The Integration of Mobile Learning App-based Quiz-Games in Higher Education Teaching of Anatomical Sciences

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Abstract

Background: Mobile learning (mLearning) and gamification are two potential pedagogical tools that are continuously evolving in Higher Education. Their efficiency as learning tools is not fully understood and their use by staff is sporadic and sometimes viewed poorly compared to traditional methods**. Aim:** To determine a framework of best practice for the integration of mLearning app based quiz-games into the Higher Education (HE) teaching of anatomical sciences. This thesis presents three studies, which aim to 1) evaluate mLearning quiz-games as a revision tool for an anatomy online examination 2) and 3) investigate the effect of pre-seminar mLearning quiz gameplay on knowledge acquisition, retention and engagement in anatomy. **Method:** The data collection was performed over a two year period in a level 4 anatomy module for Sport and Exercise Science students. All three studies employed an experimental mixed methods approach within an action research framework to allow the development of the project in a naturalistic way. *Study One* was completed over two cohorts, 2014-15 (n=125) and 2015-16 (n=121). The module has four assessment points, A1, A2, A3, A4 where A1-3 are online assessments with a mixture of Multiple Choice Questions, labelling and matching questions and A4 is a viva voce. Students did A1, A2 and A4 as normal but at A3 they were offered a choice to revise as normal, the control group (n= 164) or to play mLearning games (n=87) for 15 minutes prior to the assessment on a tablet or smartphone device. All students completed a modified Study Process Questionnaire (SPQ) post-assessment and then for triangulation of data online focus groups were completed (n=84) as well as extended semi-structured interviews (n=9). *Study Two* was completed in 2015-16 using the same module as *Study One*. Over two consecutive weeks students were videoed in a two hour seminar session where in week one they did 15 minutes of no formal class preparation (n=87) and in week two they did 15 minutes of mLearning games (n=87). Students did a plenary and recap class Socrative quiz every week where the plenary scores indicate knowledge acquisition and the difference between the plenary and recap scores of subsequent weeks indicates knowledge retention. Observational behavioural engagement analysis was completed using an adapted coding system and students completed the National Survey of Student Engagement following each seminar. *Study Three* was completed on the same cohort in semester two using a randomised repeated measures design for the knowledge acquisition and knowledge retention scores over three weeks with three 15 minute interventions; Games, Control and Games plus question generation before class**. Results:** *Study One* found that the Games group performed better at A3 with no difference at A2 or A1 ($p<0.0.01$) but no differences were found in the SPQ surface and deep learning motives and strategies. Students revealed reasons for using mLearning quiz-games were primarily the fun, visual stimulation, instant feedback and accessibility. *Study Two* found that playing quiz-games prior to class increased on-task behaviours and peer interaction and improved knowledge acquisition and retention scores ($p<0.01$). *Study Three* agreed but found no difference in the Games-plus questions group compared to the control or games groups. **Conclusions:** The studies reveal the positive effect that mLearning quiz-games can have on achievement and engagement both in class and as a revision tool prior to assessment. The results of all three studies have been used to inform the proposed Mobigames framework for the integration of mLearning quiz-games in HE teaching. The framework has four key aspects: Information, Facilitation, Learning and Timing.

Presentation of Results

Gibbs, P., Cartney, P., Wilkinson, K., Parkinson, J., Cunningham, S., James-Reynolds, C., ... & MacDonald, A. (2016). Literature review on the use of action research in higher education. *Educational Action Research*, 1-20.

Wilkinson, K., & Barter, P. (2016). Do mobile learning devices enhance learning in higher education anatomy classrooms?. *Journal of Pedagogic Development*, *6*(1).

Wilkinson, K. and Barter, P. (2015) Mobile Learning In the anatomy classroom. IADIS Mobile Learning conference proceedings. And extended version in *Journal of Mobile and Blended Learning Conference special*

Wilkinson, K. and Miller. S. (2014) Integrating technology into HE sports programmes; the good, the bad, and the ugly. http://www.slideshare.net/UKSportSci/integrating-technology-into-higher-education-sport-and-exercise-science British Educational Training & Technology Show (BETT).

1.0 Introduction

1.1 Background to the Project

Higher Education (HE) in the UK is continually evolving and has faced many changes in the last decade. The impact of the annual nine thousand pound fee is still yet to be quantified with consumerism within HE being said to be greater than ever (Nixon et al. 2016). The challenge for an institution to recruit high quality students and provide high quality teaching has been brought to the forefront in the last two years with the impending Teaching Excellence Framework (TEF). The TEF is expected to reshape the existing hierarchy of HE with many smaller universities predicted to outperform their Russell counterparts. The TEF pilot began in the 2015-16 academic year, a year that has also brought about universities raising fees on those courses with high quality teaching. Durham, Kent and Royal Holloway have set the benchmark for 2017 at £9250, which has caused much media interest and government discussion particularly surrounding teaching quality and how to assess it. Therefore, change and judgement based on teaching quality is inevitable within UK HE suggesting that teaching and learning strategies need to be modified to reflect and conform to the new ideals. One pedagogical tool suggested to potentially improve teaching quality, having the power and flexibility to transform practice is mobile learning (mLearning) (Motiwalla, 2007). Modern advancements in technology and innovation to maximise student engagement (a TEF parameter) have placed mLearning in the limelight with huge potential changes to learner experience, expectations and demands.

mLearning has been defined in many ways, constantly evolving from learning using small devices (Mcconatha et al. 2008) to specifying the role of the smartphone and tablet (Shuler et al., 2013; Traxler, 2013). Within the construct of mLearning there is the mobility of learner, educator and technology perspectives to consider, resulting in much variation of current research in the field (Emran et al. 2016). mLearning encompasses both roles, as a vehicle for teaching and learning and as a platform to create new learning tools, applications and games (Kearney et al. 2011). Bidin and Ziden (2013) highlight this disconnect between the pedagogical and technical aspects of mLearning research. Alongside any advancement of educational technology as witnessed with eLearning, is the need for positive attitudes and regular use by HE students and educators. The Technology Acceptance Model (TAM) was designed to investigate how users would accept or reject a new technology. Attitudes towards a new technology will inevitably influence its effectiveness as a learning tool due to usage and the staff-student dynamic of usability and resources (Bagozzi et al. 1992).

Much of the research into mLearning usage has suggested approximately two thirds of students use mobile devices at University (Emran et al. 2016). Gikas and Grant (2013) found that mLearning perceptions and use were generally favourable but the most commonly used learning tools were the internet and social media agreeing with Cochrane (2014). This further highlights the need for mLearning practice to be defined as to whether it is pedagogical or technical in nature. For example in Gikas and Grant (2013), the internet and social media are listed as tools but there is no teaching or learning information as to how they are being used to create mLearning experiences. The internet and social media represent a superficial mLearning layer with the potential for further development, the use of applications (apps), social learning communities and games can provide more depth and unlock enormous possibility. Current research suggests that students are initiating and leading the implementation of mLearning devices in the classroom, showing great potential for student mobility but suggesting a potential lag time for the educators' mobility (Emran et al. 2016; Cochrane, 2014; Gikas and Grant, 2013). Educators may need to catch up and embrace new relevant technology to ensure they maximise the potential for learning mobility on the student success cycle and learner experience (Wong et al. 2015). One of the aspects of mLearning that needs to be investigated further and recognised as study aids is the use of educational apps.

According to the top 100 iTunes apps of all time (iTunes, 2016), Angry Birds is at number five, Candy Crush Saga at number 15 and the more complex game, Clash of Clans at number 24. A game featuring in the top downloaded apps reveals the somewhat addictive nature of gameplay and how regularly they are used on mobile devices. If gameplay can be incorporated into learning environments, particularly mLearning to the same extent then user engagement could mimic this trend. Gamification, the use of gaming elements in a non-game context has been used in learning for many years particularly in younger learners (Deterding et al. 2011). It is also emerging as a popular concept within the workplace with many companies predicted to adopt an element of it in the future (Gartner, 2011). Gaming has accelerated in popularity over the past two decades, with some gaming events attracting mass spectator and television audiences suggesting that it is an integral part of many young peoples' lives and hobbies. Pokémon Go hit the headlines earlier in 2016 with an estimated 25 million daily users at its peak highlighting the potential lifestyle impact a game can have (De-Oliviera Roque, 2016). Whilst app based mLearning games will unlikely reach this kind of usage, it demonstrates the potential engagement gaming can have.

In this thesis elements of gamification, play and learning games have been integrated into the term mLearning quiz-games. The aspects of gaming and gamification relevant to the study are evaluated further in Chapter 2 and used alongside the more traditional learning games for the purpose of this thesis. Elements of learning games (applications) already in use and gamification and gaming principles were recognised as being able to enhance the educational impact of these applications when used together. This perspective of what a mLearning quiz-game is was developed through my own teaching practice and scholarship over the past five to eight years. The term app based mLearning quiz-game as used by Wang (2008) is used because it is thought to most accurately describe the gameplay used.

Gamification has been integrated into HE via social competition and rewards or pointification for many years but recently the concept has become more widely accepted and the focus of research. This recognition has led to the idea that gamification could transform the learning environment increasing engagement, enjoyment and motivation, particularly for the more "tedious" learning tasks (Hanus and Fox, 2015). Elements of gamification and mobile gaming that have been combined in this thesis alongside learning games are described as mLearning quiz-games. Using mLearning quiz-games to engage students and improve student success has the potential to affect the student learning, the TEF, University rankings and satisfaction scores. If student engagement improves this will positively impact on attendance and achievement (Fredricks et al. 2004) as well as potentially demonstrate a wider range of teaching methods and innovation therefore enhancing the learner experience. Adding the construct of mobility to gaming in learning is a relatively under-researched idea, which could help transcend formal and informal learning environments. This doctoral project aims to address the gaps in knowledge highlighted in the literature review (chapter 2) and inform educational practice in this emerging area. It is envisaged that the results can help educators integrate mLearning quiz-games into their teaching to maximise the potential benefits to student learning. The next section details the doctoral project structure and the aims and objectives.

1.2 Aims and Objectives

The aim of the doctoral project is to study the potential learning impact of mLearning quiz-games to develop a model of best practice for their integration into HE teaching of anatomical sciences. This will be informed from the study of current use and attitudes towards mLearning quiz-games and the efficacy of their role as a revision, pre-classroom and classroom learning tool for students.

Objectives:

- To examine the existing literature in the use of games, play, quizzes and mLearning in HE.
- To investigate the effect of mLearning quiz-games on student learning.
- To investigate the effect of mLearning quiz-games on student achievement.
- To investigate the effect of mLearning quiz-games on student engagement in the classroom.
- To investigate student views of mLearning and mLearning quiz-game use as a learning tool in HE.
- To develop a framework for the use of mLearning quiz-games in HE teaching of anatomical sciences.

1.3 The Project Overview

The project includes an action research (AR) cycle of three studies detailed in chapters 4-6 to attain these objectives. Each chapter will detail the individual study aims and objectives, which will be evaluated together in chapter 7 to result in the model for the use of mLearning quiz-games in HE teaching of anatomical sciences. Figure 1 shows the action research cycles included in the project.

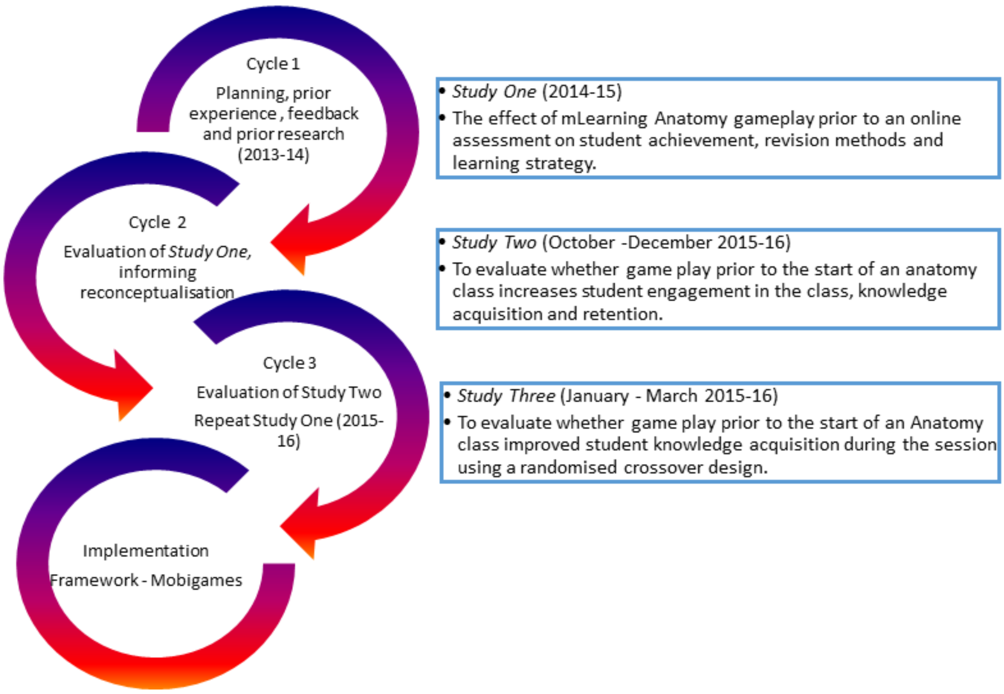

Figure 1: The sequence of studies in the doctorate based on an experimental approach to the research process in an action research pedagogical model.

1.4 Contribution to Knowledge

The studies in this professional doctorate aimed to explore the use of mLearning quiz-games and their effect on student learning prior to class and as a revision aid prior to assessment. The current state of knowledge in the field requires us to look at the areas of quiz based learning, game informed learning and mLearning separately because there is very little, as yet, integrating them. Specifically, we know that quizzing student knowledge aids performance in assessments and repeated quizzing can benefit knowledge retention. We know that game informed learning can increase student engagement or flow in a subject and positively affect student learning via the repeated play or success-failure cycles. Lastly current knowledge on mLearning suggests that it can be a positive addition to the classroom and to student learning in general, however the details as to how, when, what and where to integrate mLearning remain largely under researched. There is very little research investigating the three areas together, particularly in the anatomical sciences where the apps currently available have activities for students to play that struggle to fit into the accepted definition of a game, however, this definition comes from the world of video gaming. Using the definition of play and traditional definition of a game the app-based activities would indeed be classed as games, for the purpose of this thesis they have been termed quiz-games.

The studies contribution to knowledge is summarised below and further discussed in sections 7.1 and 8.0.

- Playing app-based mobile quiz-games prior to assessment in anatomy increases performance.

- Students valued the quiz-games because of their mobility, simplicity, ability to give instant feedback, availability offline, competition and visual nature.

- Students generally play the quiz-games whilst commuting, at university during timetabled gaps and at home.

- Playing quiz-games prior to a seminar class increased knowledge acquisition during the class.

- Playing quiz-games prior to a seminar class increased knowledge retention between two seminars one week apart.

- Playing quiz-games prior to a seminar class increased behavioural engagement measured by on and off task behaviours observed.

These findings have been integrated into the proposed Mobigames framework aimed at teachers and educators to be able to use mobile based quiz-games into their classroom, in both the formal and informal settings. The framework development is detailed in section 7.2 and contributes to current knowledge by integrating both gameplay and mobile learning findings into a framework to add to a teacher's toolkit. The framework shows teachers how to integrate quiz-games into their teaching, when to do so and what attributes an app-based quiz-game should have. It is based on anatomical sciences teaching but could be applicable to other subjects that have a similar type of learning with a large volume of fundamental knowledge required such as languages and other sciences.

Chapter 2 provides a literature review detailing current research in the areas of anatomical sciences education, student engagement, mLearning and gameplay. The sections explore areas required for each of the cycles and therefore informing the different studies. Section 2.1 and 2.2 evaluates the underpinning literature in HE and anatomical sciences education. All three cycles (studies) are completed in the subject of anatomy and therefore the relevant national framework and learning theories are explored to allow a full pedagogical discussion of the thesis findings in chapter 7. Engagement is discussed in section 2.3 as a key component and success outcome in the student learning experience but also as an integral part and measure of cycle 2, *study two.* The measurement of HE classroom engagement is then further evaluated in the methodology, chapter 5.2. Assessment (section 2.4) is used in all three studies and cycles but study one (cycle one) uses the summative assessment points whereas studies two and three involve formative assessment success measures as indicators of knowledge acquisition and retention. Sections 2.5 and 2.6 review the current literature in mLearning and learning games to bring together the aspects of gamification, gaming and learning games integrated in this thesis.

Chapter 3 explores the general methodology providing a justification for the ontological mix chosen and the exploration of the experimental approach within action research. Data analysis and statistical analysis approaches common to all of the studies are stated in section 3.3 with more detailed specific discussion in each of the study method sections. Chapters 4, 5 and 6 show each of the three studies culminating in chapter 7 bringing them together to discuss the Mobigames Framework. The conclusion is chapter 8, which includes the limitations and future research suggestions.

Current ideas are explored and evaluated focussing on the practice based approach throughout. There is a technical component to both mLearning and gamification but this project aims to concentrate on the pedagogical, professional viewpoint to improve teaching quality in Higher Education.

2.0 Literature Review

To more fully understand the prior knowledge and research available in the field of mLearning and games in HE, the following literature review will evaluate current knowledge to inform the Studies within this doctorate. Throughout the literature review studies from all levels of education from across the developed world will be reviewed, and therefore a brief overview of key differences and pedagogical approaches is needed to allow comparisons to be drawn. Section 3.1 evaluates the different approaches to learning commonly used In the literature to justify the pedagogical viewpoint used in this thesis.

2.1 Educational Approaches

Firstly, both pedagogical and andragogical literature will be reviewed but I will use the term pedagogy to encompass both throughout. Pedagogy translates as the art and science of teaching children (Ozuah, 2005) and assumes the learner is dependent. Pedagogy was also associated with the assumptions that their prior knowledge was irrelevant, motivation was primarily extrinsic, and curricula should be subject specific (Knowles et al. 1998). This model is very much a teacher led model, which has infiltrated modern curricula and teaching methods in both primary and secondary UK education. HE is targeted at being more student-led and encouraging autonomy of learning. However, with modern funding constraints, fee increases and league tables, the traditional pedagogical model is central to all levels of education. Andragogy was initially derived from Plato's philosophies of learning and further explored early in the 20th century concluding that it is more of a problem based, student-driven approach to teaching. Knowles (1990) added assumptions for the adult learner that opposed the pedagogical assumptions, intrinsic motivation, prior learning and the independent learner at the heart of this framework. Knowles (1990) tabulated key differences, which were adapted by Taylor and Kroth (2009) as shown in Table 1. The level of maturity assumed in andragogy makes it slightly unrealistic as the primary model in undergraduate students.

Table 1: Andragogical and pedagogical assumptions (Taylor and Kroth, 2009)

Regarding	**Andragogy**	**Pedagogy**
Concept of the learner	The role of the learner is more self-directed, but the movement from dependency to self-directedness occurs at different rates for different persons.	Role of the learner is a dependant one.
Role of the teacher	The teacher has a responsibility to encourage and nurture this movement towards self-directedness.	The teacher is expected to take full responsibility for determining what is to be learned, when it is to be learned, how it is to be learned, and if it has been learned.
Role of learner's experience	As people grow and develop they accumulate an increasing reservoir of experience that becomes an increasingly rich resource for learning. People attach more meaning to learnings they gain from experience than those they acquire passively.	The experience learners bring to a learning situation is of little worth. The experience from which learners will gain the most is that of the teacher, the textbook writer, the audio-visual aid producer, and other experts.
Primary technique of delivery	Experiential techniques – laboratory experiments, discussion, problem-solving cases, simulation exercises, field experience, and the like.	Transmittal techniques – lecture, assigned reading, AV presentations.
Readiness to learn	People become ready to learn something when they experience a need to learn it in order to cope more satisfyingly with real-life tasks or problems.	People are ready to learn whatever society says they ought to learn. Most people of the same age are ready to learn the same things.
How learning should be organized	Learning should be organized around life-application categories and sequenced according to the learners' readiness to learn.	Learning should be organized into a fairly standardized curriculum, with a uniform step-by-step progression for all learners.
Orientation of learning	Learners see education as a process of developing increased competence to achieve their full potential in life. Learners want to be able to apply whatever knowledge and skill they gain today to living more effectively tomorrow. People are performance-centred in their orientation to learning.	Learners see education as a process of acquiring subject-matter content, most of which they understand will be useful only at a later time in life.
Organization of curriculum	Should be organized around competency or development categories	Organized into subject matter units which follow the logic of the subject from simple to complex.

The argument for using a pedagogical approach in certain topics, which require a volume of didactic learning, such as anatomy at Level Four is fairly strong. There is also a strong suggestion that current undergraduate (UG) students at many institutions may still fit within the pedagogical assumptions, especially where a modular curricular is taught under modern student expectations of consumerism and the need for more of a transitional, development towards the andragogical student-led, independent learning model. The andragogy-pedagogy dichotomy remains a contested domain with Holmes and Abington-Cooper (2000) arguing that those that believe in a true segregation between the philosophies may not be as adaptive to all learner groups. Nixon et al. (2016) describes students as the “sovereign consumer” and Nordin et al. (2016) discuss the readiness of students for self-directed study following a “spoon fed” approach at school. Parkinson and George (2003) suggest that in medical and veterinary students in particular there is a cycle of pedagogy through to andragogy whereby fundamentals of a topic are learned and then built upon. It is this perspective, that they are complementary rather than antithetical that will be used in discussion of learning and teaching levels but the term pedagogical will be used for consistency. Although the andragogical approach would suit the aims and goals of HE, the terms are consistently interchanged in the literature with pedagogy being far more commonly used as an overarching educational term. Therefore, in this study both andragogical and pedagogical terms were used in the literature search but the key assumptive differences acknowledged for potential application where required.

It is necessary to filter the pedagogic and andragogic assumptions in the light of the learning context that may affect both learner and educator. This thesis is focused on anatomical sciences and therefore the educational fields of medicine and health that governs this work can restrict the potential application of the andragogical model. The traditional and potential learning methods used in anatomy are discussed in section 2.2 and related to the level of learning described in Figure 2 where the focus is on knowledge and understanding.

2.2 Anatomical Sciences

Anatomy is an integral part of most Sport and Exercise programmes of study as well as being core to medical and veterinary degrees. Within a Sports Science programme, students are required to construct a comprehensive and sophisticated understanding of basic anatomy, and then apply that information to the athlete for performance, health or rehabilitation (Ward and Walker, 2008) purposes. Anatomy requires students to learn a large volume of Latin terminology and functions including muscle names, origins, insertions, joints, connective tissue and cellular, micro and gross anatomy. Students traditionally use a rote or surface learning approach and have suggested anatomy is “boring, hard, dull” (Noguera, 2013; Hopkins, 2011). Miller et al. (2002) discuss the perception of anatomy as a subject, primarily for health practitioners but agree that a common problem is the reliance on memorising words and facts without the subsequent integrated understanding and fundamental concepts.

For medical students in particular, a high workload, the volume of new information, and the pressures of a vocational course can often cause students to prepare for exams using ineffective study methods for long-term recall potential, which could limit understanding (Schoenfeld, 1987; Radcliffe and Lester, 2003). This has also been demonstrated in other subjects (Lam et al. 2012) and related to assessment strategies (Scully and Kerr, 2014), both of which highlighted negative perceptions of high workload at key assessment points of the year. Moreover, some learners continue using the first study method they adopt, no matter how detrimental such practices eventually become to their success and long-term recall and knowledge acquisition (Newble and Gordon, 1985) limiting progression through the learner journey. The notion of revision methods and workload would be further complicated in students with learning difficulties or additional needs. The integration of study skills into most degree programmes has possibly positively influenced this, encouraging more student self-reflection (Koole et al. 2012) on study and revision techniques. However, there is still evidence of single method use and reliance on copying, memorising and visualisation in anatomy (Ward and Walker, 2008; Miller, 2002).

Learning objectives and the British Framework Higher Education Quality (FHEQ) are written based on the hierarchy of classifications within Bloom’s taxonomy (Figure 2) beginning with knowledge, the lowest level of cognitive assessment. Masters et al. (2001) assess student knowledge within four of the six levels of Bloom’s Taxonomy, which is frequently referenced as a measure of appropriate assessment in education (Clifton & Shriner, 2010). Morrison and Free (2001) describe knowledge as memorizing, or habitual thinking.

