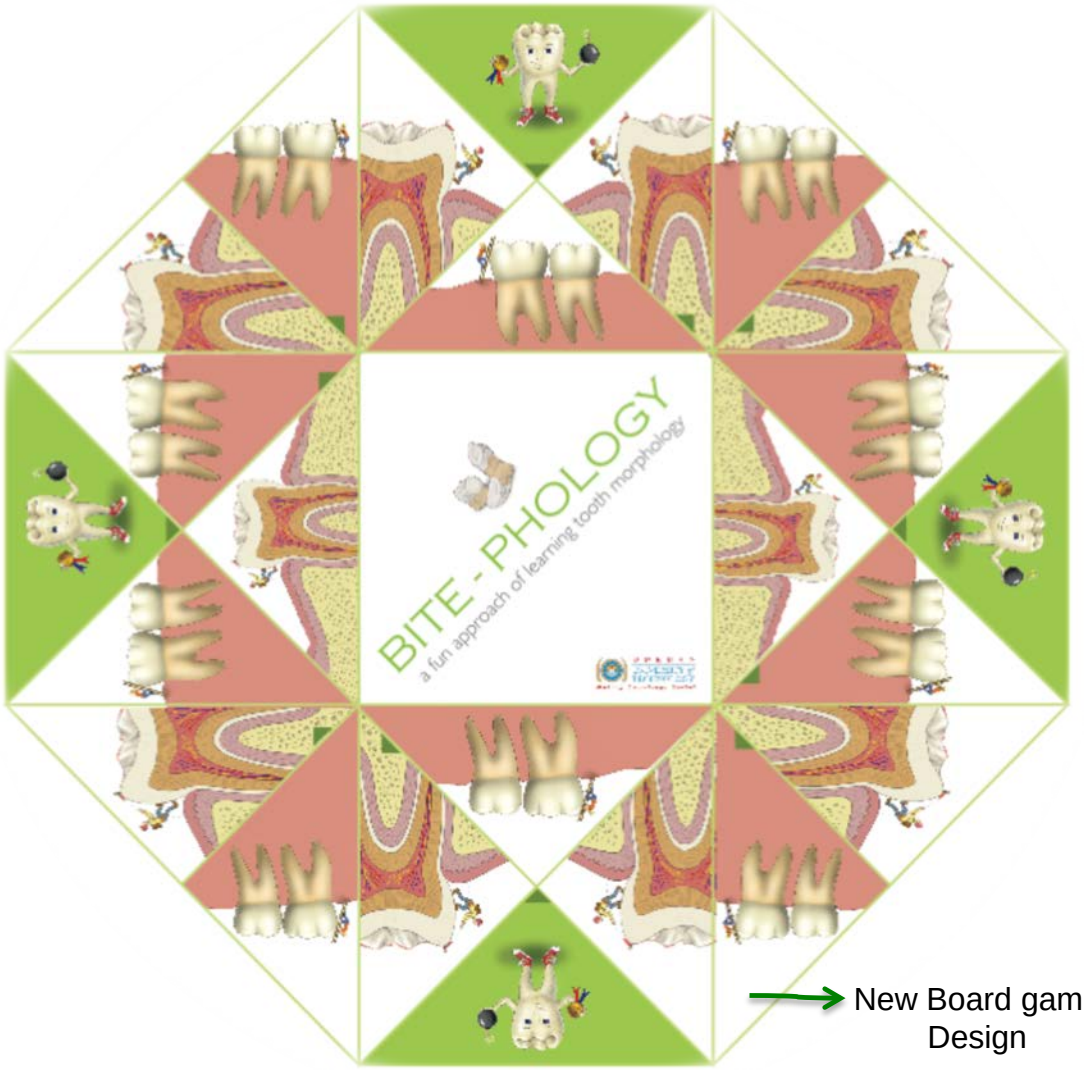
9.3 I understood the questions.

	Year			Total
	2011	2010	2009	
Undecided	0,0%	0,0%	4,2%	1,3%
Agree	60,0%	54,5%	50,0%	54,5%
Strongly Agree	40,0%	45,5%	45,8%	44,2%

9.4 The materials were sufficient & can be used without the assistance of the lecturer.

	Year			Total
	2011	2010	2009	
Disagree	0,0%	0,0%	4,2%	1,3%
Undecided	5,0%	6,1%	0,0%	3,9%
Agree	50,0%	36,4%	33,3%	39,0%
Strongly Agree	45.0%	57.6%	62.5%	55.8%

Appendix 13: Bite-phology™



New Board game Design

Full mouth model (*Hard durable plastic material)*