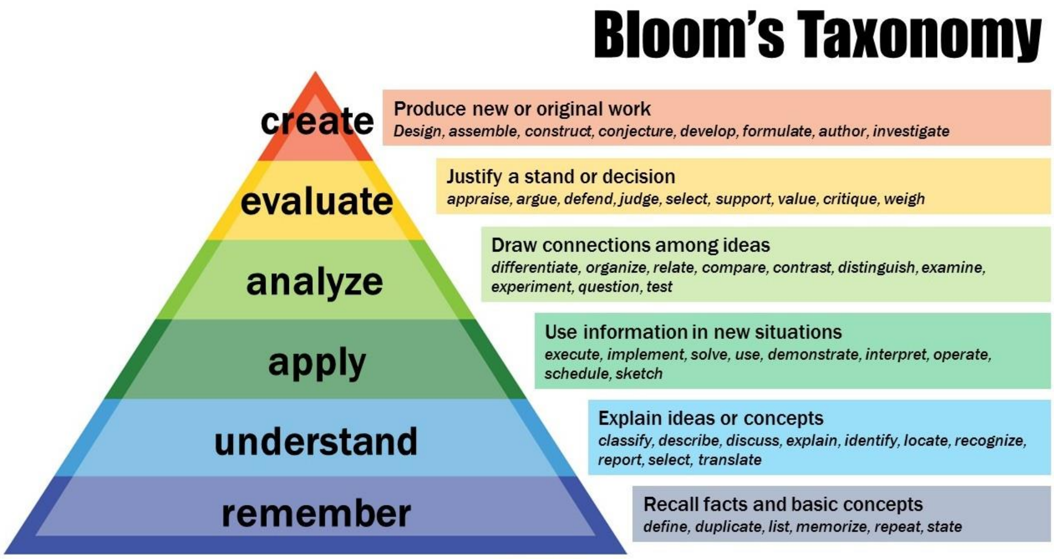

Figure 2: Bloom's taxonomy pyramid (Wineburg and Schneider (2009)

Comprehension, an understanding of the knowledge, encompasses the second level of Bloom's taxonomy, followed by application, analysis, evaluation and synthesis (create). To appropriately evaluate higher-level cognition and critical thinking, higher level assessment questions should be written at a greater cognitive level, particularly in upper level courses (Morrison & Free, 2001; Reichert, 2001). This has been incorporated into the teaching and assessment methods used in this thesis as described in section 2.4.

Anatomy is generally taught in the first year of study and therefore predominantly based around knowledge acquisition; however it should be understood in context bringing together the first two levels of Blooms' taxonomy. Higher level cognitive skills require application of this knowledge to an alternative scenario or in conjunction with other knowledge. In subjects such as anatomy, but also seen in language learning and many other Science Technology Engineering Mathematics (STEM) subjects, success in learning is coupled with students' knowledge of the basics, which for struggling students can initiate a vicious cycle (Busch et al. 2015). Where failure can occur when the basics are not mastered, either by lack of understanding, absenteeism or lack of motivation, self-efficacy and intrinsic motivation can further decline (Csikszentmihalyi, 2010). This has been negatively associated with future success in school aged children and completion of secondary education (Persons, 2010). In anatomical sciences in HE the nature of the subject could further hinder progress through a course and negatively affect completion if knowledge foundations are not built adequately to keep pace with the rest of the cohort. This can also affect whole class learning in a group learning environment witnessed in seminars and laboratory sessions where peer assisted and group tasks are commonplace. This could further demotivate students and affect learning success. This is important for students and institutions who are graded on retention and it is likely to be part of the TEF scoring system alongside the parameter of student engagement (HEFCE, 2016).

2.3 Engagement

Student engagement has been increasingly researched, theorised and the subject of much research at all levels of education but in HE it seems to be even more important. It is an integral part of the future TEF as a measure of teaching quality (Kuh, 2009) where many potential methods of measurement have been suggested and trialled (Kahu, 2013). Trowler and Trowler (2010) support the notion that the proposed positive effect of engagement on learning and achievement is “no longer questioned”. Engagement is a complex construct, which is multifaceted and has been used as a meta-construct in the identification of student success measures. The exact nature of engagement and how to measure it is contested within the literature and many frameworks have been suggested over the years. Most of the frameworks agree that there are four approaches to engagement, the behavioural, the socio-cultural, the psychological and the holistic.

The National Survey of Student Engagement (NSSE), which is discussed in chapter 5 was implemented in 2010 and has five sections, academic challenge, active learning, interactions, educational enrichment, and learning support; its predecessor, the Australian version has an additional section, work-related learning. There is much discussion in the research about how closely engagement should be related to the NSSE sections because it assumes the survey is valid whereas in reality there are a number of studies that put it in doubt (Pike, 2006; Payne et al. 2005). Engagement is meant to directly relate to student achievement but in much of the research actually looking at this success outcome, the associations are relatively weak (Carini et al. 2006). Behaviour measurement often relies on self-reporting and generic surveys, which can often lead to a lack of reliability across subjects and types of education provider or course type (Ahlfeldt et al. 2005). The purely behavioural engagement perspective is therefore suggested to result in a narrow, somewhat unclear comparative tool, which needs to be more accurate considering the funding, prowess and quality measures associated with engagement.

In contrast to the behavioural approach, psychological engagement attempts to broaden the outlook and research using this approach has a high prevalence in school-aged children. It assumes that engagement is a developmental, longitudinal psycho-social process that includes behaviour, cognition, emotion and conation. Huitt and Cane (2005) define conation as a mental process that causes or directs behaviour and actions; it encompasses intrinsic motivation, goal- orientation, self-regulation and effort (Broadbent & Poon, 2015). Behaviour is measured by involvement in the learning process, attendance and activity in class (Fredricks et al. 2004) whereas cognition is related to deeper learning strategies and effort as measured in the Study Process Questionnaire (SPQ) described in chapter 4. Psychological engagement fits more into the assumptions made in the andragogical model of education and therefore may be more suited to HE than the behavioural approach.

The emotive or affective dimension identifies is often not measured or even discussed within the engagement meta-construct (Kahu, 2013). There is evidence to suggest this perspective includes enjoyment, sense of belonging and subject interest, commonly assessed in module evaluation. Studies using module evaluations as a measure of engagement therefore need to be analysed carefully.

The holistic approach as suggested by Bryson et al. (2009) combines all three and, when used it highlights the multidimensional nature of engagement, and goes some way to explaining why it is so difficult to measure. It is this perspective that I will use as a construct to measure engagement within *Study Two.* It is discussed in more depth in chapter 5.

Engagement at HE levels should not only be looking at in-class engagement but also a measure of independent learning, which further confuses the construct. Over fifty percent of learning should be completed as independent study in most HE institutions and therefore engagement in the topic itself and additional learning materials needs to be a part of the measure. This further emphasises the need for the holistic approach to ensure affective or emotive engagement is measured. Fredricks et al. (2004) reviewed many methods used in measuring engagement on a number of pedagogical changes and contexts looking at outcomes of engagement. The review focusses on the outcome measures of achievement, completion, discipline and emotional qualitative measures. There are a number of mLearning and gamification studies that use engagement as a measure but there remains an inconsistency of measurement and therefore a lack generalisability and comparability. Bruce-Low et al. (2013) investigated the adoption of a mLearning device loaded with interactive exercises in Undergraduate (UG) Sports Science students. They used a focus group to complement the achievement data but used no recognised definition of engagement, although they concluded a positive effect. Achievement increased, but the intervention was for a three week period with no crossover design and therefore the increased performance could have been due to the novelty effect. Many studies have not found a direct positive effect of integrating mLearning into classrooms on achievement but most agree that classroom use encourages collaboration and social engagement (Parker et al. 2008; Kuh, 2005). Harper and Quaye (2009) showed not only a positive effect on achievement, but also on retention. Diemer et al. (2012) looked at student perceptions towards iPads in classes using a Likert scaled questionnaire including four questions to measure engagement suggested a narrow approach in an attempt to measure holistic engagement.

Although engagement is an indicator of student success and an element of the TEF and via various analytics, University rankings a key component of the learner journey remains achievement. Progression and completion through the levels towards the students' target award ultimately relies on some form of assessment to measure achievement.

2.4 Assessment

In educational psychology there are a number of perspectives used to discuss learning theories and "knowing". The two main perspectives applied to the educational setting are the behaviourist and constructionist; the cognitive rationalist perspective is discussed within the constructionist ontology (Greeno et al. 1996). In terms of learning theory, the concept of deep and superficial learning can be integrated into these theories. Surface learning being the prerequisite for deeper learning is suggested by Gagne (1968) where memorisation is the fundamental step in the learning hierarchy. Smaller units need to be mastered before higher levels of conceptual understanding and reasoning can be gained. However, the decomposition hypothesis suggests that this can limit deeper learning and result in purely mechanical knowledge. The constructionists and rationalists believe that active learning by intellectual activity is better than the passive rote memorisation that the behaviourist accepts as a part of the learning pathway as discussed in section 3.2 concerning anatomical sciences. Measurement of a students' learning preference is detailed in section 2.4.1.

Assessment is suggested to mirror these theories where constructionist and rationalist viewpoints favour question design based around problem solving and application. The behaviourist or empiricist tends to build questions based on the learning hierarchy, resulting in a mix of questions; both short and longer answer. The key for the teaching, learning and assessment methods is to allow for behavioural conditioning so that students become accustomed to the tools and environment they are in. There are differences between types of learning and subject matter, which partly explain why metacognitive awareness of students and teachers can affect achievement (Biggs, 2011).

Computer based assessment or e-assessment as considered to offer many advantages to academics and practitioner including time and cost efficiency, prompt feedback and grade storage and analysis on Virtual Learning Environment (VLE) platforms (Bugbee, 1996; Drasgow & Olsen-Buchanan, 1999; Gvozdenko & Chambers, 2007; Mazzeo & Harvey, 1988;

Mead & Drasgow, 1993; Parshall, Spray, Kalohn, & Davey, 2002; Smith & Caputi, 2005; Thelwall, 2000; Tseng, Macleod, & Wright, 1997). One thing that should be noted, as with all integration of technology in teaching, is that if technology delivers an assessment, it is important that it does not interfere with the nature of the question (Smith, 2007). VLEs have obviously expanded to incorporate much more than described here with many blended learning and online learning platforms being utilised in the delivery of Mass Open Online Courses (MOOCs) across the world. Their capacity for assessment has also improved but so has the requirement to use a wider variety of assessment types to allow all learner types to excel.

Multiple choice questions (MCQs) have been seen by many to be advantageous because they allow educators to test a large number of students objectively and efficiently and they can be graded electronically. However, some contest this notion suggesting that breadth and depth of understanding cannot be effectively assessed using MCQs and that application of knowledge is also limited. Studies showing a positive use of MCQs (Hansen & Dexter (1997); Masters et al. (2001)) suggest that MCQs can assess a wide variety of content, and help in the preparation for future assessment. Many of the studies investigating MCQ assessment are based within the medical or veterinary subject areas, which require a large volume of rote learning and baseline factual knowledge. More recently MCQs have been widely used and studied in clicker response systems and feedback (Ryan and Dunne, 2012). Anatomy is part of both of these subject areas and therefore this evidence should also apply to Sports Science students.

Masters et al. (2001) also assesses student knowledge within four of the six levels of Bloom's Taxonomy, which is frequently referenced as a measure of appropriate assessment in education (Clifton & Shriner, 2010). Learning objectives and the FHEQ are written based on the hierarchy of classifications within the taxonomy beginning with knowledge, the lowest level of cognitive assessment. Morrison and Walsh Free (2001) describe knowledge as memorizing, or habitual thinking. Comprehension, an understanding of the knowledge encompasses the second level of Bloom's taxonomy, followed by application, analysis, synthesis, and evaluation. To appropriately evaluate higher-level and critical thinking, higher level MCQs should be written at a higher cognitive level, particularly in upper level courses (Morrison & Walsh Free, 2001; Reichert, 2001).

In this study, Anatomy is taught at level 4 (first year UG) and therefore predominantly based around knowledge acquisition, however, it should be understood in context. Higher level cognitive skills require application of this knowledge to an alternative scenario or in conjunction with other knowledge. Scouller, (1998) investigated the use of MCQ and essay questions for Education students and found that surface learning techniques were employed more successfully for the MCQ assessment and deeper learning strategies resulted in poorer performance, the opposite of the essay based assessment. This highlights the importance of student perception of different types of assessment and their associated learning strategy as well as the construction of the question to assess a higher level of cognitive function and intellectual skills. Considine et al. (2005) discuss the requirement for empirical research for the validity of MCQ questions in nursing and education and recommend that robust equivalence and reliability processes are carried out in a pilot assessment, which was used as a model for the eviva assessment construction in Wilkinson and Barter (2016).

Studies have identified within-student factors that affect assessment performance in HE including prior study and entry criteria. Demographic variables found to influence achievement and assessment performance include age, employment, workload and gender (McKenzie and Schweitzer, 2001). Sport and Exercise Science programmes are traditionally male dominated in the UK and therefore gender may be a factor, not only in teaching and learning strategies but also for assessment (Sheard, 2009). Alongside traditional standpoints regarding gender and gaming the factor is therefore discussed with respect to assessment and different learning strategies.

Gender differences have been examined in various studies investigating the receptiveness to e-learning and factors affecting its use (Gefen & Straub, 1997; Ong & Lai, 2006; Wang, Wu, & Wang, 2009). Some studies on e-learning usage in different contexts such as universities, schools and organizations found that males had significantly higher positive perceptions regarding e-learning than females (Enoch & Soker, 2006; Hoskins & Van Hooff, 2005; Koohang, 2004; Ong & Lai, 2006; Zhou & Xu, 2007). Other studies showed no gender gap regarding perceptions (Davis & Davis, 2007; Zhang, 2005) but they were at different ages, cultures and education level and therefore it is difficult to draw common conclusions.

Terzis and Economides (2011) looked at gender-based differences in perception and acceptance in computer based assessment (CBA). Male students were found to value play most, followed by usefulness, content and social influence. They concluded that for males (1) the CBA should be playful, (2) the CBA must be useful to enhance the male student's knowledge and performance, (3) the CBA has to deliver the appropriate content, which has to be clear, understandable and relevant to the course, and (4) the CBA should be recommended and suggested by their fellow students and teachers because male students are influenced by their social environment. On the other hand, female students were mainly influenced by Playfulness, Ease of Use, Content and Goal Expectancy. The authors suggested that a CBA for females should follow these guidelines; (1) the CBA's environment has to be easy to use with simple design (buttons, figures, etc.) and with logical flow in order the user to understand where exactly she is and how to move back and forward, (2) the course has to stimulate the female student's interest in order to maximize her desire for preparation and raise her expectations. Scouller, (2001) also showed a gender difference with males preferring the MCQ type questions rather than essay type questions, which agrees with their learning preference, deep or surface. Other research disagrees and suggests no gender differences for assessment preference, Furnham et al. (2011) and Hewson (2012) found no performance differences related to student assessment preference. However, these studies did not look at online assessment or e-assessment as a factor. As discussed previously it may be more important that all students are familiar with the mode of assessment through facilitator led learning.

Scouller (1998) investigated the use of MCQs and essay questions in Education students and found that surface learning techniques were employed more successfully for the MCQ assessment and deeper learning strategies resulted in poorer performance, the opposite of the essay based assessment. This highlights the importance of student perception of different types of assessment and their associated learning strategy as well as the construction of the question to assess a higher level of cognitive function and intellectual skills.

2.4.1 Measurement of Learning Preference

Surface and Deep scaled learning approaches as described in the previous section have been measured using various questionnaires in the literature. Since the original Biggs (1987) SPQ there has been much discussion over how to measure student study approaches (Phan and Deo, 2007) and the revised 2 factor questionnaire has since been developed (Biggs, 2001). Those considered in the current study included the Approaches to Student Inventory (ASI) (Entwistle & Ramsden, 1983), the Approaches and Study Skills Inventory for Students (ASSIST) (Entwistle, et al. 2000), the Learning and Study Strategies Inventory (LASSI) (Weinstein & Palmer, 1990) and the Learning (LPQ) and Study Process Questionnaire (SPQ) (Biggs, 1987). Some research groups have more recently argued for the reconceptualization of learning approaches but they have focussed on a number of different social, cultural and educational groups which, could be argued to lack comparability and generalisability.

The ASSIST approach links learning styles such as the VARK method to Biggs (1987; 2001) to try and integrate the concepts and identify those students who may have poor study skills. It is a flipped method where it attempts to not put students in a specific box but to try and identify areas of weakness that could be improved. The ASSIST questionnaire is 52 items, the LASSI 60, some of which are not appropriate for the subject and project in question. It can be used in two ways; the first is by getting the students to consider each of the learning styles suggested by ASSIST, the second is by considering whether those results help inform the design and construction of individual learning environments(ILE). The aim of this paper was to categorise and gain a score for each learning approach not to use the questionnaire as it was designed, as a learning tool (Webster, 2002). The Deep scale has the associated sub-scales of seeking meaning, relating ideas, use of evidence, interest in ideas. The sub-scales of the Surface approach are: lack of purpose, unrelated memorising, syllabus boundness, fear of failure. The strategic approach has five sub-scales: organised studying, time management, alertness to assessment demands, achieving, monitoring effectiveness.

The LASSI has been widely used, particularly in the United States since the 1990's and like the SPQ, been questioned by many, however, it is still regularly used and shown to have some valid constructs for study skills and academic performance (Dill et al. 2014; Cano (2006); Ning & Downing, (2010)). It is widely used for studies on academic difficulties and problem students suggesting it may not be relevant to the current study. Cano (2006) identified two constructs that were valid predictors of end-of-the-year grade point average: Affective Strategies and Goal Strategies, which consisted of the LASSI scales on Time Management, Motivation, Concentration, and Attitude; and Anxiety, Test Strategies, and Selecting Main Idea. These are fairly similar to some of the sub scales In the ASSIST method which are more longitudinal study skills compared to the SPQ, which can be revised more easily for a pre-post comparison. When the subject nature is as a revision tool in anatomical sciences, as discussed it is a subject built on surface knowledge and therefore the questions of the SPQ were adapted to reflect this. The SPQ was deemed more appropriate at a subject level because it was shorter and the questions more adaptable to a module or acute time frame period as opposed to a course or general study skills. The ASSIST questionnaire sub categorises surface learning into The SPQ is said to be more about what a student did in relation to a course text whereas the ASSIST measure is more about what the student does. In this study the focus was on the pre-assessment period only, not their general approach to studying and therefore the Biggs questionnaire was adapted using Scouller and Prosser (1994) and Biggs (2001) with additional mLearning questions added as described in section 4.1. Justici et al. (2008) evaluated the issues that had previously been highlighted concerning the use of the SPQ. The revised SPQ was deemed valid and appropriate if the 2 main scales were used, sub scales were shown to be less reliable. It did highlight that one potential issue was that the questionnaire assumes that there is only distinct deep and surface learning approaches. Deep and surface motive and strategy scores lack of reliability has been well documented but the revised SPQ as used in this study continues to be used in pedagogical research (Ellis et al. (2009); McLaughlin and Durrant (2016); Everaert et al. (2017)).

2.5 Mobile Learning (mLearning)

Shuler et al. (2013) and Traxler (2013) define mLearning as learning using mobile technologies such as mobile phones, smartphones, e-readers and tablets, and argues that these devices offer 'unparalleled access to communication and information'. Shuler et al. (2013) suggest that the increased affordability and functionality of mobile technology compared to traditional technologies means that they can support learning in new ways within the classroom and at home. Tossell et al. (2015) report that in 2013 there were as many mobile subscriptions as people in the world, identifying the potential reach and growth of mobile technology and therefore mLearning. Eagle (2005) suggested that mobile technologies have infiltrated developing countries at an equal if not faster rate than the developed world, once again suggesting that this potential reach is even bigger. Mobile devices are said to differ to portable devices by their common use, so a laptop, which is commonly shut down or closed between uses is portable (Reinders and Pegrum, 2016) whereas a smartphone can be continually used between points and is therefore mobile.

There are two distinctly different ways of engaging with mLearning, through a web based application or by downloading a single purpose software, named an app. Apps are suggested to provide a more streamlined approach but there is less freedom, control and collaboration for the user than using a web-based programme. This is a concern for many educators and can potentially limit autonomy of learning at the higher levels of HE (Quitney et al. 2012). This could impact on gameplay through apps where it could be more linear in nature than using a web-based game.

The advent and success of the Mass Online Open courses (MOOC), which rely on reaching a population beyond the environmental constraints of a classroom has increased both student and staff awareness of e and mLearning resources. The MOOCs aim to be accessed any time anywhere, a marketing concept that has been adopted by those using the term mLearning in other contexts (DeWaard et al. 2012). The MOOC can be delivered using any online platform and therefore is not always an mLearning application, but many use an app for delivery to increase accessibility and usability and social interaction within a course (De Waard et al. 2012). mLearning via social media is suggested to facilitate learner communities and self-regulation of learning via the provision of bite sized chunks (Welch & Bonnan-White, 2012). However, the MOOC and the smartphone have been suggested to be different and therefore the social and educational potential of the smartphone needs more research. There are also increased costs associated with smartphone learning use compared to the MOOC, which has been a concern for educators (Gupta and Koo, 2008). General consensus is that mLearning devices enhance, support and improve access to learning without traditional environmental constraints (Guy et al. 2010). Much of the research into tablet and mLearning education has been done in school-aged learners but the integration into HE has been less uniform, mirroring the inconsistent use by HE academics (Nguyen et al. 2014). This may be, in part due to HE being less constrained by a curriculum framework than in schools with more variation of teaching methods.

mLearning is purported to educate the learner to identify how and where they learn best hence potentially increasing the autonomy of the learner. Personalisation of learning is highlighted as an important factor in engagement, and mobile technologies claim to allow the student to contextualise and take ownership of their own learning (Clarke and Svanaes, 2014). They can also bridge the gap between formal and informal learning environments and transcend environmental limitations. Pegrum (2014) suggests that mLearning devices have three affordances towards learning, which need to be integrated into any framework for mLearning. Firstly, they describe the linking of local to global, then episodic to the extended and the personal to the social. These have to be considered within the pedagogical approach and methodology (chapter 3) to evaluate the use of mLearning and their relative contribution depending on subject, level and aim of the tool.

Smartphone and tablet devices have also been highlighted as being influential in improving the feedback process between staff and students allowing greater understanding of the wider learning process. Mobile applications such as Skype, audio playback, FaceTime and other social media and communication portals have been identified in the feedback process and therefore increase students' ability to achieve their potential (Cochrane, 2014). iPads were released by Apple in 2010 as the first tablet style device. Windows and android have since released alternative tablets but Gartner (2011) suggested that the iPad will remain the most commonly used (Gartner, 2011). The tablet device has forced communication and technological changes in business, entertainment and for education. The iPad has been adopted especially by the younger generation and professionals with surveys showing male under 35s initially dominated the market (Nielson, 2010) but gender no longer is a significant factor. Immersion in technology at a young age has been suggested by some to result in a future fundamental difference in the way people learn (Lai and Hong, 2015). This may not have as many implications for HE currently but in the near future the tablet generation will be graduating! More recently over one third of UK and US population owns a tablet with higher education increasing this figure to 56%. Demographics of ownership also vary by income, age and ethnicity but the data suggests that integrating iPads or tablets into HE is sensible (Zickhur, 2013). Since then, many education service providers have started exploring how to use iPads for teaching and learning in this ever-changing digital mLearning world. mLearning, as stated by Dorman (2007), is an ever-changing digital world where Higher Education can thrive or potentially be left behind.

The smartphone has the potential to be a link between the classroom and the student's independent study at home (Cochrane, 2010). It has been previously discussed in terms of social media, video feedback and note-taking apps but here I will focus on the smartphone educational apps specific to anatomy. Studies have found that smartphones are becoming habitual in everyday life with average internet use from a smartphone being 2.7 hours, overtaking the PC (Oulasverta et al. 2012). Habits were seen to be more frequent than logging on with laptops but for shorter periods of time and intermittent usage. Interaction with Facebook, news updates and emails were seen most frequently during idle time, commuting, lectures(!) and time at home. Killing time, awareness gains and entertainment were seen as the key motivators – which should possibly be used to encourage smartphone use in students for educational purposes. These studies would suggest that finding motivation for student learning via the smartphone could increase studying time and quality.

Woodcock et al. 2012 found that only 37% of students used subject specific apps compared to 56% for the internet. Student interviews revealed that negatives associated with the smartphone were screen size, battery life and limitations of app based programmes. It should be noted that the main use in their study was for word processing, reading articles and the internet and therefore these issues may not exist for products specifically designed for smartphone use. Payne et al. (2012) investigated smartphone app use in junior and student doctors in the UK. It was found that approximately 80% of student and clinical placement doctors used an app daily compared to 70% in junior doctors. 50% responded that they used apps for 1-20 minutes daily. Only 1.2% used it for more than 60 minutes. The apps used were predominantly for calculations and drug dosage reminders, utilising tools rather than knowledge acquisition. A study by Bice et al. (2016) looked at the use of an mLearning app, Essential Skeleton 4 (34D Medical, Dublin, Ireland) on a non-prescribed self-determined basis in an UG anatomy and physiology class. The study did not use a control group so developmental learning effect could not be eliminated but using the app did improve performance in examination scores but only for one of the two instructors. This begs the question as to whether it was the app itself, the teacher or the teacher's advocacy of app usage (Duffy and McDonald, 2008) that influenced this increase.

The iPad or tablet device has been found to help engagement and potentially enhance students' learning experience (Brand *et al*, 2011; Diemer, Fernandez & Streepey, 2012; Fontelo, Faustorilla, Gavino & Marcelo, 2012; Perez *et al*, 2011). The definition of engagement has been contested as to how it can be measured and is therefore sometimes not a reliable outcome and although students perceived them to be positive to learning they had no measurable effect on achievement of learning outcomes in final module results. (Perez *et al*, 2011). Other research of various designs agrees that iPads and tablets generally have a positive reaction from students, however cannot directly be linked to impact on their grades. Positive areas identified are deeper learning material resources from YouTube, Google Scholar and Blackboard (Alyahya & Gall, 2012; Fontelo *et al*, 2012). In addition, students often used iPads for information seeking (Alyahya & Gall, 2012; Geist, 2011; Wakefield & Smith, 2012) notetaking and presentations within classes. Photos and videos (Alyahya & Gall, 2012;Hahn & Bussell, 2012; Mang & Wardley, 2012; Sloan, 2012) were seen to be a positive and generally seen to increase efficiency in group work (Geist, 2011). A consistent finding across several studies was that the iPad could potentially be a distraction because of non-educative usage (Kinash *et al*, 2012; Robinson, 2012; Rossing *et al*, 2012; Wakefield & Smith, 2012) agreeing with many academics (Gong & Wallace, 2012). The scepticism seen by many academics in the research (Hargis et al, 2013; Link et al, 2012; Rossing et al, 2012) was most often because of its role as a potential distraction, however, this may highlight behavioural management and pedagogical limitations rather than a direct association with the tablet device. Link *et al* (2012) reported additional concerns including regarding percentage of tablet ownership and the need for a clear role and storage space of the iPad in classroom to avoid its distractibility. The proportion of academics utilising tablet devices in classes ranges from 20% (Yeung & Chung, 2011) to 37% (Lindsey, 2011) but many more reported using it for administrative tasks and meetings. Vu et al. (2014) investigated student-teacher use of the iPad in secondary aged classes finding that interactive time increased with one iPad for each group as opposed to one iPad for each student compounding the facilitation of group work. The least positive teacher comments from the qualitative data was from those who used the iPad as a teacher tool, one per class and therefore the level of active learning increase was not apparent.

The distinction between tablets and smartphones here could fade because many functions highlighted as positives can also be accessed and utilised on the smartphone and this may suggest that the full potential impact of the tablet in learning has not been fully explored in most academic environments. This suggests that m-learning should not be adopted independently from curriculum design and student engagement and those academics need to integrate iPads and tablets for mLearning and facilitate directed use rather than allow individual independent uptake (Brand *et al*, 2011; Bice et al. 2016). Bice et al. (2016) further suggests that educators need to be confident using and integrating technology into teaching and curricula and that it can improve teaching ability (Schacter, 2015). Nguyen et al. (2014) suggest that not only do the long term effects of the iPad and tablets need to be investigated further but also the pedagogical transformation they can have on teaching methods, curriculum and classroom dynamics.

Smartphone and tablet devices have also been highlighted as being influential in improving the feedback process between staff and students allowing greater understanding of the wider learning process. Mobile applications such as Skype, audio playback, FaceTime and other social media and communication portals have been identified in the feedback process and therefore in the students' increased ability to achieve their potential (Cochrane, 2014). Furthermore, mLearning allows students to access education in a flexible and seamless manner, at any time and any place, which substantially increases their access to learning. Moreover, m-learning offers the potential for significant innovation in the delivery of even more flexible education by allowing for the personalisation and customisation of the student learning experience (Johnson et al. 2011).

Mobile applications (apps) are critical in the provision and adoption of mLearning and can be used across devices, a necessity so as to not disadvantage certain platform users over others (Mang & Wardley, 2012). MobiThinking (2013) summarised various research findings stating that there were over 20,000 educational apps for all kinds of learners in the App Store (Apple Inc, 2012). Not surprisingly, there have been many attempts to explore how iPads could be used in the Higher Education sector around the world (Lindsey, 2011; Brand, et al. 2011) but mainly in constructionist classrooms as group based tools. There remains little known research into the independent use of tablet devices outside of the classroom but it remains an evolving area.

In a review by Nguyen et al. (2014) they suggest that not only do the long term effects of the iPad and tablets need to be investigated further but also the pedagogical transformation they can have on teaching methods, curriculum and classroom dynamics.

There are several studies in the relevant literature showing the increasingly important role of mLearning in HE. Chen and deNoyelles (2013), instructional designers at the University of Central Florida explore students' mLearning practices in HE finding, as expected that a significant proportion of students who owned mobile devices used them for learning purposes but found the tablet to be more popular than the smartphone. Their study, involving more than 1,000 students showed that mLearning occurs outside the classroom, and that there is typically limited guidance from instructors. A key conclusion identified the need to adopt effective learning and teaching practices integrating mLearning, which is in line with the aim of this study. An extensive review of 164 studies from 2003 to 2010 also identified that most mLearning studies focus on effectiveness, and that phones would likely be replaced by emerging mobile learning devices (e.g. tablets) (Wu et al, 2012). This is in line with earlier studies demonstrating mLearning trends up to 2008, focusing on frequency of topic over time. According to Hung and Zhang (2012), the most popular topics in mLearning included effectiveness, evaluation and personalised systems.

Tossell et al. (2015) studied a naturalistic cohort of 24 students who had never owned a tablet or smartphone for a semester at University. The most commonly accessed applications were games (Angry Birds, words with friends) at 48%, YouTube (8%) and the Utilities (torch, calculator) (6%). Only 3% used an educational application, however, they were not informed of educational potential or given apps to use. They were primarily used as an iPod, for text messaging, Facebook and email agreeing with other studies of this nature. Although the games were not educational, they were small, easy to use, repetitive and cheap apps suggesting that if an educational game could infiltrate this area of usage the potential for learning could be extensive.

Understanding the trends of mLearning is not sufficient for adapting gamification practices for mobile learning devices. It is essential to understand that the focus of research should also cover pedagogic aspects of the way learning is delivered in mobile settings and across telecommunications gadgets used by learners of all ages. According to Schuck et al. (2010) their work with a community of learners and their experiences with mLearning led to the term ‘mobagogy’. The project that was referred to as the Mobagogy Community of Learners was based on interventions including regular meetings, immersion through participation in mobile learning projects, interviews with experts is the mobile learning field, and individual plans of actions and reflection.

2.6 Games for Learning

Games and quizzes and some principles of gamification have been used in education for many years, primarily in school-aged pedagogical environments (Kirriemuir & McFarlane, 2004; Beavis et al. 2014) but there remains a paucity of literature on how the learning process occurs or is facilitated through games. Most of this classroom-based research relies on the evaluation of interventions that either focus on the representational dimension of the game (Ballon and Silver 2004; da Rosa et al. 2006), or on the practice of using games for motivation through the integration of play and factual knowledge (Eckert et al. 2004; O'Leary et al. 2005; Gareau and Guo 2009).

Serious games have been used for education in various formats (non-digital games, digital games, gamification, live action role play games based on pervasive technologies, etc.) and ways (commercial off-the-shelf games and bespoke custom-made games), and based on different philosophies of education (instructionist and constructionist philosophies) (Erenli, 2013). Learning can happen more effectively when people are active in making or doing things, termed active learning (Petty, 1998). The bulk of the current research uses deeper learning problem-based games and is not specific to the topic of anatomy but accepts that games are classified as being outcome or achievement focussed (Coller and Scott, 2009), which could relate games to assessments in nature. The recent advances in gaming and mobile technologies puts forward interesting opportunities to expand upon these approaches to learning by bringing the lessons learnt from playing and developing games into the classroom.

Su and Cheng, (2015) define the terms game based learning as the game being the primary focus, learning in secondary whereas with game informed learning being primarily focussed on learning, the game is merely a tool for the job but both can sit within a play framework (Wu et al. 2011). I will concentrate on game informed learning because I am looking at mLearning quiz-games as a medium of learning rather than the game being the subject of learning. Gamification is a relatively modern concept which combines elements of digital games for non-game or play applications (Robson et al. 2015). It has been suggested for use in social environments including education, sustainable behaviours and exercise with many studies now documenting its efficacy (Girard et al. 2013). It has also been adopted successfully in businesses where a layer of gamification has added to both user and employee productivity, for example for energy companies using social media to compete for savings (OPower, 2017) or staff rewards (Gartner, 2015). Hamari et al. (2014) suggests that gamification can be a means of supporting user engagement, enhancing user activity, social interaction and productivity. They also show the increase in the prevalence of academic searches and publishing in the field from 2010 to 2013. Gamification has many principles that could be applied to different environments depending on how it is utilised. The principles of gamification that have been selected for discussion and use in this study are taken from the MDE (mechanics, dynamics, emotions) framework suggested by Robson et al. (2012). The mechanics or rules and progression and how "players" interact with opponents so for learning games this equates to how the educator implements these aspects to learning. The dynamics are dependent on the mechanics but describe how players interact with each other and the rules and can therefore differ significantly between individuals and different cohorts. The emotions describe the affect participation in gameplay has on the players, which can be related to student engagement, learner psychology and attitudes towards subjects or different classes.

Kapp (2012) identifies several important elements of gamification, such as a story or plot, game play, characters, competition, rewards, increasing levels of complexity, challenges, and individualised feedback. Sung et al. (2015) simplify this to feedback, curiosity or adventure and achievements. Games provide clear objectives, an important factor in the learning experience and a consistently reported area of improvement needed in student feedback (Nicol, 2010). In games, these objectives are further divided into achievable short term goals or levels to provide clear progression routes of achievement and intermediate feedback at the end of each level. Frequent rewards (for example, by completing a level or going up the leader board) are said to improve engagement or intrinsic motivation (Hamari et al. (2014) but can also drive their internal curiosity and reflection skills to improve at the next attempt (De-Marco et al. 2014). Gamification in education is primarily associated with badges, stickers or an equivalent to illustrate levels of achievement, points systems, leader boards and progress bars (Hamari et al. 2014). Researchers have also highlighted the potential benefits of games to reframe failure into an integral part of the learning process where repetition or further play can overcome failure to progress to the next level or progress (Lee and Hammer, 2011). Busch et al. (2015) describe this as a potentially vicious cycle of failure, reduction in self-efficacy and avoidance strategies and therefore fostering success is suggested to be the primary way to break this cycle. This could be applicable to student retention where failure of one component can lead struggling students to detach themselves from the course and end up withdrawing from education. This could also mean that unless classroom success is bred, self-efficacy will still be reduced, which would impact independent learning. Gameplay in class could therefore help provide moments of success and engagement, which could continue the cycle into independent learning outside the classroom. Games for learning encompass many forms including digital games, app based games, quizzes, video games, board games and physical games but all will fall under the umbrella term "serious games" if they have a primary learning element.

There are a number of games that have been labelled "serious games" suggesting a learning aim. These include console based, exploratory or problem based, outcome focused using technology, board games or quizzes and active learning traditional games (Connolly et al. 2012). Pedagogical level is often negatively associated with the type and frequency that games or play are used in learning explaining the paucity of research and possibly their use in HE.

It is important to note that gamification alone is unlikely to lead to a wholly, successful mobile learning experience but could help to trigger learners' motivation, and ensure commitment and engagement throughout the learning process (Dominguez et al. 2013). The work of Malone and Lepper (1987) focused on those factors affecting motivation towards learning in school settings. The taxonomy of intrinsic motivation identified a number of individual intrinsic motivators (i.e. challenge, curiosity, control and fantasy) and interpersonal motivators (i.e. cooperation, competition and recognition). It is critical to ensure that gamification elements are combined in a way that learners' motivation remains high throughout the learning process. McGonigal (2011), in her "gaming can make a better world" talk at TED2010, provided some good reasons for using gaming in HE, including the urgency for discipline-specific problem solving, social engagement through interaction and group work, a sense of productivity by achieving attainable goals and the ability to learn by doing that satisfies kinaesthetic learning needs.

Clark and Garza (2012) suggest that conceptually embedded games are forms of game based learning, where the game is the primary focus but the content will allow learning but it is not formally associated with learning outcomes. Conceptually integrated or game informed learning opportunities are suggested to allow a deeper, systemic learning to unfold if facilitated by a teacher or module guidelines. This is an interesting concept in the literature, suggesting that the former allows rote learning to occur whereas the latter allows more implicit learning that has been likened to the flipped classroom (Tucker, 2012). The value of the app or game used and its specificity to the subject will affect which type of game the chosen system fits into. For learning, which requires large volumes of memorisation or basic knowledge building blocks, conceptually embedded games could well be seen as game informed learning, particularly at level four. Games have therefore been suggested at school level for an alternative for at-home tutoring or as an additional learning tool where both types discussed above have potential learning benefits.

Successful games on all platforms have been shown to keep the elements of a psychological concept of "flow" or the theory of flow experiences (Csikzentmihalyi, 1990) stimulated. The two main elements of flow are challenge and skills, which are shown to somewhat predict engagement and immersion within a game, which is further related to perceiving learning effect. The integration of work and play has been linked on a psychological and behavioural level to flow resulting in increased concentration and elevated enjoyment levels (Shernoff et al. 2013). Studies have positively related flow to gameplay (Hamari et al. 2014; Procci et al. 2012) and then to learning outcomes (Chang et al. 2012; Liu et al. 2011). A lack of academic challenge is often associated with disengagement (Shernoff, 2010) and if students do not perceive challenge it is unlikely their perceived skill or knowledge will improve (Hamari et al. 2016). Competency is associated with motivation via the flow theory which can impact on student performance and achievement and feed into the failure cycle (Busch et al. 2015) described earlier in this section. Hamari et al. (2016) looked at flow on engagement and immersion in a physics game in secondary aged students. They found that engagement and perceived challenge positively affected learning but skill level did not, suggesting that as long as students remain intrinsically motivated to play the game the learning effect will remain. Therefore maintaining the challenge and rewards within a game is an important factor in choice or recommendation of games for learning.

Repeated shorter study sessions have been shown to be beneficial compared to singular, longer sessions for knowledge retention (Dempster, 1989). Formative testing is purported to aid long term knowledge or memory retention by the act of retrieval of information during the test strengthens students' memory for this information when compared to repeated reading of notes (Roediger and Karpicke, 2006). Formative testing also can encourage more frequent studying to be performed throughout a course rather which can help reflection and identification of areas of weakness allowing time for the student to seek help or address knowledge gaps (Roediger and Butler, 2011). Lameris et al. (2015) introduced a formative testing smartphone app (Physiomics, to the next level) to a four week course. The app invited students to participate in seven formative tests during this time once every four or five days depending on each mini module. Out of the 439 students who volunteered to be part of the study, 72% used the app. Those who used the app intensively had a greater increase in study time compared to non-users and gained higher marks on the end of module assessment. Only 59%, however, wanted the app to be integrated further in the future but no reasons were ascertained for this. This is difficult to understand if the students were aware of their improved test scores. If not, they obviously did not perceive the app to be the primary reason for this, otherwise more student would be expected to welcome its future use. This could also be explained by students' general dislike for regular testing and additional work.

In a study from Perera et al. (2009) it was found that a mobile quiz with single player and multiplayer mode, allowing peer feedback and interaction increased student enthusiasm for the subject. It should be noted, however, that any novel intervention or teaching method can increase temporary motivation because of the novelty value. A longitudinal and adherence study would eliminate the Hawthorne effect. (Fraij and Al-Dmour, 2013) Similar findings have been shown when quiz-based feedback voting devices are used, mainly in the classroom, but they have the potential to be used for independent study (Caldwell, 2007). A recent study by Wang et al. (2015) looked at the possible wear out effect of using a student response system in class over five months. Following the initial use there was an increase in student engagement and behaviour but after using it for five months, engagement remained elevated but a decrease in classroom behaviour was witnessed. This suggested that the system was still a good learning tool, however, the novelty effect had worn off thus affecting the classroom dynamics further reinforcing the requirement for technology to be integrated into high quality teaching not take its place.

Anatomical simulations, models and audio-visual aids are commonly used as pedagogical tools in anatomy (Mackenzie et al. 2003; Miller et al. 2002). There is a general consensus within the anatomical teaching fraternity that fundamental knowledge is required to enhance clinical or performance applications. The traditional memorisation method of learning anatomy has been suggested by some to be redundant. Exploratory learning, through clinical or laboratory based scenarios is purported to increase understanding by memorisation occurring as of course during active, exploratory learning (Perotti, 2002). There are a number of anatomy games and quizzes available on iTunes or android platforms suggesting a market demand but there remains a paucity of research of their efficacy in learning.

Games have been investigated by various researchers in the medical field with varied success, however, the aim and age of students varies significantly making comparable conclusions difficult. Coyne et al. (2003) investigated the use of computer games in learning demonstrating that “mindless repetition” using computer games does positively impact on knowledge acquisition and understanding. There has been a volume of research on the efficacy of board games in teaching anatomy agreeing that in general they can help group dynamics, achievement, active participation and motivation to learn; making learning fun is a common theme (Fukuchi et al. 2000; Moy el al., 2000; Steinmen and Bladtos, 2002; Ballon and Silver, 2004; Eckert et al. 2004; da Rosa et al. 2006; Breylefeld and Struwig, 2007; Reece and Wells, 2007; Teyner et al. 2010). Sung et al. (2015) investigated a health education contextual mLearning game compared to more traditional eLearning methods. It was found that motivation towards learning and achievement increased using game play but the study was only conducted over one week without any crossover design suggesting a potential novelty or Hawthorne effect.

Huizenga et al. (2009) developed a mobile game based learning activity for secondary education which aimed to provide a situational, active learning environment based around the idea of making learning fun. It was shown to have the potential to increase engagement and enhance motivation to learning. The notion that a mobile device can create more opportunities for active learning is suggested to explain the increase in engagement and course retention (Joosten, 2010) agreeing with Petty, (1998).

Games using technology have been studied less in depth but both Akl et al. (2008) and Bregg (2008) found learning using computer based games was comparable to a normal lecture. If games, through the visual stimuli and repetition can enhance memorisation of the fundamental facts, this may allow more classroom time for the application and therefore understanding of the subject (Ricci et al. 1996). Digital natives will have a different learning style that includes more multitasking and technology driven processes that currently may affect the learning within a classroom due to different past experiences and ages (Prensky, 2001). Students born after 1993 are said to be part of “generation next” accounting for most of the UK HE population. Labelling students in this way could be problematic and assumptions that all students of this age will have a homogeneous technology background is very misleading and in practice, contestable (Bennett and Maton, 2010). Rondon et al. (2013) investigated how a PC based simulator game compared to a traditional lecture for knowledge retention. It was, however the quiz function on the PC game used as the intervention and only as a group in-class tool. The study also looked at pre-post scores and 6 month post assessment score but no apparent control or factor recognition occurred in the 6 month post assessment period. No detail was provided on assessment type or differentiation of cognitive type. Computer Assisted Learning (CAL) games can be seen to be similar to mLearning games but the context of the learner and accessibility are distinctively different. Agarwal et al. (2012) that found quizzed material in middle school students resulted in greater achievement and longer term retrieval although compared to the UK, the US education system is more test driven, which could skew the results. Students could think that non-quizzed material was less important and therefore retention is lower due to less motivation to acquire the fundamental knowledge.

Competition Based Learning (CBL) and social comparisons are key elements of gameplay and often adopted by educators as an engagement tool (Cheng et al. 2009). CBL is said to be the knowledge acquisition within a competitive setting (Burguillo, 2010). In game based learning, CAL allows learning to occur no matter of the outcome of competition whereas CBL is based around the result primarily. Social comparison is commonplace in the learning environment whether it be facilitated by the students or educators and has been shown to have positives and negatives, which can effect behaviour and judgements (Corcoran et al. 2011). Student validation of learning and performance by social comparison can help identify weaknesses but also motivate students towards academic improvement but for some it can form part of the failure cycle and therefore have a further negative effect. Van Nuland et al. (2014) investigated students who participated in an online anatomy tournament versus non-competitive peers on a level 5 undergraduate programme. The online tournament was based around MCQ’s and matching questions and was scored according to speed of response and answer. Competitively active students achieved greater test scores and course scores than their non-competitive peers but this could be due to the repeated testing effect rather than the competition or social comparison effect. Participation in the tournaments did result in an increased positive reaction to academic competition, which again could have many reasons for it. It does suggest that engaging students in outcome focussed activities can improve academic performance and possibly engagement with the subject. Janssen et al. (2015) also investigated a team based digital game for anatomy learning where no achievement scores were measured. Student perception showed a positive effect on engagement; they enjoyed the challenge and appreciated the feedback and self-reflection of strengths and weaknesses of their knowledge base.

Video gaming has long been associated with being a male-dominated area including market audience, player base, and character representation in games. Some studies focused on games solely for console platforms (PlayStation, Xbox, etc.) (Miller & Summers, 2007; Burgess et al. 2007; Jansz & Martis, 2007), whilst others included both console and PC games (Williams et. al. 2009; Ivory, 2006) both of which revealed gender differences. Statistics differ by type of game with females being less represented in fighting, sports and racing games compared to story based games which is more equally distributed (Jansz and Martis, 2007). Females are still perceived to be the minority in the gaming industry (Shen et al. 2016) which has in part been shown to be due to competition, self-identification, and motivation, social and time reasons. Males have been shown to thrive more on competition (Cassell & Jenkins, 1998) compared to females who prefer cooperation. The type of game preference is also gender specific with females steering away from violent or lone-player gaming (Shen, 2014). Although video gameplay is very different to the gamification of education there will be elements of transfer; this highlights the importance of gender consideration. In veterinary students gaming ability has been associated with career choice and gender, with more females wanting to specialise in general medicine with lower video skill levels whereas males were more likely to pursue surgery with higher gaming scores (Bragg et al. 2016). Kim and Shute (2015) investigated game based assessment (GBA) for physics UG students comparing a linear (sequential, level based) and nonlinear (choose their own path, more variation) game. There was no learning difference between the two games but there was a gender divide, showing females were less engaged with the games than males and gained lower scores on both types of GBA. These studies would suggest that gameplay is more highly perceived by male students who also perform better in gamification of assessment. However, as a learning tool skill level has been shown to be less important than challenge in the flow model and therefore as long as challenge is maintained the gender difference may be irrelevant.

It is necessary to reflect on the way mLearning applications are used in specific settings. User acceptance of mobile technology is an important factor affecting the success of mLearning solutions in HE. mLearning may be part of current learning experiences in HE but the full extent of its use is not always fully understood or adequately assessed. This doctorate attempts to provide some insights into how mobile learning is applied, used and experienced by learners. There are some common themes between this study and other work available on the use of technology acceptance models for evaluating and predicting use of mLearning applications (Chen et al, 2013).

The review of the literature has highlighted key aspects of mLearning, gamification and engagement relevant to the current studies. Although the areas of learning games or game based learning and mLearning have been investigated separately there is little known research looking at the potential combination, particularly in HE. Much of the research has been carried out on school-aged children, which may not translate to the independence and structure within Higher Education. Anatomy is a STEM type subject which requires a large volume of learning that builds in a step by step manner to master the subject. The anatomical sciences are therefore different to many subjects where topics can be taught in a distinct fashion and so any learning problems or disengagement had much more of an effect on student future success. It is therefore imperative that teaching and learning strategies employed in HE reflect the distinctive features of the subject and that relevant elements of mLearning and gamification are integrated into them effectively.

The literature review has helped drive the methodology described in the next section by informing current knowledge of all of the relevant areas and directing the focus of the research and methods. For example, the literature discussed on game informed gaming and gamification was used to select appropriate gameplay, timing, dynamics and mechanics within the experiment to ensure gamification of learning took place. Further methodological discussion of the literature is completed in chapter 3 and in each of the study chapters where those topics are used including engagement and achievement measurement.

3.0 Project Design & Overall Methodology

The project contains three studies that are combined in three action research cycles (Figure 1, Section 1.3) where each of the specific studies has a different method but the core ontology is maintained throughout. The action research is underpinned by an empirical approach with additional qualitative data collected to try and gain further pedagogical insight into the topics and increase generalisability, all of which are discussed.

In this chapter the methodological approaches will be reviewed that have contributed to the project design. The literature review has shown that there is a lack of consistency and varying quality in much of the pedagogical research particularly in HE where engagement is an outcome measure. The current studies will be discussed alongside the relevant literature found to ensure generalisability and increased academic rigour.

The cycle of epistemology (knowledge), ontology (reality) and methodology needs to be integrated into any project design to ensure that an appropriate method is chosen, which reflects the nature of the research, subjects and wider social context (Randler and Bognor, 2008). The paradigm reflecting the researcher's individual world view will impact on the method and therefore wider epistemological application. Educational or pedagogical research represents its own set of tacit ideologies and inconsistencies, which present ontological and methodological challenges for the researcher (St Pierre, 2006). The ontological direction to take in the current study is discussed relative to previous pedagogical research detailed throughout.

Positivism is traditionally associated with experimental empirical approaches using a pure quantitative research approach, which assumes an objective perspective on everything in the natural world (Johnson and Onwuegbuzie, 2014). Interpretivism is an ontological perspective based on a subjective reality where the wider social constructs of history and culture can make the situation more multifaceted than from a positivist perspective. The belief that the individual is important means that a more subjective, qualitative approach guides research methodologies but this then limits the application or generalisability of epistemology gained by a population (Guba & Lincoln, 1989; Lincoln & Guba, 2000; Schwandt, 2000; Smith, 1983, 1984; Johnson and Onwuegbuzie, 2004).

In a classroom environment at any level of education, a purely objective, positivist approach can sometimes not reveal the true epistemological value of research (Palek and Walls, 2009). Teachers' beliefs guide the decisions teachers make and actions they take in the classroom

(Cuban, 2002; Fullan, 2001; Fullan, 2003; Guskey, 2002; Ringstaff & Kelley, 2002; Sandholtz, Ringstaff, & Dwyer, 1997). Any inquiry into teachers' practices should involve a concurrent investigation into teachers' educational beliefs, as beliefs profoundly influence teacher perceptions and judgments, which in turn influence their classroom behaviour (Pajares, 1992). This is commonly seen in behavioural observation studies but difficult to address where there is an insider researcher directing the research within the HE institutional scaffolding.

Education is, by its nature, informed by culture and history and therefore leans towards the interpretivist viewpoint (Carter and Little, 2007). "Many contemporary problems or crises in education are, in themselves, the surface manifestations of deeper historical, structural and ideological contradictions in education policy" (Grace, 1995). However, using critical theory this can address the structured contradictions by removing tacit ideological biases. In the classroom this suggests action research can be performed using a social constructivist approach to study the student group reaction to a problem or change initiated by the teachers. This involves examining the intervention or situation through the eyes of the student cohort rather than those of the researcher in as close to the natural state as possible, the naturalistic approach (Hoyo, 2006). The proposed project will be a real life assessment and classroom situation of students where all observations are from the researchers' perspective but they may be influenced by the intervention itself.

The normative and the interpretive approach can be argued to influence student reaction to a situation but a more normative view allows a wider social context to the resultant epistemology. I as the researcher represent some bias compared to other ontological approaches, which through postmodernist approaches can embrace a more pragmatist approach to research methodology and therefore method. The pragmatist approach allows more freedom than other ontological perspectives in terms of world view and makes me lean towards a more mixed method approach to reflect the complexity of pedagogical research from an insider's perspective (Franco, 2005). Although a randomised controlled trial (RCT) would be methodologically more standardised than a method integrated into the timetable, it is not naturalistic and requires additional student participation. Some studies use the incentive of extra credit to participate in pedagogical studies; however, this in itself could bias students and is difficult in the UK HE framework. It would also mean that students will not experience the same physiological and psychological factors that real life assessment situations initiate (Huxham et al. 2012).

Technology within education presents another challenge to the methodological design process. The smartphone itself can be seen to be a toy and the classroom, the playground (Swertz et al. 2010) where the game players are both staff and students who play (or teach and learn) respectively. Swertz suggests that technology is, by nature, objective and consistent but in a pedagogical environment it becomes artistic and changeable due to the inconsistencies with student interaction and facilitation by staff. Wang et al. (2015) investigated using a clicker response system over time where the system is repeatable, consistent and reliable, however they looked at student interaction during a lecture over a five month period resulting in a more naturalistic evaluation. Student interaction could vary depending on the classroom dynamics and timing and utilisation of the system in reaction to this. (The curriculum and assessment present an objective scaffolding where the student cohort and facilitator or teacher build a more subjective, complex reality, informed by the history of learning, experience and belief (St Pierre, 2006). Adding technology to the ontological mix informing my methodology again leads me towards a mixed methods approach to the research process and method design (Johnson et al. 2009).

Based on the analysis of the ontological approaches, sampling strategies, and multiple variables a mixed methods approach has been chosen to minimize errors that may arise from a single technique or research approach and maximize the meaning and validity of the results (Patton, 2002; Tashakkori & Teddlie, 2003). Using assessment measures and validated questionnaires for the quantitative data alongside focus groups, observations and interviews qualitatively, the approach merges positivism and normative/naturalistic epistemologies. Leger et al. (2013) used a similar approach to measure a course redesign choosing the questionnaires used in this thesis (NSSE, SPQ) alongside focus groups and an online survey. This should increase both population and ecological generalisability, discussed later in this chapter (3.5). The mixed methods approach combines elements of Action Research and Experimental (Scientific) research. The next section explores both methodologies with particular reference to ethics and generalisability; two key aspects limiting the quality of existing pedagogical research.

3.1 Action Research

Mills, (2003) defined action research (AR) in education as any systematic inquiry conducted by teachers, or others with a vested interest in the teaching and learning process, for the purpose of gathering data and improving current individual, institutional or wider practice. Expanding on this concept, Suter, (2006) outlined the potential contributions of action research by teachers and defined them as reflective practitioners who have the potential to make exemplary contributions to the advancement of teaching and learning. This project will be an example of action research due to the pedagogical nature of the studies in terms of the naturalistic approach over two academic years. There will be a dynamic evolution of the studies due to ethics and maintaining the student learning quality and curriculum whilst working with multiple cohorts and staff or institutional changes.

Although not necessarily overtly emancipatory, it could be argued that pedagogic research utilising AR to improve teaching practices has led to more wide-ranging improvements in learning and teaching within higher education. AR findings have advanced pedagogical practice via innovation in assessment (Ward and Padgett 2012; Bisman, 2011; Hume, 2009; Simms, 2013), curriculum design (Walton, 2011) and teaching (Bar Shalom & Schechet,2008; Abell, 2005; Abraham, 2014; Wrench et al. 2013; Zambo et al.2012; Tormey, Liddy & Maguire 200)). There has been much discussion of innovative teaching practice with the emergence of mLearning and online systems. Virtual worlds have been introduced as learning environments as a means to introduce participants to opportunities not possible within real world settings (Matthews et al, 2011). Strategies have been formalised following research into postgraduate students' reflections on self-efficacy in the use of Social Media tools to enhance learning (Machin-Mastromatteo, 2012). Overall, however, AR has primarily remained embedded in assessing the impact of curriculum changes and based around specific localised case studies. These types of studies generally have limited generalisability and lack a repeatable scientific method so have limited potential impact on wider educational contexts.

In studies by Abell (2005), Walton (2010), (Zambo) 2011 and Ward and Padgett (2012) changes to curricula were made and analysed using small-scale AR but lacked the generalisability that is needed to impact further afield. One intervention focussing on the provision of learning support utilising online technology and multimedia has the potential for replicability across a range of disciplines and toward a variety of diverse applications (Brudermann, 2010). Another project targets the development of undergraduate critical thinking skills through the development and deployment of a bespoke strategy tool that could lend itself to wider use (Eales-Reynolds et al, 2012). The growing imperative to utilise technology to support learning has led to research into a strategy for the integration of tools, content and pedagogy entitled TPACK (Stover and Veres (2013). TPACK evolved from the recognition of the need for a guiding theory of e-Learning drawn from principles of experiential learning has led to the construction of a multi-use and cross-disciplinary pedagogical tool in one project (Beard et al. (2007)) to help improve validity and quality. TPACK has been evaluated with respect to the current studies where mLearning approaches have been integrated into both the curricula previously and as a learning and engagement tool. Trends to increase the quality emerging from the research reviewed are maximising sample size, use of repeated cohorts and triangulation of data, which have been integrated into all three of the current studies. Elements of the TPACK method to evaluate technology in a pedagogical setting have been integrated into teaching methods but not adopted fully due to limitations of the transfer to HE and aims of the current studies.

Much of the AR in the current literature is, however, performed over one cohort by insider researchers (Adler, 2010; Cornellison and Van der Berg, 2013; Zambo, 2012; Kur et al 2008) seeking to inform their own personal practice or assess a pedagogical modification. In many instances the research process is neither transparent nor explicit and therefore it is difficult to compare and attempt to generalise the findings. Bisman (2011), however, looked at the modification of an assessment from multiple submissions to one longitudinal learning journal over a five year timeframe. The thematic analysis of the data used percentage of pages and deep vs surface analysis. This data was scrutinised by numerous markers and the conclusions drawn were more generalisable, resulting in a framework for integrating a learning journal assessment to enhance learning strategy. Greater detail of the methodology and epistemological matrix, as in Bisman's work, (2011) would enable scrutiny of validity and rigour of the process, which may result in an improvement and greater generalisability of AR studies in a broader arena. Insider research and the ethical issues raised have been considered in the current studies. Some studies attempt to counteract the insider nature of AR by using research assistants to observe, perform interviews and run focus groups but the very nature of small scale AR projects to improve practise means that this is often impractical due to staff availability, cost and institutional support (Simms, 2013). Insider researcher issues have been minimised here by using anonymous online focus groups, graduate assistant invigilators and a strong crossover design in *Study Three* and repeated academic cohorts for *Study One*. A particular future focus emerging from the literature in utilising AR was for me to explicitly address ethical challenges, which have been overlooked in much of the literature to date (Brydon–Miller, Greenwood and Eikeland, 2006). Walton (2010) addresses institutional level ethics and Halai (2011) reflects on the ethical differences of researchers and insider practitioners inherent in AR in their meta-syntheses of work on AR dissertations. Again, the general lack of ethical consideration evident in AR publications could be seen to widen the research gap between traditional and AR further. AR is often used in projects connected to personal practice and so raises ethical issues in relation to insider-researchers. Within higher education, action researchers also need to be aware of the dual set of responsibilities held. Teachers and researchers have professional 'fiduciary responsibilities' (to act in the interest of the student)(Pecorino, Kincaid and Gironda, 2008) towards students; the researcher's actions are intended to be undertaken for the benefit of student learning alongside the underpinning responsibility of a researcher to do no harm. The more explicit integration of ethical issues in planning AR projects and the subsequent accounts would strengthen the quality of subsequent research and enhance claims to trustworthiness. This has been attempted in this doctoral research.

The AR in the bulk of the literature centres primarily on describing the reflective process rather than offering a detailed critical evaluation of the intervention or innovation and methodology. Such accounts rely heavily on personal teacher and student reflection; although this is an integral part of the AR process a more mixed methods approach could widen the impact and scrutiny of the research. When a study focuses on a staff member's reflection it becomes very dependent on their own social values, experience and beliefs (Adler, 2010; Van Donche, 2004). Therefore, from this perspective, the more positivist outlook in the current study emerges in this domain looking primarily at the scientific notion of an educational intervention evaluation rather than any form of educator reflection.

There is an increasing trend to investigate AR at an institutional level that blurs the lines between traditional scholarship, research and administrative and organisational roles (Levin and Martin, 2007; Donche and Petergem, 2004; Hubball & Burt, 2006; Sankaren et al. (2007); Lucas 2007; Kur et al. 2008; Avdjieva 2005 and Paulsen 2007). Much of this reflection is based on the Schon (1995) and Boyer (1990) contention that a new epistemology of practice in the form of action research would be required to realise Boyer's (1990) vision for a new paradigm of scholarship, which includes research, teaching, application and integration (Walton, 2010). The institutional boundaries between teaching and research are considerably blurred through AR but it requires the support from within the establishment to enhance this interconnectivity that may be even more of a priority due to the impending threat of the Teaching Excellence Framework (TEF). Tormey et al. (2008) brought together AR pedagogic case studies to look at the role of AR in narrowing this gap and agreed with Walton, (2010) Hubball & Burt, (2006), and Sankaren et al. (2007), concluding that barriers between the two mind-sets need to be reduced at an institutional level. The symbiosis of increasing AR quality and the number of prestigious journal publications accepting AR as an established and credible research method may then be more easily realised. Studies have been presented at international conferences and published in educational journals. However, a major point of contention on feedback from subject specific journals submitted to was the action research element to the approach, which seemed to be misunderstood even at the reviewer level. This will have to be considered when evaluating potential publishing mediums looking for high impact journals with a precedent for publishing pedagogical action research.

3.2 Experimental Research

The traditional scientific approach to research in the natural sciences uses the experimental, empirical method. Empirical research is based on observed and measured phenomena where the epistemology derives from actual experience rather than from theory or belief. The facts that arise from the research are said to be repeatable over time and not specific to a population or place. One form of empirical research is the experimental or scientific approach, which is a systematic and scientific approach to research, in which the researcher manipulates one or more variables, and controls and measures any change in other variables. The experimental approach is often suggested to be “true” research that can include both quantitative and qualitative measures but more traditionally takes the quantitative form. The physical and natural sciences have long used the experimental, scientific approach to define laws and trends and has been adopted in behavioural educational psychology research more recently; out of this the mixed methods approach has become more accepted as part of this “true” form of research.

According to many educational psychologists, the most influential text advocating the adoption of the experimental approach in education is considered to be Thorndike and Woodworth (Cronbach, 1957 in Davis, 2008). They suggest the experimenter’s interest in treatments, also referred to as an effect of environmental change used standardised procedures to hold all conditions constant except the independent (experimental) variable. This standardisation ensured high internal validity in comparing the experimental group to the control group on the dependent or outcome variable. That is, when internal validity was high, differences between groups could be confidently attributed to the treatment, thus ruling out rival hypotheses attributing effects to extraneous factors, the cause and effect model. Traditionally, experimenters have put less emphasis on external validity and hence the generalisability of findings to practice and environmental transfer. Educational technology has been plagued by inconsistent methodologies and poor research questions but in educational psychology it has emerged as an area for scientific, experimental research in more recent years (Ross et al. 2005).

Within the "true" experimental approach the gold standard of design is the randomised controlled trial using a repeated measures approach. This would involve an experimental and control group of equal numbers, randomly allocated, and as many variables as possible controlled for standardisation. In education, the pedagogical limitations present a more quasi-experimental approach where groups or classes are not randomly assigned and where pre-test or baseline measures are taken to compare within groups. Randomly assigned groups are unlikely to be significantly different (between control and experimental) but classes may have ability, gender or prior experience differences due to course choice for example. This approach has been used successfully in pedagogical research, usually in a naturalistic ontological approach such as in Ross, Smith, & Morrison, (1991). In this study, to minimise the quasi-experimental effects of using real classes, all studies used a pre-post test that did not present bias as it was part of the normal testing procedure for the module. In *Study Two* a time-series effect impinged on the generalisability but this study was repeated using a randomised repeated measures design in *Study Three*. This was done to minimise internal errors allowing the design to maximise the experimental aspects and minimise quasi-factors. The quest for high internal validity has led researchers to design experiments in which treatment manipulations can be tightly controlled. In the process, the use of naturalistic conditions (e.g., real classrooms) has been discouraged, given the many extraneous sources of variance that are likely to operate in those contexts. Where the intervention or subject is technology the application to a real life, naturalistic classroom or student population outweighs the potential reduction in internal validity. Therefore a combination of action research and the experimental approach has been used in the current studies to maximise both generalisability and potential impact further suggesting the mixed methods approach. By combining action research with the experimental approach in a controlled, repeatable study I hope to buck the trend of low impact, low quality pedagogical research.

3.3 Data analysis

There are two types of data, quantitative and qualitative requiring analysis by two types of statistics, descriptive and interferential (Cresswell 1999). Quantitative research is defined as research that employs empirical methods and empirical statements . An empirical statement is defined as a descriptive statement about "what is?" rather than "what ought?" to be the case. Typically, empirical statements are expressed in numerical terms, Moreover, Creswell (1994) formulated the definition of quantitative research as a type of research that is `explaining phenomena by collecting numerical data that are analysed using mathematically based methods (in particular statistics).' Qualitative research gathers information that is not in numerical form. For example, focus groups, open-ended questionnaires, unstructured interviews and unstructured observations. Qualitative data is typically descriptive data and as such is harder to analyse using statistics than quantitative data. The questionnaires used in this experiment are quantitative but demographic and open ended questions included result in qualitative data as do the online focus groups and interviews.

Descriptive statistics are primarily used to organise and summarise a particular set of quantitative data (Lind, Mason and Marchal 2002) making no inference or predictions but they will be used to portray a summary of the experimental results. Both univariate (descriptive) and bivariate (causational) descriptive statistical procedures will be used to analyse the quantitative data in this study. Univariate, cross-tabulation and frequency counts will be used to analyse the questionnaire demographic information and the students' responses to separate items on each survey subscales (Tashakkori and Teddlie 1998). Johnson and Christensen (2012)state that inferential statistics seek to explore beyond the immediate data using the laws of probability to make inferences and draw statistical conclusions about populations based on sample data, testing the hypothesis (Cresswell, 2009). The Statistical Package for Social Sciences (Windows, version 21) was used for all quantitative analysis; statistical significance was set at 95% P=0.05. The individual statistical tests for the individual studies are reported in the experimental study. All graphs and figures were created using Microsoft Excel 2010. Qualitative data analysis is described in chapter 4.5.

3.4 Ethical Issues

The ethical issues that arose in the previous DProf Accredited Learning Project modules undertaken from an insider research and educational equality perspectives were considered in the methodology for the final project (Appendix A). Controlled interventions are fairly difficult to perform in the pedagogical environment because of these ethical considerations. This led me to use an assessment-based intervention for *Study* One, which relies on some students' non-participation to form a control group. Giving students a choice as to whether they participate in a study with no known education gain or loss allows the experiment to be ethical. However from a methodological perspective there will be issues with self-selection in terms of group sizes, demographics and uncontrollable variables. Using the action research model it meant that repetition of the experiment for the second cohort required additional ethical approval. It was deemed unethical to force all students to revise using the mLearning methods and therefore student choice remained in the grouping process, which obviously affects bias and forms a more quasi-experimental model.

Any form of pedagogical research raises a number of ethical dilemmas. Primarily in these studies it is the possible perceived abuse of power by doing insider research on the cohort of students I am tasked with teaching (Norton, 2007). Using the British Educational Research Association's (BERA) revised ethical guidelines (2004) the general ethical requirements are:

1) informed consent
2) privacy and confidentiality
3) protection

The third consideration, protection, can encompass disadvantaging them academically. Therefore no known positive effects can be restricted or taken away. This can limit standardisation or validity studies using repeated cohorts but fits within the action research framework well, allowing for modification following epistemological gains.

As the module leader, I have over three hours contact time with each student on a weekly basis. I also review attendance, achievement and liaise with the student achievement officers regarding student progression. I therefore had to think about how to limit any undue influence or coercion on the students as an authority figure. This became more difficult as the nature of the research, action research, aims to improve practice. Therefore I believed that my pedagogical change would benefit the students. I had to be careful when explaining the study to the students prior to consent that I did not push the potential benefits of the intervention; I merely stated what the study involved.

Other requirements, anonymity and confidentiality, are blurred at points during pedagogical research and it is important that they are not confused. 'Anonymity' refers to the requirement that a researcher will conceal the identity of the participants in all published research findings, which is fairly simple to do on an individual student level. However, as a cohort this is much more difficult. Once again, this is more of an issue when presenting the findings within Middlesex University, where anonymity becomes even harder and the ethics of the practice can sometimes have a negative institutional impact. Again the practice-based improvement goal of action research would suggest dissemination of findings would be an objective of the study, but the ethics of anonymity may make certain vehicles for this impossible. The project in question will not be investigating any issues that may cause institutional harm but preserving anonymity is something I will address at every publishing opportunity.

The term 'confidentiality' means making clear who has the right of access to the data provided by the participants. For example, my online discussion forums are on Moodle, which is not open to the public, but can be accessed by internal staff members and students on the module. When using focus groups or interviews, quotes are often inserted into the discussion or results sections; so whilst maintaining anonymity by not disclosing the name or year, confidentiality is not maintained. These three parameters were addressed in the study by using coded student numbers, high privacy and security settings on Moodle and careful consideration when publishing work to maximise confidentiality.

Ethical approval was sought for each cycle of the thesis (Appendix A) and gained for each study. Gatekeeper permission from academic registry was submitted with each ethical application to allow for demographic information to be used that is normally freely available to the module leader. Informed consent from the students was also gained prior to each data collection session and additional ethical and permission discussions are provided for each study for the particular methods used.

3.5 Generalisability

Generalisability has been mentioned throughout the methodology discussion so far. Therefore I thought it should be discussed with respect to pedagogical research in general and for this study. Pedagogical research relies on the deconstruction of social constructs in the student learning environment, attitudes, behaviour, interactions, engagement and much more. Direct observation occurs in the form of assessment, classroom observations, focus groups and interviews but certain educational measures cannot be directly observed. Assessments make inferences as to knowledge and skill acquisition but can be argued to not be a valid measure (Ercikan & Roth, 2009). The validity of assessments is discussed in section 3.4 but the interpretative nature of all direct measures make them subject to the generalisability theory. The concept of pedagogical generalisability discusses how far a specific project with a certain degree of cultural bias can be transferred to the wider population, or external validity (Cronbach, 1987). In empirical research, the planning process, whereby the population to be studied, methods to be used, study period and data analysis are considered, ultimately impacts on the scope of generalisability. In action research the scope of generalisability can potentially change year on year or as the project progresses.

Population generalisability is commonly used in educational contexts, where a study that looks at one or a small population of students can be applied to a larger or broader population of students. For example, in the current study measures are taken on Sports Science students taking level 4 anatomy. Population generalisability as an outcome would be that the results can be applied to any anatomy students, and potentially to students of other subjects requiring a similar type of learning process. Ecological generalisability widens the scope to beyond the environmental constructs, for example beyond Universities. Understanding the constraints of generalisability allows the researcher to acknowledge, minimise and address the potential limitations of the research study. Many qualitative researchers have previously discounted generalisability in their projects due to the methods commonly used in this type of research (Kilbourn, 2006). However, in education there are many generalisable means that have and will continue to stem from qualitative roots. This further compounds the need for triangulation of data and the benefits of qualitative data in a mixed methods approach to pedagogical research. Generalisability has dependability at the centre that increases the requirement for repetition of a study using different populations to increase it, a concept used within both of the current studies. Repetition can attempt to demonstrate whether the research can transcend the cultural pattern of one population to allow population generalisability.

Generalisability had been addressed in the current studies by using multiple cohorts, a repeated measures design and triangulation of data; it has been integral to the project design and method selection process from the beginning rather than an afterthought, which is so often the case in pedagogical research. The three studies have all been informed by the methodology discussed in this chapter but the different methods and a discussion of the project design for each will be discussed in the next three chapters. Ethnography represents an additional potential issue to generalisability that has been widely criticised in the literature (Cohen et al. 2013) and has been addressed in this thesis by combining the naturalistic and experimental approaches.

A common element in all of the studies is the use of assessments as a key part of the experimental, quantitative, positivist approach. Assessments are discussed in section 3.4 including the elements of assessment and learning levels relevant to the study design for increasing reliability and generalisability of the project.

In chapter 2, Figure 1 showed the proposed action research cycles of the project. The methodologies of each of the studies evolved from the preceding study where *Study One* followed a study investigating the integration of iPads within the anatomy classroom (Wilkinson and Barter, 2016). Between cycles the action research model was used to evaluate the study, reflect on the findings and methodologies and plan for the next cycle. The findings and evaluation of the study (cycle) were then evaluated from an ethical perspective to ensure the impact on learning was fair between cohorts and student groups. Any ethical concerns were discussed with the London Sport Institute (LSI) ethic committee and incorporated in the plans for the next cycle.

All three studies were designed with generalisability as an objective and therefore used an experimental approach for scientific rigour alongside qualitative data collection in an attempt to find explanations for the experimental findings. This veers away from traditional action research, where using statistical analysis for emancipatory ends discredited by some, although the requirement for increased quality in the area means more experimental and mixed methods approaches are being advocated (Herr and Anderson, 2015). All of the studies integrate an intervention within an action research cycle moving away from the social science tradition where only naturalistic environments are studied in action research. *Study One* uses module assessment achievement as the main dependent variable whereas *Study Two* and three use in-class assessment. As discussed in section 3.4 assessment provides a student success outcome for learning that is comparable and reliable, however, assessment has been criticised as a real measure of student learning. HE is unfortunately assessment driven and therefore the outcome measure is at the forefront of much institutional and national evaluation. Generalisability objectives initiated a repeat of *Study One* in the 2015-16 academic year and the repetition of *Study Two* as a randomised repeated measures design in *Study Three*.

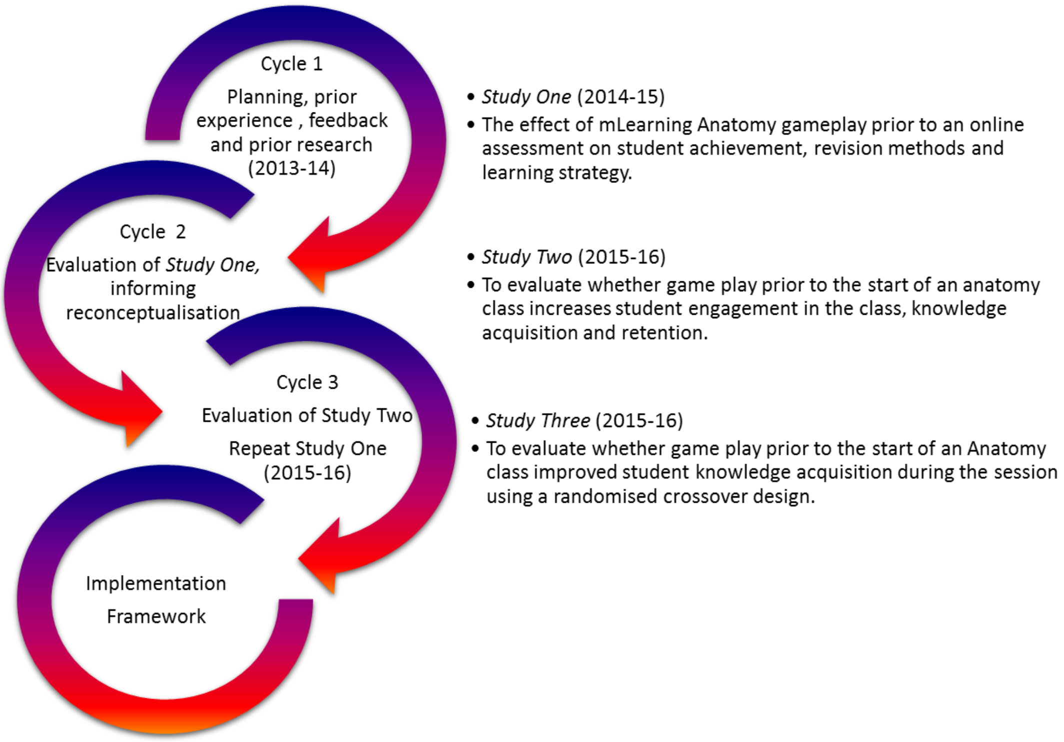

Figure 1: The sequence of studies in the doctorate based on experimental approach to the research process in an action research pedagogical model.

For each of the studies in the following chapters, the specific requirements in the methodologies are discussed followed by a scientific method. The results and discussion of each individual study are also presented, which are then brought together in an integrated discussion in chapter 7.

4.0 Study One: mLearning Anatomy Quiz-games as an Acute Revision Aid in Higher Education

Study One was conducted following an initial project comparing student achievement in an iPad integrated classroom with a control group with no iPads in the classroom environment in 2012 (Wilkinson and Barter, 2016). The iPads allowed a wide range of functions, apps and games to be used in class but it concluded that they did not transcend to their individual, independent learning strategy. The main aspect of the iPads use highlighted by students as positive was the use of interactive games and visual quizzes on the apps used, in particular RealBodywork Muscles and Skeleton. As part of my general Action Research ethos into teaching, *Study One* evolved in response to my experience of the project and future teaching goals. This chapter details the method, results and discussion of *Study One* and how it led onto *Study Two* and *Three (*Figure 1, chapter 1).

The aim of *Study One* is to investigate the effect of playing mLearning Anatomy quiz-games prior to an online assessment on student achievement, revision methods and learning strategy. The objectives of the study are:

1) To evaluate whether students who play mlearning quiz-games prior to an online MCQ assessment improve their scores.

2) To analyse level four Sport and Exercise Students' Learning strategies in Anatomy using the Study Process Questionnaire (SPQ).

3) To document level four Sport and Exercise Students' approach to mLearning (chapter 2) in Anatomy using an adapted Study Process Questionnaire (SPQ).

4) To investigate relationships between student approach to learning and achievement in different types of question.

Research hypothesis: Students who play quiz-games as a revision tool will perform better than using their normal revision and peers who do not play quiz-games. Students who have a greater deeper learning strategy will achieve higher scores than those with a surface strategy but these students will be less keen to use quiz-games as a revision tool (Scouller, 1998; Gagne, 1968).

Sections 5.1 to 5.3 discuss the methodology and the reasoning behind choosing the specific methods employed and statistical justification in this study before section 5.4 which details the actual method for *Study One*.

4.1 Methodology: The SPQ and Qualitative Method

Triangulation is described by Guion et al. (2013) as a method to check the validity of qualitative data by comparing multiple sources of the same data or cross-validation (Wiersma, 2000). Inconsistencies in triangulation can be used to identify further questions of the data and explain the data (Patton, 2002). Triangulation can be performed using different investigators, environments, sources, data or methods all investigating the same research question. In this case, triangulation will come from different methods; the SPQ, the quantitative data and focus groups and interviews within my chosen epistemological methodological viewpoint of interpretism in a naturalistic environment.

The modified SPQ (Appendix B) is a two-part questionnaire, which aims to elicit students' responses on their learning approaches, perceptions of the levels of intellectual skills being assessed, and their preferences for assessment methods. The questionnaire was adapted from Biggs' (1987) Study Process Questionnaire and Scouller and Prosser's questionnaire (1994). It consists of 35 statements, describing surface learning approaches and deep learning approaches further divided into motives and strategies. Many questionnaires were reviewed and the subject of deep versus surface learning type researched extensively (Chapter 2) particularly in the anatomical sciences. Although there is much research showing no relationship between the SPQ results and academic achievement (Choy et al. 2012) there remains a lack of alternative to investigate learner motivation type. Most studies still use the SPQ or an adapted version and therefore, for comparison it was felt that the SPQ was the most effective choice. The aim of using the questionnaire was to compare between and within students following an intervention and therefore as a relative measure it was seen to be a viable outcome measure. Further discussion of online questionnaires can be found in section 5.1. Each statement is contextualised to focus students' attention on the assessment and revision type. They are required to indicate how strongly they agree or disagree with each statement by circling the most appropriate number on two visual 5-point Likert scales.

Surface strategy: When preparing for this assessment I summarised a lot of material without understanding it well.

Deep strategy: When preparing for this assessment I tried to integrate the theoretical and practical components of the course so that they had some meaning for me.

Surface motive: When preparing for this assessment I chose topics that I thought I could pass rather than those I was really interested in.

Deep motive: I became increasingly absorbed in my work the more I read and studied for this assessment.

The final 10 questions are adapted from Chen, 2013 Learner Attitude Survey and Courtois et al. (2010). They assess learners' attitudes towards the effectiveness, usability and potential of tablets and smartphones for learning, adapted further to be contextualised for quiz-games and anatomy. Finally there are three open questions at the end to determine qualitative data regarding the student's perception of mLearning quiz-games, when and where they use mLearning and how they felt about their preparation for the assessment. The full questionnaire can be found in Appendix B.

The modified SPQ Questionnaire uses Likert scales producing scores (Allen and Seaman, 2007) that produce ordinal type data. The Deep v Surface Learning preference will be determined using the scoring method suggested by Biggs, (1988) and then the scores for the last 10 questions added together to indicate the use and preference for mLearning. There is discussion as to whether parametric statistics can be used on ordinal data from questionnaires and recently most researchers agree that if other parametric conditions are met parametric tests have greater statistical power (Norman, 2010). Therefore the quantitative ordinal data was also analysed using an independent t-test for the Games (G) and Non-Games (NG) group differences. Following the e-assessment all consenting students (control and intervention groups) completed the modified SPQ as described in section The questionnaire resulted in Deep Motive (DM), Deep Strategy (DS), Surface Motive (SM) and Surface Strategy (SS) scores described by Biggs, 2001 as well as a mobile learning (mLearning) score (ML). The ML score was the total score of the additional questions to the SPQ specific to mLearning (21-23, 26-35) – (24 & 25), questions 36-38 were longer qualitative questions regarding mLearning and quiz-games.

Scoring system for Deep v surface Learning (Biggs (2001))

– Deep Approach Score (DA): Σ All Deep Motive scores + all Deep Strategy scores

– Surface Approach Score (SA): Σ All Surface Motive scores + all Surface Strategy scores

4.2 Focus Groups

This section discusses the evolution of the methodology regarding focus groups, which initially began with a traditional real time focus group leading to the use of an online focus group with additional semi-structured interviews. In the original project proposal I had decided on an actual face to face focus group with a selection of students following the online focus groups as described in the literature review (Bruce-Low et al. 2013; Stewart and Williams, 2005). This was changed to be online focus groups followed by semi-structured interviews as shown in Figure 3. Following data collection of the modified SPQ and online focus groups, themes requiring greater depth were emerging. I did not think that I was going to get any more detail in a focus group considering the saturation of themes and responses in the online data collected.

In-depth interviewing is an alternative qualitative technique that involves conducting intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea or subject. In-depth interviews are useful for detailed information about a student's thoughts or behaviour and are often used to provide context to other data offering a more complete picture and can increase the validity via triangulation. Using online forums the depth of information is limited and although there are limitations with interviewing students, I calculated that a different source of qualitative data represented a greater chance to explore the topic of mLearning and quiz-games in greater depth. This then presented me with the issue of the insider researcher and the ethical power conundrum that coexists. The two options open to me were to ask someone else to do the interviews or for me to do them myself using guided questioning to ensure structure and lack of bias. The problem with someone else doing the interviews is that they would not be as knowledgeable or be able to divert questioning based on the project and therefore as part of an insider action research project I decided that the positives outweighed the potential negatives. In-depth interviews also add to the ethical consideration of anonymity where data presentation in the form of quotes could identify a participant when it is published.

The aim of the focus group is to elicit data from selected or specific groups of people, processes and normative understandings where, instead of generalisable findings, the emphasis is placed upon achieving an increased depth of understanding (Bloor et al. 2001). Focus groups are an important way of discovering what interviewees think about a concrete theme, what feelings, attitudes, reactions, and doubts they have concerning it, in a situation in which they can compare their opinions. In pedagogical research they remain underused with most researchers sticking to traditional in-depth interviews (Cousin, 2009). However, focus groups pose an ideal situation for the pedagogical researcher; an efficient way to identify student perception in the form of a group discussion to identify key themes (Gilflores and Alonso, 1995). The researcher (s) is the facilitator, directing discussion rather than the more direct approach of the interview. The focus group will enable triangulation of qualitative data to enhance validity and be more time-efficient than 1:1 interviews (Stewart and Shamdasani, 2007). Focus groups can be used in the same way as other qualitative techniques (Fielding and Fielding 1986) to interpret the results obtained by other methods. They are frequently employed after the application of questionnaires to interpret numerical data. Such data may make the existence and importance of certain behaviours or attitudes clear but fail to offer in-depth explanations for these behaviours or attitudes; focus groups can be used to enable further depth or enlightenment.

In order to achieve samples that are representative of the class, the samples will be stratified based on programme, gender, and ethnicity. For instance, the student population in this course consists of 25% SER students and 75%, SES which was consistent in the selection process. Focus group selection was voluntary using randomly generated invitations, however grouping of gender, age and programme took place to ensure that a range of opinions will be gained. These factors are all shown to affect mLearning and gaming use and perception (Papastergiou, 2009). Optimal focus group size has been suggested to be 6-12, (Baumgartner, Strong, & Hensley, 2002;Bernard, 1995; Johnson & Christensen, 2004; Krueger, 2000; Langford, Schoenfeld,& Izzo, 2002; Morgan, 1997; Onwuegbuzie, Jiao, & Bostick, 2004; Gibbs, 1997) and last between 1-2 hours. (Morgan, 1997; Vaughn et al.1996) The focus group will use the phenomenological hermeneutic framework (Alvesson & Sköldberg, 2000; van Manen, 1997) allowing student discussion on their experiences of mLearning. It was envisaged that two levels of coding would occur; at the first level there was discussions on general themes about mLearning and at the second level, these themes were further broken down into sub-themes. The specific sub-levels were to be smartphones and quiz-games (Kinsash et al. 2012) but more sub-levels emerged increasing the breadth of the thematic analysis.

A focus group analysis relies on audio recording and can involve observations made by a secondary researcher during the focus group (Krueger & Casey, 2000). The facilitator needs to create a non-threatening and non-evaluative environment in which group members feel free to express themselves openly and without concern for whether others in the group agree with the opinions offered. As the module leader and researcher my role may lead to a perceived inability to communicate openly due to a conflict of interests (Stuart et al. 2007). A fully transcribed focus group can produce vast volumes of data and is time ineffective (Wilkinson, 1998). An abridged transcript will produce less data. Notwithstanding, this type of analysis can be helpful because the researcher can focus on the research question and only transcribe the portions that assist in better understanding of the phenomenon of interest (Onwuegbuzie et al. 2009). Having discussed focus groups above and evaluated the potential benefits to the research study, it was decided to change to an online discussion forum.

An online discussion decreases the vast amount of manual transcription needed and also increases the potential number of respondents that can participate in the study (Im and Chee, 2012). Online discussion forums have been used extensively in recent medical research but still remain potentially underused in pedagogical studies (Loncar et al. 2013). Im and Chee (2006) describe them as "an online forum discussion site on the Internet facilitated by the researcher where participants can discuss specific topics through posting a series of messages. Studies have suggested numerous positives and negatives of using online forums, some of which are not applicable to this study's' student population. One reason that researchers question the accessibility is due to the potential technological literacy of the participants (Mann and Stewart, 2000). This should not be an issue with the student population in question because of the requirement to use online interfaces throughout their studies. Another was the lack of face to face interaction; again as the researcher is known to the students the potential perceived distance is greatly reduced (Mann and Stewart, 2003). The final concern reported in the literature is that of confidentiality and security on the site; this is due to public access being necessary for participants. Using Moodle (the University VLE) the security is good and therefore not a potential problem.

The role of the facilitator is very important both in traditional and online focus groups. Research has suggested that one issue is the lack of ability to ensure consistency in terms of depth, breadth and participation in the discussion forum. As with all focus group, interviews and other face to face methodologies, the facilitator can direct topics or themes and ensure active participation from all members; this is harder using an online forum (Loncar et al. 2013). Finally, the social and cultural details of participants will remain anonymous compared to the focus group, which has sometimes been purported to affect data collection, however, it is not a factor for analysis in the current study. The decision was therefore made to use an online discussion forum instead of multiple focus groups followed by interviews, as discussed earlier in this section. This was to reduce the volume of data collected as well as to reduce the physical impact on the student body and be more inclusive. It also meant that the traditional focus group was formed of active participants of between 14-16 people in each.

Deutskens et al. (2004) reports a response rate of approximately 20% that varies with length, timing, visual score and incentive for internet based surveys. Students have been identified as a low responding group in general. Andersen et al. (2004) showed that response to course evaluations done via email link have a rate of 24% as opposed to 71% response rate in class suggesting that online responses are less than in-class. This mimics the research performed on participation of students in course online discussion forums, where the rate is between 15-25% and the average response to a thread is 2.2 posts (Foon Hew et al. 2009). This was important in the way that the focus group was delivered online to maximise discussion and depth of feedback given by as many students as possible. From a quality and ethical perspective no assessment incentive could be offered for participation unlike in similar studies (Padilla et al. 2005) so therefore the response rate was predicted to be approximately 25-35%.

There remains much discussion around using online focus groups (Stewart and Williams, 2005) and whether they can be compared to traditional face to face methodologies. Although similar in many ways, covert observations of online group discussions that occur due to chance fall outside the definition of an online focus group in just the same way that a covertly observed group discussion could not be classed as a traditional focus group (Bloor et al. 2001). Traditionally, a focus group is described as an organised, facilitated discussion around a given topic or topics distinguishable from natural discussion by the group dynamics eliciting interaction to further discussion. Online focus groups were utilised by the market research population much earlier than in academia following successful computer mediated advances for telephone and skype interviews and online questionnaires (Stewart and Williams, 2005). Robson, 1997 initiated an academic online focus group using an email mediated group discussion to avoid threads branching the discussion too much, one issue with non-structured or guided online discussion forums.

Online discussion forums and focus groups provide many benefits over the traditional focus group, lower cost, more efficient data collection periods, greater access to modern lifestyles, and greater geographical reach (Gaiser 1997; Chase & Alvarez 2000; Scholl *et al.* 2002; Hopewell 2007; Richardson 2007). However, critics also assert that qualitative research via the internet is simply not the same as traditional, face-to-face research and the most identifiable absenteeism in the online focus group is non-verbal communication and the subsequent effect on discussion. Silverman (2002) also suggests the anonymity of the internet questions identity and truth, however, in my focus group the identity of respondents is selected and known, although the survey is run using student number not name so that students feel comfortable speaking their mind. A pilot online focus group was done using my dissertation students and my experience of online discussion forums finalising the decision to use an online focus group.

mLearning is an individual educational concept in theory due to the nature of truly mobile learning where the learner chooses the direction, pace and environment of study (Traxler et al. (2013) . A traditional focus group may be more valuable if I were looking at a group or classroom based aspect of teaching and learning where group and peer ethnographical dynamics were a primary part of the data collection. Therefore, following the online focus groups, interviews were used with a small selection of students to gain further explanation and depth into their perceptions and use of mLearning and quiz-games. The individual nature of the interview also provides a true triangulation of data by complementing questionnaire data, quantitative data and online focus group data. It was to allow me to engage the student in their thoughts for future directions within their own learning, which may be useful to feed into the action research cycle of the thesis.

The semi-structured interviews in *Study One* were conducted after class in week 20 lasting for ten minutes as advocated by (Drever, 1995). Six to ten questions were recommended for a short interview and therefore six questions were used to elicit the depth and subject matter from students if required. If the information was covered by the student the question was not asked, the conversation just directed into the next topic area but the semi structured choice of method allowed further probing if necessary. This was deemed appropriate for students of university age and the insider role of the interviewer. A structured interview would have created a false interaction between student and teacher as a relationship already existed (Barriball and While 1994). A structured interview implies that words have the same meaning to all participants, semi-structured interviews allow the researcher to explain points and use terminology specific to the student in question.

Analysis of the different methods employed for triangulation within *Study One* are discussed in section 5.3. This section also provides background information on the types of data and design from a statistical viewpoint.

4.3 Statistical Analysis

In the project proposal originally I was going to look at two different games compared with the control. However, in class the games used were a mix of quizzes and labelling and so it was decided to have only one intervention group that allowed students to do both. This was so as to not disadvantage students participating by enabling a wider choice and personalisation of their revision. The data from the student achievement, attendance and MyUnihub interaction is quantitative scale data which was tested for normality using the Kologoromov Smirnov test ($p>0.05$) (Fillion, 2015) showing the two samples are comparable. The non-significant result suggests that the data can be presumed to be parametric (Cresswell, 2013). The method resulted in two sample analysis for both within and between student analysis for pre and post and Games and control (no games) measures. Therefore, the most effective statistical methods were an independent t-test to investigate the games and control group differences and a paired t-test for within-student analysis (Pituch et al. 2015). A 95% confidence limit ($p<0.05$) was used for analysis.

A mixed methods approach to the study was chosen to allow for triangulation of data via both quantitative (achievement, Study Process Questionnaire (SPQ)) and qualitative (online focus groups and in-depth interviews) as discussed in chapter 3. In part, this was to try and gain information to explain any empirical results as well as to increase the validity and reliability of the study with inherent pedagogical constraints afforded by action research in Higher Education. The method for *Study One* analysis is detailed in the next section, 4.4.

Anatomy is a first year core module that sits within the Sports and Exercise Science (SES) and Rehabilitation (SER) programmes. The 24 weeks module schedule included 12 whole group lectures, 24 seminars and four assessments; the lectures were given by the module leader (Wilkinson) in the first semester (October- January). In the 2014-15 academic year the module was split into seven seminar groups of 20 students as per the normal timetabling for the module. Five seminar groups were SES degree students, two were SER groups. No students were knowingly disadvantaged and all students followed the same content and online learning activities, the only difference in teaching methods being the addition of the in-class tablets (iPads) for the SES groups. The iPads were available in all seminars but were utilised as part of group tasks depending on the session. This included Socrative™ teacher-paced plenary quizzes, Real Bodywork™ Muscles and bone and skeletal 3D apps as well as the video features and apps such as Flipagram™ and Magisto™ alongside more traditional tools such as Youtube™ and Safari/internet. In each session, a lesson plan was used as is customary practice on the module to ensure consistency across all seven seminars; the six iPad groups had the tablet specific tasks integrated at specific points. Tasks were designed to encourage group learning and opportunities for independent mLearning. For example, students were encouraged to use the Real bodywork apps outside the seminars and videos made in class were published on Moodle (myUnihub), the virtual learning environment (VLE) via Youtube to allow student-owned revision aids to access these resources autonomously.

4.4 Method

Ethical consent was gained from the Middlesex University, School of Health and Education (LSI sub-committee) prior to the start of the 2014-15 academic year for a study using an action research (AR) approach (Appendix A). Informed consent was gained from students to allow the use of their results and data for the study in week one of the module when they were instructed that they could withdraw from this at any point in the year.

4.4.1 Anatomy Assessments

There are four points of assessment throughout the course, A1, A2, A3, and A4 as shown in Table 2. The module aims to give students the fundamental anatomical knowledge required for Sports Science and is assessed on Moodle using a time-limited computer-based assessment comprising matching, labelling and MCQs (A1, A2, and A3) that the students complete in a controlled examination environment. A4 is a viva voce lasting 15 minutes where students are asked to utilise the skeleton and coach exercises to show applied knowledge and understanding on the topic.

Assessments were tested for internal consistency using an expert review panel and reliability using Alpha-Cronbach's coefficient. The coefficient was calculated at 0.796 for A1, A2, and A3, greater than the 0.7 required for reliability and therefore deemed comparable (2014-15: 0.76; 2015-16: 0.79). The reliability between A1-3 and A4 was 0.14 and therefore not comparable.

Table 2: The schedule of anatomy assessments (A1-A4) for type, content and timing as well as the intervention/testing overview at each point.

Assessment	**A1**	**A2**	**A3**		**A4**
Timing	Week 8	Week 14	Week 20		Week 24
Type	Online MCQ	Online MCQ	Online MCQ		Viva voce
Content	Anatomical microstructure	Applied gross anatomy (lower limb)	Applied gross anatomy (upper limb)		Applied gross anatomy (trunk and nervous system)
Intervention	N/A	N/A	**Games** (20 minutes anatomy	**No Games** (20 minutes	N/A

			mLearning games)	normal revision)	

The overview of the method is shown in Figure 3 and described below. In A3 the students were invited to participate in the study with no positive incentives offered. A1 and A2 and A4 were carried out as normal with no intervention. A1 and A2 were completed by all students using their normal revision as the within-subject control or baseline value and to allow comparison to previous and future cohorts. The Games (G) intervention was added prior to A3, which is directly comparable to A2 (lower limb v upper limb) in type of assessment and questions.

In A3, students were invited to do their normal preparation or a quiz or labelling-based game prior to the assessment (personalised by theme and choice of game activity) for 20 minutes in a controlled environment. Originally the games (G) revision was to be 30 minutes, but in the pilot study students preferred 20 minutes; 30 minutes was deemed too long in terms of concentration span for acute revision. The control group (NG) was those students who consented to participate in data collection, but chose to do their own normal preparation.

The pre-assessment revision sessions were invigilated by Graduate Assistants (GAs) or other staff members so that the researcher did not know the groups or revision tool chosen. All data was analysed using student number for anonymity and marked online using an automatic marking scheme.

The students completed the assessment online and then were asked to complete a modified SPQ online (Appendix B) on the same Moodle page following A2 and A3. The SPQ took approximately three to four minutes to complete.

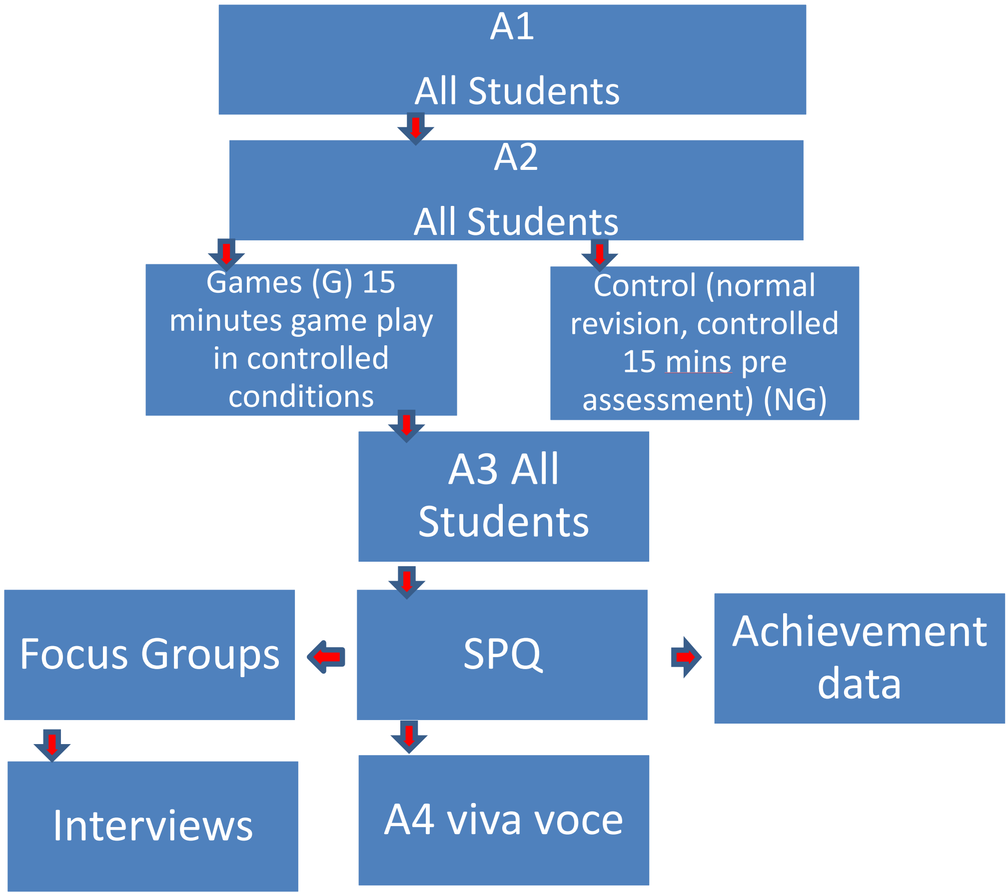

Figure 3: A Schematic overview of *Study One* showing the G and NG pathways for data collection.

Following the quiz-games intervention in A3 those students who used quiz-games prior to the assessment were invited to participate in an online focus group and then a selection (N=16) were invited for extended interviews. The online focus groups were performed on Moodle using an anonymous invite only forum. Again, this was optional and the response rate was 66.4% (N=84). The focus group and the open ended SPQ mLearning question transcripts were exported as word documents, spell check applied and then uploaded to QDA Miner (Provalis, version 4.1) for coding and thematic analysis. Wisemapping was then used to produce concept maps of the thematic analysis. To allow further depth and to identify any contradictory responses in the online focus groups, in-depth interviews were used to enable the researcher to probe further into the topics in question and address any conflict (Harrall and Bradley, 2009).

20% (N=16) were invited to complete extended one to one interviews, Nine (N=9) students completed these following A3, a response rate of 56%. The interviews were recorded using the Recorder app on the iPhone 6 and then transcribed using the built in software. The questions can be found in Appendix D. Transcriptions were checked by student learning assistants and then I listened to them whilst reading the transcripts to check the accuracy and spelling whilst beginning the thematic analysis and coding level choices.

Consenting student scores were taken from the Moodle Gradebook and added to the Excel spreadsheet after coding for student number to ensure anonymity and then all data was transferred to SPSS (Microsoft, version 20.0). Data was tested for normality using Kolmogorov–Smirnov and Maulchy's test of Sphericity indicating parametric data for analysis ($p>0.05$). Each of the individual assessment scores were also input into SPSS and total marks from surface MCQ, labelling and deeper learning questions separated. These scores were also analysed between intervention and control group, gender and whether they were taught with iPads in class. The Assessments, A2 and A3 were split into three question types, MCQ, matching and labelling. They were converted to % correct per question type and an independent t-test used to see if there was a difference between the G and NG groups.

Scores of those students who consented to participate were taken from Gradebook and the questionnaire data after each assessment added to the spreadsheet after coding for student number to ensure anonymity. The SPQ Deep Motive (DM), Surface Motive (SM), Deep Approach (DA) and Surface Approach (SA), Mobile Learning (ML) scores were calculated in Excel (MS, 2010) and then all data was transferred to SPSS (version 20) for analysis. Firstly, an independent t-test was used to see whether there was a significant difference between the A2 and A3 scores between the games (G) v non-games (NG) groups and between genders. Paired t-tests were used to compare within-student data for A2 versus A3 for achievement and all questionnaire question data scores. A Pearson correlation was used to investigate the relationship between achievement score and DM, DS, SM, SS and ML scores at each assessment point. Each of the individual assessment scores were also input into SPSS and total marks from surface MCQ, labelling and deeper learning questions separated. These scores were also analysed between intervention and control group, gender and SPQ results.

Following the analysis of the results from 2014-15 academic year it was decided that the quantitative part of the experiment would be repeated in the 2015-16 academic year to increase the generalisability and ensure the 2014-15 cohort was not a special case. No changes were made to the assessment schedule in 2015-16 and the same assessment questions were used for A2 and A3 to ensure consistency. Minor changes were made to the numerical range of motion questions but the format and type of question remained the same. SPQ scores for A2 and A3 were measured and achievement scores for A1 to A4 recorded using Moodle Gradebook. The analysis was then repeated for the 2015-16 data and then combined with the 2014-15 data to analyse the whole group data from both years.

4.4.2 Participants

In the 2014-5 academic year, 147 students were initially registered on the Anatomy module, but only 132 were deemed active. An inclusion criterion for the study was to complete the module having completed at least three out of the four assessments. Therefore the final number of students for analysis was N = 125.

In the 2015-16 academic year, 129 students were initially on the anatomy module but resulted in 121 for analysis after A4. The total number of students for the two cohort analysis was N=246, which is detailed in the results in the next section.

4.5 Results

The whole group data in 2014-15 (N= 125) included 29 female (23.2%) and 96 males (76.8%), which is representative of the sports cohort. The whole group data in 2015-16 (N = 121) included 31 female (25.6%) and 90 males (74.4%). The optional formative assessment, A5, was additional to the module requirements and only had 14 participants in 2014-15, which was deemed too few for analysis. The breakdown of numbers following each assessment point is shown in Table 3. In A3, the games intervention group had 54 participants and the control group 71 (Games; N= 54; control N= 71).

Table 3: The number of participants at each Assessment point (A1-A4) throughout both cohorts tested (2014-15, 2015-16) and the mean achievement scores in each.

	A1	**A2**	**A3**	**A4**
N (2014-15)	147	129	127	125
N (2015-16)	129	127	121	121
Mean (2014-15)Score(%) =	63.7	51.8	51.7	49.2
Mean (2015-16)Score(%) =	66.7	56.1	52.3	56.1

Paired analysis within-student testing of the 2014-15 cohort revealed no significant difference between A2 and A3 scores ($\Delta = 0.200 \pm 11.9\%$; $p>0.05$; $t = 0.187$) whereas in 2015-16 there was a significant decrease ($\Delta = 2.74 \pm 15.8\%$; $p<0.001$; $t = 4.026$). In both 2014-15 and 2015-16 there was a significant increase from A2 to A3 ($\Delta = 3.96 \pm 11.8\%$; $p<0.05$, $t=2.469$) in the G group whereas in the no games (NG) group there was a significant decrease ($\Delta = -2.65 \pm 11.33\%$; $p<0.05$, $t= -1.986$). The analysis of 2014-15 and 2015-16 (N=255) combined revealed a significant increase in score for the games (G) group ($\Delta = 3.64 \pm 11.3\%$; $p<0.001$, $t=-3.019$), a significant decrease for the no-games (NG) group ($\Delta = 6.15 \pm 13.5\%$; $p<0.001$, $t=-5.835$) and a significant decrease for the whole group together ($\Delta = 2.97 \pm 14.9\%$; $p<0.05$, $t=-3.184$). Bonferroni corrections were made based on 2 dependent variables, therefore p was set to 0.025 and therefore all significance levels remained valid.

The between-subject group analysis at each assessment point is shown for G and NG groups in Table 4. The whole group data (N=255) analysis using an independent t-test revealed a significant difference between G and NG groups in A3 ($p<0.001$) where the G group had a significant increase in score ($p<0.01$) and the NG group had a significant decrease in score ($p<0.01$) (Figure 4). Bonferroni corrections were made based on 4 dependent variables, therefore p was set to 0.0125 and therefore all significance levels remained valid (Appendix E).

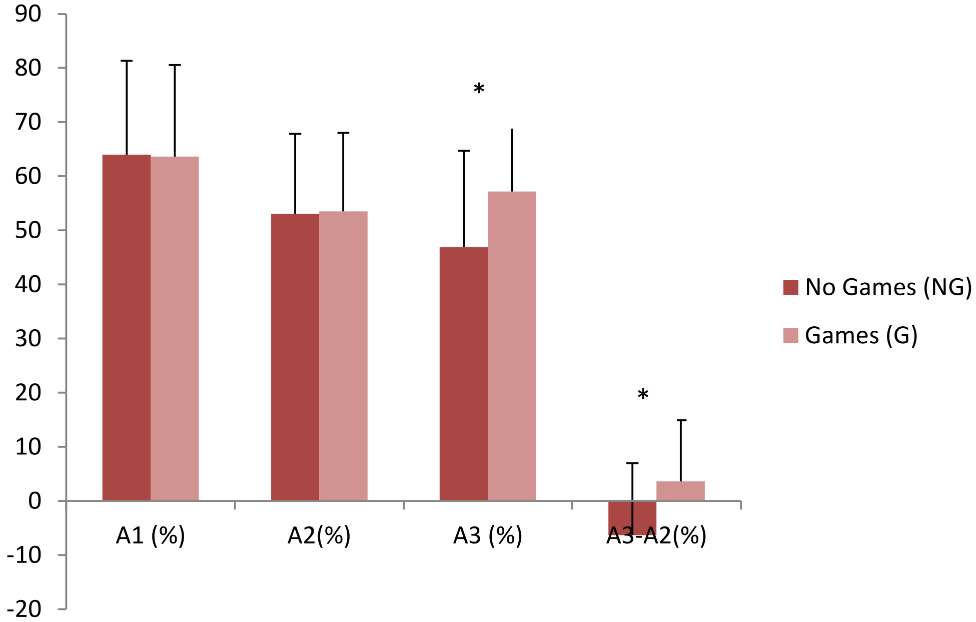

Figure 4: A comparison of the MCQ assessment mean scores ± SD (A1-A3) and the A3-A2 difference for the G and NG groups. A significant difference was seen between G and NG groups at A3 and A3-A2 difference. (*) significant at 0.1% ($p<0.001$)

Further analysis was only carried out on the 2014-15 cohort. Question type analysis revealed no significant differences between the groups, however, in the paired sample analysis the G and NG groups here was a significant increase ($p<0.01$) in the labelling tasks achievement and the NG group demonstrated a significant reduction in MCQ and matching question types ($p<0.05$) at A3.

In terms of achievement therefore the study revealed that the G group performed better in the intervention assessment (A3) using both within and between-student analysis. There was not a difference at any other assessment points. The next section will detail the results from the SPQ.

Table 4: Achievement results for Games (G) and no games (NG) groups at A2, A3, A4 and A3-A2 difference

	games	N	Mean	SD	Significance (p)
A3-A2 difference (Δ%)	no	164.0	-6.3	13.3	0.000**
	yes	87.0	3.6	11.3	
A3 (%)	no	164.0	46.9	17.8	0.000**
	yes	87.0	57.2	12.1	
A2 (%)	no	164.0	53.1	14.8	0.803
	yes	87.0	53.5	14.5	
A4 (%)	no	71.0	48.5	24.1	0.854
	yes	54.0	49.2	21.7	

** Significant at 99.9% confidence limit

Whole group data for this analysis resulted in N=251 due to non-completers and A4 consisted of 2014-15 only resulting in N=125.

4.5.1 Modified SPQ Analysis

Table 5 shows the mean SPQ scores, individual question responses and the independent t-test scores are shown in Appendix E for both games and control groups and gender (male versus female) (N=78). The mean scores presented are of the ranking, where 1 was a negative, "rarely true of me" and 5 was "always true of me" therefore the greater the score, the more positive the reaction. The response to the statement, "My aim is to pass the course while doing as little work as possible" resulted in a significant difference in both the games (G) and No Games (NG) groups and by gender. The NG group and females had a highly significantly lower (negative) score ($p<0.01$) Females also had a significantly lower (negative) score for deep motive, surface motive, deep approach and surface approach to studying (** p<0.001, * p<0.05).

Table 5: The SPQ Question analyses for learner scores sorted by gender and Games (G) or No Games (NG) groups showing a significant difference by gender for Deep Motive (DM), surface Motive (SM), Deep Approach (DA) and Surface Approach (SA).

Games		N	Mean	P value	**gender**	N	Mean	P value
Deep Motive Score	no	48	14.48	0.3	female	21	13.24	0.01**
	yes	30	15.27		male	61	15.33	
Deep Strategy Score	no	48	14.83	0.22	female	21	14.52	0.27
	yes	30	15.7		male	61	15.38	
Surface Motive	no	48	13.02	0.16	female	21	12.14	0.03*
	yes	30	14.1		male	61	13.93	
Surface Strategy	no	48	12.94	0.29	female	21	12.29	0.11
	yes	30	13.77		male	61	13.61	
Deep Approach	no	48	29.31	0.2	female	21	27.76	0.03*
	yes	30	30.97		male	61	30.7	
Surface Approach	no	48	25.96	0.18	female	21	24.43	0.04*
	yes	30	27.87		male	61	27.54	

The Pearson correlation analysis (Table 6) showed a significant negative relationship between A1 achievement score, Surface strategy (SS) and Approach (SA) (p<0.05). All other achievement scores had no significant relationships with SPQ learning strategy (p>0.05) however, only DM produced positive correlation coefficients. The ML score was significantly correlated to DA (p<0.01), DS (p<0.01), DM (p<0.01) and SM (p<0.05) but not to SS and SA (p>0.05).

Table 6: Pearson correlations between SPQ learner type scores, Mobile Learning scores (MLNG/G) and Achievement at the different Assessment points. Significant correlations are highlighted (** p<0.001, * p<0.05).

		DM	DS	SM	SS	DA	SA	ML
A1	R	-.173	.071	-.151	-.248*	-.060	-.218*	.104
	P	.121	.528	.175	.025	.591	.049	.248
A2	R	-.048	.094	-.115	-.128	.025	-.133	.172
	P	.671	.401	.303	.250	.825	.234	.056
A3	R	-.138	.092	-.184	-.090	-.028	-.148	.279**
	P	.217	.409	.098	.423	.804	.183	.002
A3A2diff	R	-.104	.021	-.068	-.008	-.049	-.041	-.189*
	P	.351	.854	.546	.942	.664	.715	.035
DM	R	1	.560**	.628**	.480**	.887**	.603**	.324**
	P		.000	.000	.000	.000	.000	.003
DS	R	.560**	1	.511**	.476**	.879**	.538**	.312**
		.000		.000	.000	.000	.000	.004
SM	R	.628**	.511**	1	.684**	.646**	.915**	.233*
	P	.000	.000		.000	.000	.000	.035
SS	R	.480**	.476**	.684**	1	.541**	.920**	.131
	P	.000	.000	.000		.000	.000	.242
DA	R	.887**	.879**	.646**	.541**	1	.646**	.360**
	P	.000	.000	.000	.000		.000	.001
SA	R	.603**	.538**	.915**	.920**	.646**	1	.197
	P	.000	.000	.000	.000	.000		.076
ML	R	.324**	.312**	.233*	.131	.360**	.197	1
	P	.003	.004	.035	.242	.001	.076	

ML score was highly significantly related positively to A3 achievement ($p<0.01$), A3-A2 difference ($p<0.05$), all question types, ($p<0.01$) and also to A2 labelling ($p<0.05$). The correlations between all of the SPQ learning scores revealed very highly significant positive relationships ($p<0.001$). ML scores correlated with all of the SPQ approached except SS and SA.

4.5.2 Focus Group Analysis

The qualitative feedback was entered into QDA miner (Provalis, version 4.1) for coding and a thematic analysis undertaken. Wisemapping was then used to produce concept maps from the thematic analysis as described in chapter 3. The feedback was coded for the themes that occurred most frequently for Q36 and Q 37 combined then Q38 separately. Table 7 details the raw coding counts and percentages for both questions. Further detail of the retrieved coded data is in Appendix D.

Table 7: Coding counts of all of the key themes extracted from the focus group data using QDA miner (Provalis, version 4.1).

Category	Code	Description	Count	% Codes
36	positive		201	42.70%
36	learning		90	19.10%
36	mobile		45	9.60%
36	why		43	9.10%
36	games		34	7.20%
36	Different		15	3.20%
36	feedback		11	2.30%
36	negative		11	2.30%
38	travel		42	8.40%
38	time		6	1.20%

A concept map was developed from the coding and thematic analysis to four levels shown in Figure 5. All coding analysis and data retrieval is shown in Appendix D.

Figure 5: A concept map for the qualitative responses exploring the students' perceptions of mLearning.

The responses for Question 38 regarding where and when they use mLearning are shown in the concept map developed from the qualitative responses, coding and thematic analysis in Figure 6. The coding data and retrieval is detailed in appendix D.

Figure 6: A concept map for student responses to Q38 concerning where and when they used mLearning.

The interview data was transcribed using Microsoft Word and further thematic analysis performed to gain greater depth and triangulation of the focus group data. Key quotes and common thoughts have been presented in Table 8 to parallel the thematic analysis in Figures 5 and 6.

Table 8: Student quotations from the transcribed interviews expanding on the key themes retrieved from the focus group data described in the concept map in Figures 4 and 5.

Feedback	"It is a very useful resource if used correctly. It is great for anatomy, because it acts like an electronic flashcard. While also being a great tool to answering any questions that come to mind" (student, male) "Helps me a lot as I don't have to search things up in books or internet as I have answers and tasks on the phone/ tablet apps." (student, male)
Games	"I use games anyway as I feel it gets it into my head quicker and I remember it more accurately then I would when compared to revising something by reading." (student, male) "Games are the best to revise, pictures and multiple answers gives you a better way of learning. I always feel more comfortable in my knowledge after playing games/quizzes in class." (student, female)
Different	"Playing online games that involve anatomy is good - it's interactive and I'm actually doing something, rather than just sitting there with notes in my hand." (student, male) "An exciting new twist that makes it more fun to learn otherwise ""heavy"" material" (student, female)
Overall	"I have many different anatomy apps just because some are better to see different positions of the body. I use them frequently through enjoyment. I hardly spend time sat at my laptop at a decent hour of the day so having the apps to look at whilst I'm out and about when topics arise is a big help I would never get rid of it from my phone. I'd like to find more great apps for other studies that include labelling etc." (student, male)

Why do you feel that way about games?	“I am a visual person so when I play the anatomy games, the information sticks in my brain and gives me a better understanding.” (student, male) “Playing online games that involve anatomy is good - it’s interactive and I'm actually doing something, rather than just sitting there with notes in my hand.” (student, male)
negative	“it is a different way of learning, but can distract people from actually learning important facts when they are on their phones.” (student, female) “It's fun however I don't feel like I’m learning a significant amount. If I feel that it will help me to start with I will use them to learn the basics then will verge towards books for the more complex information.” (student, male)
Learning	“…by constantly playing those Label games for 10-15 minutes, I was thinking only about anatomy and nothing else... It enables me to memorise the topic more clearly.” (student, male) “I concentrated on muscle origins and insertions as I find it a bit hard but playing the games on my smart phone and tablet makes it much more enjoyable and easier to learn them!!” (student, female)

The next section, 5.6 discusses the results with respect to current literature and bringing the results of the achievement, focus group and Interviews together as an integrated whole.

4.6 Discussion

The purpose of this investigation was to identify whether using a smartphone quiz-game as an acute or “last minute” revision tool in level four HE Anatomy was beneficial to student achievement. The initial hypothesis was that the students who chose to play the quiz-games (G) prior to A3 would have better achievement scores than those who did not (NG). This was supported from the within student paired analyses and A3-A2 difference between-student group analysis.

There was no significant difference between the G and NG groups at A1 or A2 suggesting that the standard and ability of students within each group was comparable. A2 and A3 follow exactly the same format for question type, number and timing where A2 is focussed on the lower limb and A3 on the upper limb. The whole group analysis revealed that students performed less well in A3 compared to A2 and therefore the difference between A3 and A2 scores was used as a parameter to indicate relative performance over two different assessments. The difference was a significant increase for the G students and a significant decrease for NG students in the paired within-student analysis. The G and NG groups were compared and the only significant difference found in the A3-A2 difference where the G group improved and the NG group did not. Where students found the assessment (A3) more difficult this could be due to many things including level of assessment, other module commitments and engagement in the topic through the academic year. The assessments were statistically comparable and showed high validity scores, both A2 and A3 were tested using subject experts and internal verification (Considine et al. (2005)) but there is inherently variation in student performance across different assessments. This difference was not significant and therefore the use of the delta value deemed appropriate (Δ%).

The quiz-games played prior to assessment were on their own smartphone or department iPad in the computer room supervised by a Graduate Assistant (GA). The normal revision done by the control group was done as normal in the spare room next door supervised by another GA. Recruitment to each group was entirely voluntary and not knowingly influenced by the insider researcher module leader reflected by the numbers in each group. If the module leader had a positive effect on recruitment numbers in the intervention group would be expected to be higher. Accessibility to mLearning has been suggested to be a limitation to its potential use in education but the provision of tablet devices and availability in classes eliminates this potential limitation. However, students who regularly play mLearning quiz-games as part of their normal learning experience may have a different response to the gameplay than those where the concept remains fairly new.

The quiz-games played were on Real Bodywork Muscles and Skeletal 3D apps that are highly visual anatomical learning tools with quiz and labelling functions. All students were familiar with these apps and encouraged to utilise them in their independent learning time, however those groups taught using iPads (N=5) could have been more familiar with these than the SER groups (N=2). This may explain why the students from SER that were in the Games (G) group had significantly greater scores than those who did not within the same cohort. The novelty factor of the tablet has been discussed across all ages of learners (Mitchell, 2014) but there seems to be an agreement that the novelty factor should and could be utilised by the educator although this obviously requires further investigation with students unacclimatised to anatomy games. The increased sensory input and novelty factor of the tablet to provide a fun, visual way of active learning could lead to an increase in engagement prior to assessment but it could also be that the concept of quiz-games for revision appealed to lower achieving students or the disengaged. Extra credit activity research has suggested that motivation to complete extra credit work or quizzes is predominately to increase grades but daily quizzes with minimal extra credit increase performance beyond this (Walker, 2006). This research presents two possible reasons; those students seeking to improve their grade or not confident in their performance could have chosen to participate in the intervention. On the other hand it could appeal to those engaged, already high achieving students based on the well-established link between academic engagement, performance, and persistence (Pascarella and Terenzini 2005; Stage and Hossler 2000), which is particularly relevant to STEM undergraduate education (Seymour and Hewitt 1997). The qualitative data collected in parallel to this study should go some way to answer the question behind student motivation to participate in the gameplay.

Quizzes have been suggested to help motivate students to complete autonomous learning tasks, increase participation in class discussion, and improve performance on exams for material covered both on the quizzes and in class (Hillman, 2012; Brothen & Warmback, 2004; Johnson & Kiviniemi, 2009). Although we cannot specify how the quiz-games increased achievement, the use of quizzes as a learning tool could potentially have an effect. The quiz-games played predominantly consisted of an image followed by questions or an image to label using drag and drop. In the e-viva there are image labelling, “matching” questions and deeper learning MCQs. The assessment is designed so that the labelling and matching questions test knowledge acquisition, labelling in the simplest knowledge recall form, matching in a more applied or unknown context to assess understanding. Applied knowledge is examined using the MCQs, some of which have a visual aid such as a figure or video clip while some do not.

Recall knowledge is an integral part of anatomy teaching and learning in medical, sports and health courses and therefore using quiz-games to enable recall in examinations could be a valuable tool in other topics such as language learning too. mLearning quiz-games could also be used on the way to an examination or prior to a learning session where fundamental knowledge is required. The mobility of smartphone and tablet games surpasses traditional notes or books by their accessibility, interaction and personalisation

The question type analysis revealed that the NG group had a significant reduction between A2 and A3 in the percentage of MCQs and matching questions correctly answered, the G group did not. Interestingly this suggests that the deeper, applied MCQs were answered better in the G group suggesting a relationship between student's fundamental knowledge through gameplay and applied knowledge. Whether this could be that better recall allows a deeper understanding to develop over time or that the gameplay encourages more than the quizzed surface learning we cannot explain from the results but there seems to be additional benefits to the pre-exam gameplay than purely knowledge recall. Further research using an unknown subject could help to see whether there was a relationship between level of knowledge acquisition and gameplay revision.

The psychology of gameplay in pedagogical theory and the learning process had been recognised by Vygotsky (1997) leading to the four principles suggested by Van Eck (2006) both of which acknowledge the work of Gagne. These principles are: 1) Games employ play theory, cycles of learning and engagement; (2) Games employ problem-based learning; (3) Games embody situated cognition and learning; and (4) Games encourage question asking through cognitive disequilibrium and scaffolding. The principles are similar to those advocated in the writing of MCQs within the taxonomy of HE. The last principle of encouraging questions through cognitive disequilibrium could be the basis of the mechanism behind quiz based or visual game play encouraging deeper, applied learning. This may also stimulate deeper independent thought and engagement in the topic which could affect a student's ability to process higher level MCQs. However, equally it could also be due to the type of student electing to participate in the gameplay – the more engaged a student is in a topic the more they will elect to do additional learning tasks (Barthakur et al. 2014). Gameplay has been shown to improve short term knowledge retention similarly to a traditional lecture (Rondon et al. 2013) and other tools such as crosswords and extracurricular quizzes (Munoz et al. 2014; Barthakur et al. 2014) have positively affected achievement however the mechanism behind the improvement remains unanswered.

The SPQ use in HE has the current teaching and learning system at the heart of it meaning that it will be governed by the learning outcome driven system. Teaching is therefore a learning related activity that either does or does not produce the desired learning outcome (Shuell, 1986). If the primary goal is to meet learning outcomes then the teacher's role is to predominantly facilitate a task that enables this to happen. Therefore the learning process measured in the SPQ is inherently biased to a certain extent especially when used in an assessment context. The student will respond to the teachers demands, therefore where rote learning is required they may have a surface strategy, whereas in a portfolio or problem based learning environment they may convert to a deeper strategy depending on their higher learning potential. Scouller (1998) investigated the use of MCQs and essay questions in Education students and found that surface learning techniques were employed more successfully for the MCQ assessment and deeper learning strategies resulted in poorer performance but this could have been due to the nature of the MCQ itself.

As discussed in the literature review, anatomy requires a platform of rote learning to enable a deeper understanding to be developed, which is a continuous process throughout the level 4 modules (Noguera, 2013; Hopkins, 2011). The results of the SPQ analysis showed no significant difference between the G and NG groups in any of the learning scores which may be due to the varied nature of the MCQ assessment. The MCQ assessments are written to allow breadth and understanding to be assessed a concept that is contested by some. However, positive studies (Hansen & Dexter, 1997; Masters et al. 2001) suggest that MCQ's can assess a wide variety of content, and help in the preparation for future assessment, in this case building to A4, a viva voce. Masters et al. (2001) also assess student knowledge within four of the six levels of Bloom's Taxonomy, which is also used by the FHEQ for writing learning outcomes (Clifton & Shriner, 2010). Morrison and Walsh-Free's (2001) descriptions of the levels are used in the anatomy module to ensure higher level thinking skills are tested alongside baseline knowledge acquisition (Morrison & Walsh Free, 2001; Reichert, 2001). The only assessment correlated with learning strategies was A1 to the surface approach and strategy and this was negative, as A1 score increased, surface learning score decreased. This is the first of the assessments and also the most knowledge based assessment requiring fundamental rote learning knowledge for 50% of the answers. This could suggest that the latter MCQ assessments (A2, A3) required a wider skill set or did indeed test more of the levels of Blooms taxonomy.

Females had a significantly lower (negative) score for deep motive, surface motive, deep approach and surface approach to studying, which highlights the possibility that females may score themselves lower for all questions no matter of the subject matter. Petrides and

Furnham (2000) found that females scored lower on self-reporting versus measured emotional intelligent tests, consistent with studies based on self-reported IQ tests. This evidence would agree that females generally rate themselves lower on self-reporting scales shown in this case by lower scores in all parameters at both ends of the scale.

The ML score was totalled from the mLearning additional question responses to give an indication of their attitude to mLearning. Those students in the G group ML score only correlated with A3 assessment but no SPQ scores. The NG ML score correlated with all but the Surface Approach score. The mLearning quiz-games used were primarily to help with the knowledge acquisition phase of anatomy learning and as an engagement tool to allow repeated revision and an alternative more "fun" way of learning. ML scores were not significantly different between the G and NG groups suggesting that many of the NG group did use ML as part of their learning strategy. The positive relationship between A3 and ML scores in the G group was highly significant, which was the point at which the intervention was staged. The fact that students had played quiz-games prior to their assessment could have biased the relationship especially if they had found the assessment easier and associated this with their use of quiz-games in revision. The significant increase in their scores from A2 to A3 and between G and NG scores would suggest they had found the assessment easier than their NG group counterparts. An alternative suggestion could be that those students who chose to play quiz-games prior to their assessment had adopted the technique as a learning tool through the year and so at A3 their ML score and achievement scores were greater because it was facilitating their approach to learning. This may also partially explain the lack of relationship with SPQ scores due to a variety of learning methods and tools used at both surface and deep levels.

Biggs (2001) suggested that learners should not be classified as deep or surface learners but merely see it as a reflection of the teacher, subject and learner in a more holistic overview. Therefore the results of the current study would suggest that the assessment does require both surface and deep learning approaches. It also suggests that there is a difference between the type of learners that engage in mLearning versus those that do not, however why and what these difference are require further qualitative analysis, detailed in the focus group analysis below.

The focus group data revealed potential information as to why and how the quiz-games helped improve achievement scores between A2 and A3 as demonstrated by the quantitative data. The focus group thematic analysis suggested that quiz-games as a revision tool was a predominantly positively viewed by the students but it should be noted that those students completing the focus groups chose to use quiz-games prior to the assessment, which could suggest they already perceived them favourably. The negative comments were expressed in the context of mLearning quiz-games rather than as a direct acute revision situation but they still provide valuable information to inform best practice of integrating quiz-games into teaching anatomy. This will be discussed in chapter 7 integrating studies one, two and three.

In terms of quiz-games the focus group and interview data suggested that quizzes with visual cues and multiple choice answers to allow instant feedback were most favourably perceived to help learning. Students spoke about the quiz-games as a learning tool for memorising facts, specifically origins and insertions of muscles where the MCQ nature of the quizzes allowed them to know the correct answer if they got it wrong. Cochrane, (2014) highlighted instant feedback as one of the key aspects of mLearning benefits. The pictures also helped them in the assessment; students suggested that they could remember the visual cue which helped them work out the correct answer. Ricci et al. (1996) found that quiz-games that provide visual stimuli and repetition could enhance memorisation of the fundamental facts.

Other aspects of quiz-games as a revision tool that the students highlighted was that the apps used were cheaper and more engaging than books and it was the interactive nature of the games and quizzes which maintained their interest and enjoyment of the subject. Ward and Walker (2008) agreed with Miller (2002) found that there is still evidence of single method use and reliance on copying, memorising and visualisation in anatomy. The focus group and interviews show that mLearning quizzes and games are more interactive and students like the "doing" aspect of playing them agreeing with active learning improving knowledge retention and understanding (Petty, 1998).

All of the qualitative data suggests that although students find the quiz-games beneficial they predominantly used the same apps that were used in the classroom environment. Focus group and interview data said that they liked being shown this innovative tool for learning. This agrees with much of the literature that shows students will only use their mobile device as a learning tool if they are show how to do so (Brand *et al*, 2011; Bice et al. 2016). Even with quiz-games, students needed to be told which apps could be beneficial prior to them using them independently.

As a revision tool, gameplay using mLearning devices was shown to have a positive effect on achievement in a MCQ assessment. Those aspects associated with gamification of learning to take forward into a potential framework for embedding them into anatomy teaching are:

- Interactive

- Fun
- Visual
- Instant feedback
- Accessibility
- Facilitator led in the first instance

From my prior teaching experience and a previous study looking at the integration of iPads into anatomy teaching (Wilkinson and Barter, 2016), I had various preconceived ideas about the benefits of using mLearning quiz-games in anatomy learning. Some of this potential bias arose from my own learning and teaching experience of gameplay and general teaching ethos of making learning active and fun. My thoughts prior to the start of this study on why the quiz-games would be useful are detailed in Figure 7.

Figure 7: My prior preconceptions of possible benefits of mLearning quiz-games in anatomy teaching.

The ideas expressed in Figure 7 could have potentially biased the student attitudes towards mLearning because as the teacher facilitating their learning having a positive attitude towards the subject in question will ultimately infiltrate my teaching and therefore their learning. However, steps were taken to minimise the potential effect of this by studying quiz-games as an acute revision method rather than as an in class tool. All students were actively using the apps and mLearning quiz-games or tools in class as part of normal teaching and use of the quiz-games outside of class was advocated as a potential learning tool. Kirkwood (2013) suggests that this type of bias, where my values and teaching methods will influence the study aims and methods is inherent in pedagogical research but the steps described above to minimise the effect surpass much of the existing literature. It could be argued that without certain preconceptions and values the innovation in teaching and desire to perform pedagogical research to inform teaching and learning that teaching would be less dynamic and potentially remain stagnant. Although my thoughts were shown to be true, the research revealed much more information about student perception and use of mLearning quiz-games. One point that I thought would be a key aspect was that students liked being on their phone; this was not mentioned in any of the focus groups, SPQ responses or interviews. This agrees with current research that students are confident using social media and the internet on their smartphone but to enable educational use means they need a facilitator to show them exactly how to do so (Brand *et al*, 2011; Bice et al. 2016). Therefore, students may not associate using their phones as an educational tool with the same emotions as normal personal use and therefore the two are more dissociated than I initially thought.

As the insider researcher these thoughts and ideas could have influenced my ability to act as the interviewer. The focus groups were online so this removed any potential positive bias towards mLearning quiz-games. In the interviews, I had already taught the students for 20 weeks and therefore we had a student-teacher relationship already existing. As discussed this is partly why semi-structured interviews were used because most of the students interviewed were confident talking to me and I felt a structured interview would make a naturally established relationship seem false, potentially changing student reaction to the situation.

The findings provide positive evidence of gamification's value in mLearning for HE. The study addresses a number of key gamification areas of opportunity as discussed in the relevant literature (Lee and Hammer, 2011) and in particular, cognitive aspects of learning, provision of emotional experiences and opportunities for learning within social contexts. Further work may be required in order to investigate which gamification aspects led to the differences observed between games and non-games learner groups.

5.0 Study Two: The effect of students using mLearning quiz-games prior to class on engagement and their learning experience.

Reflecting on *Study One* where quiz-games were seen to be a positive revision tool I wanted to find out whether this knowledge could be used to have a positive impact on both classroom engagement and knowledge acquisition in the classroom environment. Many students attend class without having done the pre-sessional reading or online activities and therefore are always a step behind those that have. This then can negatively affect the progress of the whole group in a seminar especially in a topic where knowledge is built on week by week. This is similar to language learning where a student cannot begin to compose a sentence without knowing verb tenses. If the study hypothesis is accepted, the study would suggest the teacher to recommend mLearning quiz-games as a more assessable, efficient way of learning the required information before class to help ensure all students can start at the required baseline level of knowledge.

The aim of this study is to evaluate whether gameplay prior to the start of an anatomy class increased student engagement in the class and knowledge acquisition and retention. The objectives of the study are:

1) To evaluate the level of engagement in anatomy classes using the National Student Survey of Engagement (NSSE) and video observations.

2) To investigate the level of knowledge acquisition in classes where students participate in 15 minutes of gameplay, question generation or normal preparation and look at retention the week after class.

Research hypothesis: Students who play quiz-games prior to class have greater levels of engagement In the subject matter and participate more in class as well as score better in plenary quizzes to test knowledge acquisition.

Based on the evidence from the literature review in chapter 2, a holistic approach to measuring engagement was deemed the most appropriate to take to ensure a breadth of measurement encompassing all aspects of engagement. Therefore sections 6.1 and 6.2 build on the methodology in chapter 4 to discuss the literature and reasoning behind choosing the specific methods employed in this study, 6.1 online questionnaires and 6.2, engagement measurement. Section 6.3 details the actual experimental method for *Study Two* where students undertake both pre-class conditions, Games (G) and No Games or control (NG) over two consecutive weeks of teaching. The National Survey of Student Engagement (NSSE) and video observations give an indication of engagement whilst the plenary Socrative score measures knowledge acquisition and the difference between the plenary and recap Socrative score measures knowledge retention from one week to the next. Section 6.4 includes the key results, which show that knowledge retention and acquisition increased in the G session and that the G session had less off-task behaviours and more social interaction within the seminar. The results also raise questions regarding the validity of the NSSE for class evaluation, particularly with regards to behavioural engagement. These key results and other points of interest raised in the study are then discussed in section 6.5.

5.1 Online questionnaires

There have been many studies demonstrating advantages associated with the use of technological approaches to evaluation in Higher Education (Dommeyer et al. 2004; Salmon et al. 2004; Watt et al. 2002). Watt et al. (2002) note that using online-based evaluation questionnaires reduces the strain and "bottlenecking" for the administrative aspects of the system, allowing a quicker more effective feedback method. Another advantage is avoidance of the need to administer surveys in class (Dommeyer et al. 2004), which also reduces the potential bias from having the instructor present. Unsurprisingly, there is increasing growth in the use of web-based surveying for course and teaching evaluation (Hastie & Palmer 1997; Seal & Przasnyski 2001), which is possibly because of the increasing need for statistical analysis and demand for figures within an institution. This growth is happening despite concerns from students over confidentiality, user ease (Dommeyer, Baum & Hanna 2002), and concerns from staff regarding response rates (Dommeyer, Baum et al. 2002).

Comparability of online and on-paper survey response-rate data (McCormack 2003) reported that there are modern expectations in relation to the evaluation of teaching. For example, expectations about the role of evaluation of teaching for promotion, probation, the TEF and about the public availability of student evaluation results on institution and comparison sites. The National Student survey (NSS) started in 2005 following the success and uniformity of the Australian Course Evaluation Questionnaire (CEQ). It went online in 2008 laying the foundations for the online method. These changes in expectations and focus are occurring at the same time that the use of online surveying is increasing. Considered together, this has raised interest in issues around response rates to these surveys. Yet, a review of literature regarding instruments for obtaining student feedback, (Richardson 2005) claimed that there is not a large volume of evidence available on response rates obtained between different modes of academic evaluation administration. Response rates can sometimes be found in individual methods revealing much more variability, in particular in online evaluations. In general, online surveys are much less likely to achieve response rates as high as surveys administered on paper despite the use of various practices to improve them but the potential audience reach is often wider.

Nulty (2008) reviewed eight such methods finding that the paper based average response rate was 56% compared to the online versions at 33%. Obviously these are dependent on mode of study, access and whether class based or individually targeted, especially in 2008 when online access was more restricted than today. The NSS survey has an overall response of 71%, but the institutional investment in ensuring this rate is high has possible wider implications.

5.2 Measuring Engagement

In the literature review on student engagement (chapter 2), Fredricks et al. (2004) are cited to propose that student engagement has multiple dimensions: behavioural, emotional, and cognitive. Engagement is examined in much of the UK literature aligned to the HEA framework relating it to student outcomes including student performance, progression, employability, satisfaction, skill acquisition or self-confidence (HEFCE, 2016). Behavioural engagement draws on the idea of active participation; at school level this usually includes academic, social, or extracurricular activities (Trowler, 2010). It has been suggested that behaviour is the key part of engagement when looking at both retention (Connell and Wellborn 1990; Finn 1989) and achievement, which on a modular level could correlate to completion and score. Emotional engagement focuses on the extent of positive (and negative) reactions to teachers, classmates, academics, and the institution. This can relate to a sense of belonging, the teacher-student and peer relationships and therefore impacts heavily on the learning environment. This will also affect attendance, motivation towards the subject and comfort within the learning hierarchy and therefore can directly affect student achievement, enjoyment and retention. Positive emotional engagement is presumed to create a student bond or tie to the institution or subject area and influence students' willingness and intrinsic motivation to work (Connell and Wellborn 1990; Finn 1989).

Cognitive engagement is defined as the student's own level of investment in learning; it includes being thoughtful and purposeful in the approach to academic tasks and associated with the motivation and willingness to put effort in to be able to comprehend complex ideas or master difficult skills (Fredricks et al. 2004). From a modular engagement perspective, the level of investment would be concentrated in a particular topic or module as opposed to the global level.

To try and measure engagement using questionnaires alone, which many institutions and previous research has done, is not effective in assessing all three purported components of engagement. Behavioural engagement has been measured in school-aged children using a number of different methods, predominantly using observational methods. However, the literature review suggests that observational behavioural measures do not elicit cognitive engagement suggesting there is a need for an additional questionnaire or self-reporting measure in addition to the observational measure. Engagement is dynamic and therefore some static measures and self-reporting questionnaire methods alone do not provide adequate evidence of this and are from one perspective only. Multiple methods are therefore recommended by Fredricks and McColskey (2012) and the interactive aspects of engagement require more prominence in future research.

Oliver et al. (2008) used a tool "Evaluate", to assess student engagement with respect to learning outcomes. It was based around the Southern England Consortium for Credit Accumulation and Transfer (SEEC) standardised approach to module evaluation proposed by Marsh in 1982, which is still used regularly in the UK and Australia today. Other papers have also blurred the lines between module evaluation and engagement questionnaires but previous discussion suggests that this is only targeting emotional and some cognitive aspects of engagement. SEEQ has been shown to reflect student perception and "like" or "dislike" of a teacher and can therefore be biased, more a measure of satisfaction than engagement. Even though it is a valid and reliable instrument, research findings suggest that teacher ratings do not improve over time; in fact, students' evaluations may change teachers' self-perceptions rather than teaching behaviour (Brennan et al. 2002). Another method commonly used in HE is the Course Experience Questionnaire (CEQ), developed primarily as a measure of the surface or deep learning approaches that students were being encouraged to adopt as a result of various teaching practices (Brennan et al. 2002). The focus is on the teacher not the learner and therefore could be argued not to measure engagement, rather to elicit an opinion of teaching quality and the two are not married successfully in the literature. Ahlfeldt et al. (2005) used the NSSE to compare engagement between colleges in the Midwestern US between level (freshmen to seniors) and in Problem Based Learning (PBL) versus normal classes and between different size of class. The questionnaire is linked to Bloom's taxonomy levels and has been used widely in pedagogical studies and by institutions for a number of years. It is student-reported and has a short (1 page) and longer (4 page) version where most studies use the short version to ensure maximal response rate. A strong relationship was found between the two versions further supporting the use of the shortened version. One of the issues with the various questionnaires is that reliability and validity is assumed for different student and subject populations.

Engagement literature traditionally concentrates on satisfaction and student perception in the formal learning environment, which leaves an increasingly large area of independent learning or facilitated autonomy of learning lacking. This leads researchers to question whether student satisfaction is a valid measure of engagement in a topic, which would ideally also be measured by external and informal learning environments as well. Where emotional engagement is measured, there will always be an inherent bias, which is why a measure of engagement that combined all three aspects was sought for the current study using the holistic approach discussed in chapter 3.3.

For observational engagement an in-class method was sought that was suitable for HE. Smith et al. (2013) investigated the use of a new Classroom Observation Protocol for Undergraduate STEM, (COPUS) which identified a number of in-class behaviours associated with engaged and disengaged behaviour. This included listening, writing, reading, engaged computer use, student interaction and interaction with the instructor whereas disengaged behaviours were packing up, unresponsiveness, off-task, disengaged computer use, student interaction and distracted student interaction. Alimoglu et al. (2014) also attempted to validate a new behavioural method using similar on- and off-task behaviours but looked at both the learner and teachers in the observation model. This approach is advocated as a measure of engagement because the student is so reliant on the facilitation of learning by the teacher and task-related behaviour especially in seminars where a mix of listening activities, active learning and group work means that both are needed to document the interaction in enough depth for a true measure of engagement. Most of the current literature is validated for school aged classrooms. Fredricks et al. (2011) compared 21 methods for measuring engagement, where only four were observational of, which only two observed individual students. Both the Behavioural Observation of Students in Schools (BOSS) and the MS-CISSAR involve systematic direct observations of students using a predetermined observation protocol for a set of behaviours. These measures use a form of momentary time sampling, in which an observer records whether a student exhibits a predetermined category of behaviour during a defined interval. The BOSS protocol behaviours are active engagement, passive engagement, off-task motor, off-task verbal, and off-task passive whereas the MS-CISSAR classifies behaviours as positive, negative and inappropriate. The latter was deemed too simplistic for an HE classroom and I wanted to ensure social observations were measured between peers and with the teacher as recommended by Trowler (2010) and to suit the active group-based learning environment. Validity of the observational techniques vary but both Volpe et al. (2005) and Hintze and Mathews (2004) documented high inter-observer reliability (90%). Student reliability, however, took four repetitions over a four week period to be adequate but this is suggested to be in-part due to the broad nature of the behavioural coding and variability of class subjects in school-aged education (Fredricks et al. 2011). With more specific codes, the coder may need more training or may need to use video rather than in real-time to increase reliability.

Andragogical engagement measurement literature is more limited (Ahlfeldt, 2005). O'Dair (2012) uses an adapted model of the NSSE for Masters level student, which uses the same benchmarking or dimensions. These benchmark dimensions are: (a) Level of Academic Challenge (LAC), (b) Active and Collaborative Learning (ACL), (c) Student-Faculty Interaction (SFI), (d) Enriching Educational Experiences (EEE), and(e) Supportive Campus Environment (SCE). Using andragogical learning parameters assumes that all learners are able to which at masters level could be expected, whereas at level four andragogy and pedagogy are blurred, both in teaching and learning as the foundations are laid for the higher levels (Parkinson and St George, 2003). Many studies still rely on achievement or grades as a measure of engagement in HE which either suggests high levels of andragogy or that the term engagement is directly related to performance (Chametztky, 2014).

The methods therefore chosen to measure engagement in this study are a modified NSSE questionnaire to measure emotional and cognitive engagement alongside behavioural observation of engagement using video, this is a modified version of the Alimoglu et al. (2014) method to contextualise the nature of the technological classroom used in the module studied. The modifications made were to reflect the tools used in the learner environment and to try and integrate the autonomous mLearning environment and the classroom. Additional statements added to section 1 were:

How often have you…

Come to class without completing readings or assignments?

- Discussed ideas from your readings or classes with others outside of class (students, family members, co-workers, etc?
- Used your smartphone or tablet device for learning?

All other sections remained the same and therefore the scoring system was retained but both a modified and standard score were calculated to allow comparison to other studies.

The university NSSE (Ahlfeldt et al. 2005), which measures self-reporting cognitive engagement and emotional engagement, was completed after each seminar during data collection to allow all proposed aspects of engagement to be measured. The NSSE is an established instrument that was developed to measure engagement in educationally relevant activities and the desired outcomes of Universities in the USA (Pascarella &Terenzini 2005; Kuh 2009). The NSSE is an indirect measure and therefore doesn't measure the extent of a student's engagement, merely whether they have experienced the item in question but is the most commonly used method in the literature (O'Dair, 2012). The NSSE is suggested to exhibit acceptable psychometric properties (Kuh, 2002) and items focusing on good practices in undergraduate education. It is also suggested to consistently predict development during the first year of college based on multiple objective measures (Pascarella et al. 2009) aligned to Bloom's taxonomy of levels. Items from the larger NSSE have been used to develop shorter scales to measure engagement in educationally relevant practices and engagement in online courses (Kuh et al. 2008; Chen et al. 2010). One example includes the chosen version used by Ahlfeldt et al. 2005 with an additional option (Used your smartphone or tablet device for learning) added to the question, "During your class, about how often have you done each of the following? (Scale: 4: very often; 3: often; 2: occasionally; 1:never). The NSSE questionnaire used is detailed in Appendix B.

By totalling the scores from questions 1 through 4, a cooperative learning variable was created. The scores ranged from 4 to 16, with a mean of 9 and a standard deviation of 2.7. The cognitive-level variable was created by combining questions 5 through 9. It is noted that question 5, which is a question about the amount of memorization of class material, was recoded (1 became 4, 2 became 3, 3 became 2 and 4 became 1). Memorization of material would not increase classroom engagement and was reversed to provide an accurate engagement score when statistical tests were run.

5.3 Method

Ethical approval was received from the LSI sub-committee of the School of Science and Technology Ethics board in October 2015 for the 2015-16 academic year data collection (Appendix A). The study was completed in the autumn term of semester one and then repeated in semester two using two different formats. In semester one the three experimental conditions were completed by all seminar groups in the same order, in the second semester it was repeated as a randomised crossover design over a three week period as described in *Study Three*. Initially, the crossover design was to be used in both semesters but for the video observational engagement data to be comparable, the classes had to be the same format, which was only possible with the same intervention in the same classes.

Students were asked for informed consent to allow the videoing of sessions so that observational engagement analysis could be completed after the seminar. Students were given the option of not participating in the video analysis by having one group able to participate outside of the field of view; only one student opted out of data-sharing; no students opted out of being videoed. The recruitment was voluntary and no incentives were offered. Students could opt out of the study at any time without informing the module leader, by non-attendance or by sitting in the non-videoed section. The 15 minute intervention was integrated into the two hour seminar at the beginning of the session to ensure maximal participation and so as to not impinge on any other timetabling or travel commitments. The video camera and classroom set up is shown in Figure 8.

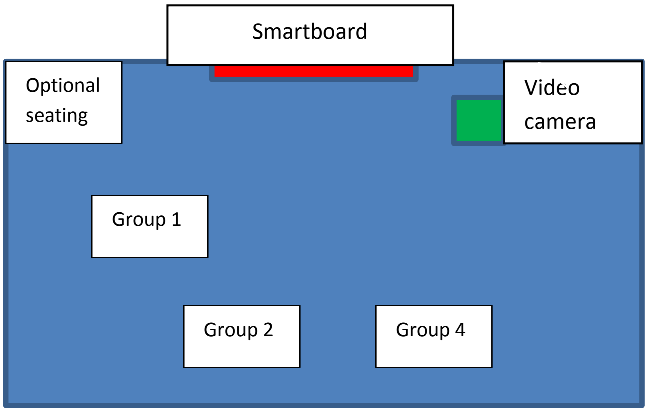

Figure 8: Classroom Video Set up sowing the camera, group positions and the smartboard

5.3.1 The Intervention

The pre-seminar 15 minute intervention was incorporated into two taught two hour seminar sessions in the level four Anatomy module for seven of the eight seminar groups. Each group had between twelve and twenty students but attendance varied throughout the semester. Students were included in the within-student analysis for semester one if they attended both of the data collection sessions. All consenting student data was included in between-subject analysis. Data analysis was completed in week six, seven and eight and nine of semester one.

The method is outlined in Figure 9, showing the data collection methods in weeks seven and eight. Week six included a plenary Socrative score and Week 9, a recap score to compare for knowledge retention norms. Normal module data for achievement, attendance and SPQ scores were also collected as of course for the module evaluation.

The data collected was part of the normal seminar structure (one two hour seminar once per week). Students were informed of the data collection but not told what I was looking at or the nature of the interventions to ensure as naturalistic an approach as possible. Socrative quizzes are a normal part of the teaching toolbox for the module and used regularly in both lectures and seminars. Socrative is a mLearning app that has a teacher and student version allowing a mobile response system to be used in, during or following classes giving the student and teacher immediate feedback as to student's knowledge depending on the settings chosen (Dervan, 2014). It is a free app that I have been using for over four years in both large group and seminar sessions enabling whole group graphical representation that can be presented to the classroom to increase social and competitive based learning aspects. The Socrative quizzes were done at the start of the session using students' own smartphones, tablet devices or the University iPads.

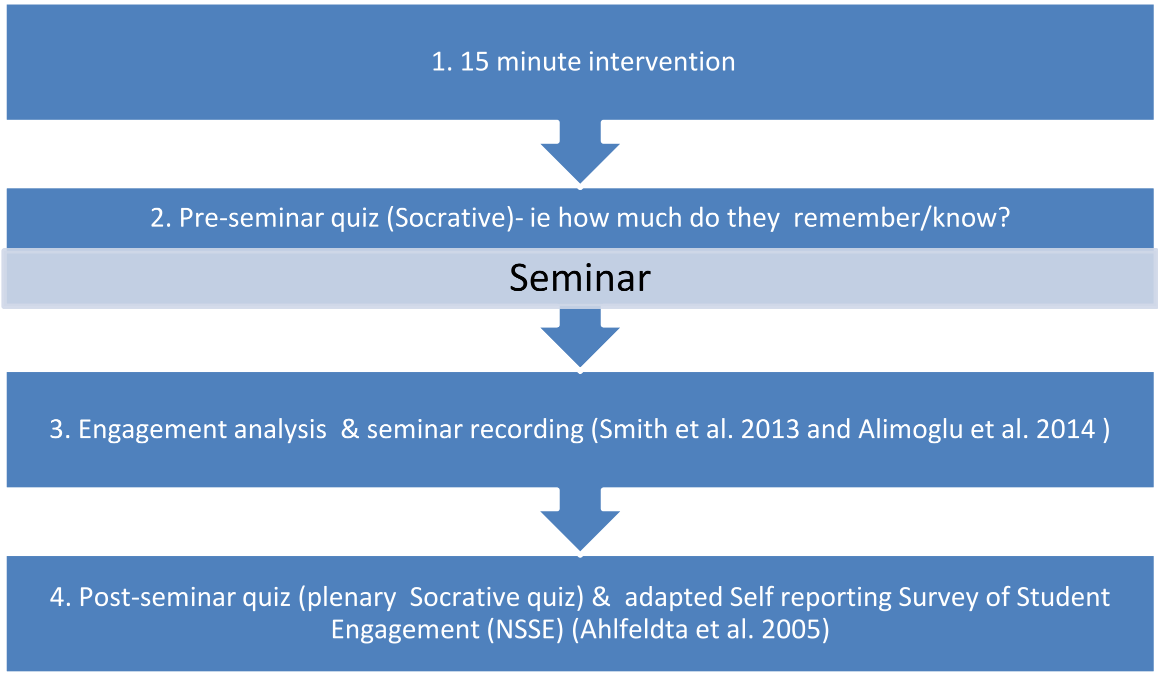

Figure 9: An overview of the method sequence for each class performed with both G and NG groups.

The Socrative quizzes all consisted of ten questions based on the taught sessions but were tested for consistency and reliability using the Alpha-Crohnbach coefficient, which was 0.84. Socrative quizzes were checked for errors and piloted using the Student Learning Assistants (SLAs) for the module and the tutor for the rehabilitation students doing the same module, but not participating in the study. They were multiple-choice questions based on material covered in the session with one question based on the additional reading available on the VLE, Moodle. In semester one the students completed the study intervention for the topics of the lower limb, hip joint, hip muscles, knee joint, and knee muscles sessions as shown in Figure 10. Students did one Socrative quiz at the beginning of each session (recap) and one at the end (plenary) to enable a measure of knowledge retention and acquisition. Knowledge retention was measured by comparing the difference between plenary score of the first week to the recap score of the next whereas knowledge acquisition was measured just by comparing the plenary scores at the end of each session.

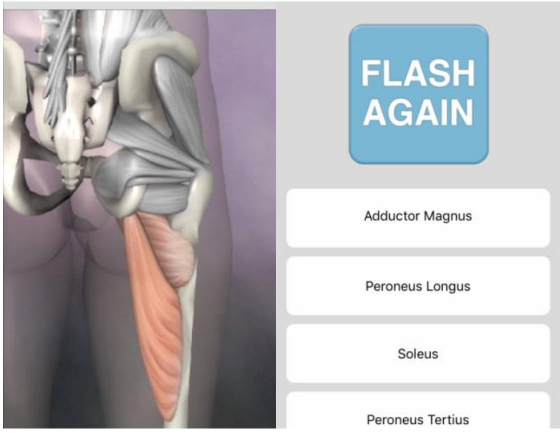

Figure 10: A screenshot of Real Bodywork and skeletal 3D quiz-games and quizzes for the lower limb

At the end of each session the modified NSSE was completed using the Bristol Online Survey. Students were emailed a link to the survey (https://mdxuni.onlinesurveys.ac.uk/national-student-engagement-class) on the morning of the seminar and were asked to complete it before leaving class following the plenary Socrative quiz. Scores for the modified SPQ were downloaded as an Excel spreadsheet each week coded by student number. Once all data collection was complete the student numbers were coded using a 4 number code for anonymity. The Socrative quiz scores were emailed to the tutor each week as an Excel spreadsheet and they were integrated at the end of the two seminar days.

5.3.2 Observational Engagement analysis

The video camera was set up in the corner of the teaching room, where the tripod position was marked using zinc oxide tape and height measured at 1.65m to support the repeatability each week. The recording was started following the Socrative quiz and intervention each week and finished prior to the start of the plenary Socrative quiz. Sampling was taken at three 5 minute periods at the start, middle and end as discussed in section 5.2. The exact period was based on a teaching cue from the lecturer which was consistent between sessions to help standardisation of video analysis (Shernoff et al. 2016). Pilot observations were made and CELT consulted over the set-up and position of the camera. Recordings were sent to the University Centre for Excellence in Learning and Teaching (CELT) for downloading where the video segments were uploaded to the researchers' Kaltura page; the internal Moodle player used by Middlesex.

Plate 1: A screenshot from the video used of the classroom with the students for analysis highlighted.

Observational engagement criteria were coded for using the Dartfish app for iPhone 6, EasyTag. The number of on-task/off-task, student-student, student-staff, student-SLA interactions coding was adapted from Smith et al. (2013) and Alimoglu et al. (2014) consisting of a mixed lecturer or facilitator and student method.

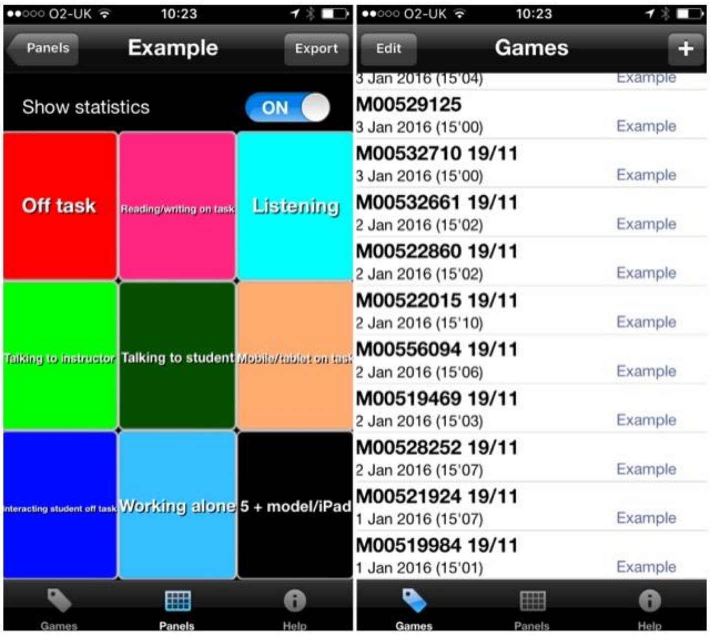

Plate 2: A screenshot of the coding screen and files on the EasyTag app

Coding used interval observational analysis for each of the five minute periods at thirty second intervals. The observations coded for are shown in Table 9 and a screenshot of the Dartfish app is shown in Plate 2.

Table 9: Coding ethogram for in-class engagement measurement using Dartfish

Code	Behaviour
1	Engaged with non-educational material such as mobile phone, hand bag etc.; browsing a book, notes etc..
2	Reading or writing something on task (maybe following the lecture from a published material or taking notes).
3	Listening to the instructor or a talking student or looking at slides or board, eye contact, look of interest.
4	Talking to the instructor (questioning, answering, discussing, etc.), reading something (e.g., seminar notes) to entire class or writing something (e.g., major signs of a disease) on the board, flip-chart etc.
5	Talking or discussing (asking, answering, explaining, etc.) with one or a group of students on the subject matter.
6	Interacting with mobile phone or tablet for a learning task as an individual or as a group.
7	Student is interacting with another student off task.
8	Student is working alone rather than in the required group situation.
9	Student is talking/discussing (asking, answering, explaining, etc.) with one or a group of students using a model, skeleton to interact.

The data for each student was then emailed to the researcher as a csv file and uploaded to Excel for analysis using student number to identify. This data was linked to the quantitative Socrative and NSSE scores for within student and between group analysis.

5.3.3 Statistical Analysis

The quantitative data from Socrative scores and NSSE scores was tested for homogeneity of variance and normality suggesting it met the criteria for parametric statistical analysis. In *Study Two* there were two conditions, Games (G) and No Games (NG) and therefore a paired t-test was used for within student comparisons whilst an independent for between. The coding data was totalled for each student so that each behaviour from Table 9 had a count and a percentage. There was a score for engaged, disengaged calculated by totalling on and off-task behaviour. Pearson correlations between variables were performed where relationships were being investigated and the significance level set at 95%, $p<0.05$.

5.4 Results

The results are presented in two sections; 5.4.1 presents the data on achievement, knowledge acquisition and retention in the Games and Control sessions. Section 5.4.2 presents the NSSE and Section 5.4.3 the video observational engagement data.

5.4.1 Knowledge Retention and Acquisition

The recap scores from the Socrative quizzes were compared between the Games (G) (N=87) (58.41 ± 15.3%) and control (NG) (N=84) (45.98 ± 20.9%) weeks using an independent t-test revealing a significant increase in the Games week ($t=-4.480$; $p<0.001$). The plenary quizzes also showed an increase from 54.48% ± 16.9% in the control to 60.37 ± 12.9%, ($p<0.01$) in the G week. Bonferroni corrections were made based on 2 dependent variables, therefore p was set to 0.025 and therefore all significance levels remained valid.

The difference between the recap and plenary of weeks 7 and 8 (NG) and weeks 8 and 9 (G) was tested using a paired t-test to investigate knowledge retention. Knowledge acquisition was compared using plenary scores of week 7 (NG) and week 8 (G) represented in Figure 11. The mean KR was 5.77 ± 21.3 % for NG and 17.8 ± 20.4% for the G seminar. Both knowledge retention and knowledge acquisition were significantly greater in the G seminar ($p<0.01$) (KA $t = -2.504$; KR $t=-3.095$). Bonferroni corrections were made based on 4 dependent variables, therefore p was set to 0.0125 and therefore all significance levels remained valid.

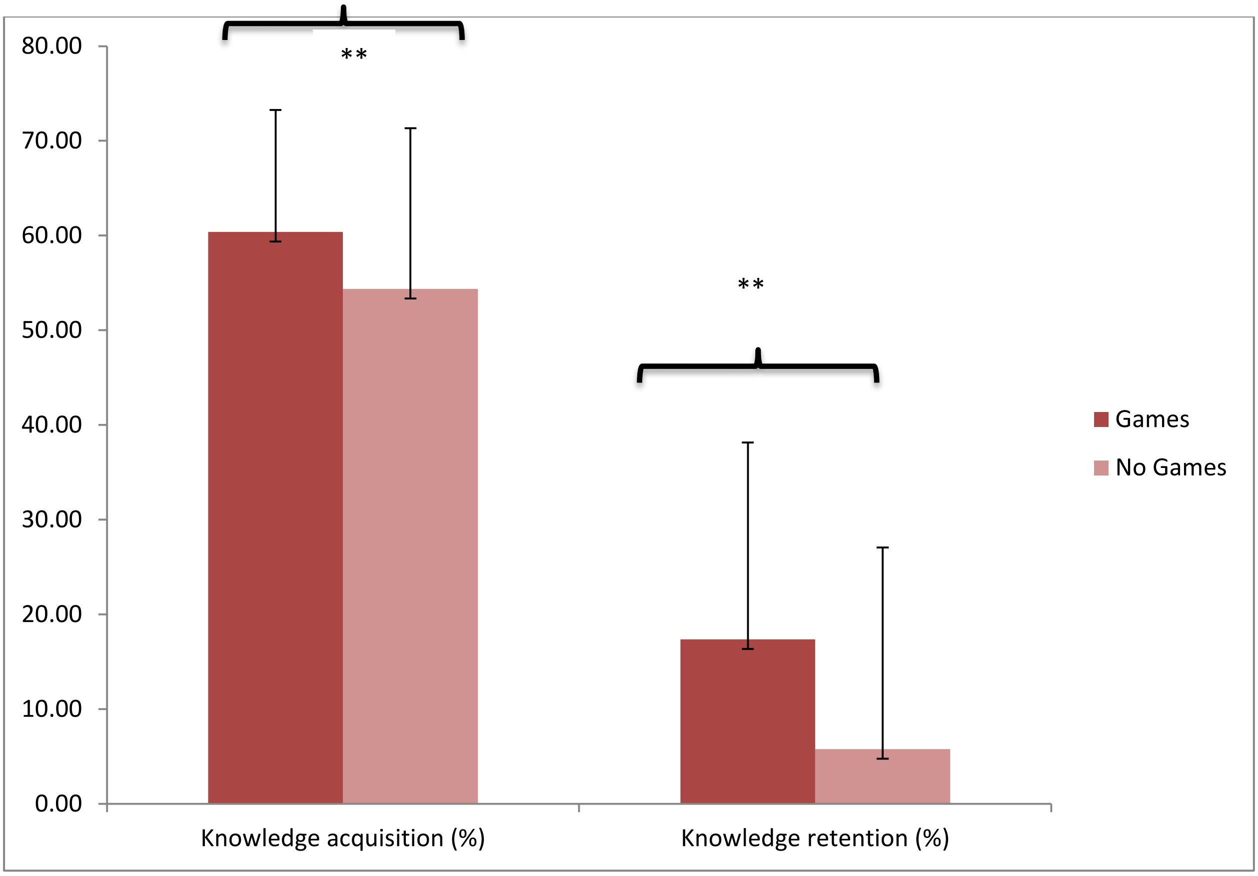

Figure 11: The mean Knowledge Acquisition (KA) and Knowledge Retention (KR) in Study 2 for G (Games) and NG (control) groups. (**) significant at 0.1% (p<0.001) using a within-student paired t-test.

5.4.2 NSSE Engagement Scores

In the first instance the NSSE Engagement scores will be described to meet Objective One and then compared between groups for objective two.

The NSSE scores were manipulated as per the method described in Ahlfeldt et al. (2005) to get the scores for Cooperative Learning (CL), Cognitive Learning (CogL), Personal Learning (PL) and Engagement Score (E) for both No Games (NG) and Games (G) groups. NSSE scores and individual questions were compared in the G and NG sessions using an independent t-test and Pearson correlations performed between all variables. No significant differences in Engagement Scores were found between the groups. A significant difference was found between the G and NG group using a paired t-test for the questions highlighted in Figure 12. A Table of the question data can be found in Appendix E. Question 3.2, 'Working with others during class' and Question 3.6, 'Use my smartphone for learning' showed significantly greater scores in the G session compared to the NG session (p<0.001) (1 never; 4 often). Question 3.5, 'Come to class without completing the notes' had a significantly greater score in the NG group compared to the G session. The correlations revealed a highly significant relationship between plenary score and engagement score in both G and NG sessions and the recap score and plenary score had a coefficient of 1.0 (p<0.001). Engagement scores were not significantly related to the recap score of the following session.

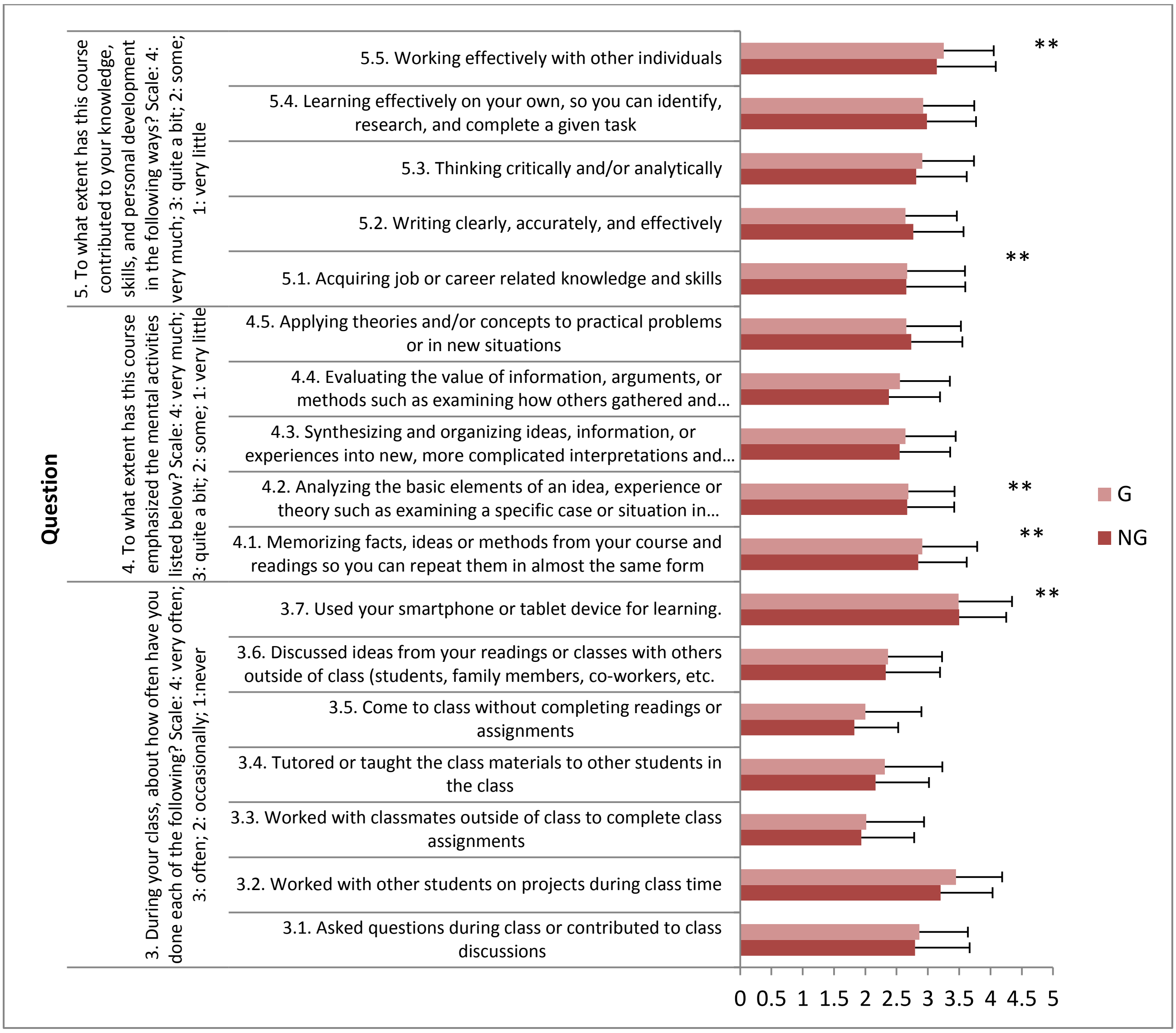

Figure 12: Within-Student Games (G) and No Games (NG) response means for the NSSE Questionnaire Results

The scores for each of the sections of the NSSE as described in section 6.4 are shown in Table 10. A paired t-test was also used to compare all NSSE scores for within student analysis (N=45) finding no significant differences (p>0.05)

Table 10: NSSE section scores Games (G) and No Games (NG) groups showing no significant difference between them.

NSSE section	group	N	Mean	SD	t	df	Sig. (2-tailed)
Cooperative learning score	no games	66	12.328	2.6789	-.483	228	.629
	games	67	12.925	2.5365			
Cognitive learning score	no games	64	12.484	2.2253	-.168	129	.867
	games	67	12.060	2.0292			
Personal score	no games	66	14.266	3.2574	-.848	131	.398
	games	67	14.358	3.0337			
Total Engagement Score	no games	66	39.0781	6.49861	-.545	133	.998
	games	69	39.9104	6.10447			

5.4.3 Behavioural Observation Engagement analysis

45 students attended both weeks allowing comparative analysis but only 20 were deemed to be valid for the video analysis due to visibility to ensure validity. Counts for the three chosen

five minute time periods (beginning, middle, and end) were combined for an overall seminar sample and are shown in Appendix D. The proportion of each session as a percentage of the total time sampled for each of the behaviours is shown in Table 11. Activities were categorised further into engaged and disengaged activities to account for session variability considering the tasks required slightly different learning activities and therefore learning responses from the students. The mean percentage time students were engaged in the NG session was 85.6 ± 9.56% and 97.3 ± 2.3% in the G session as shown in Figure 13.

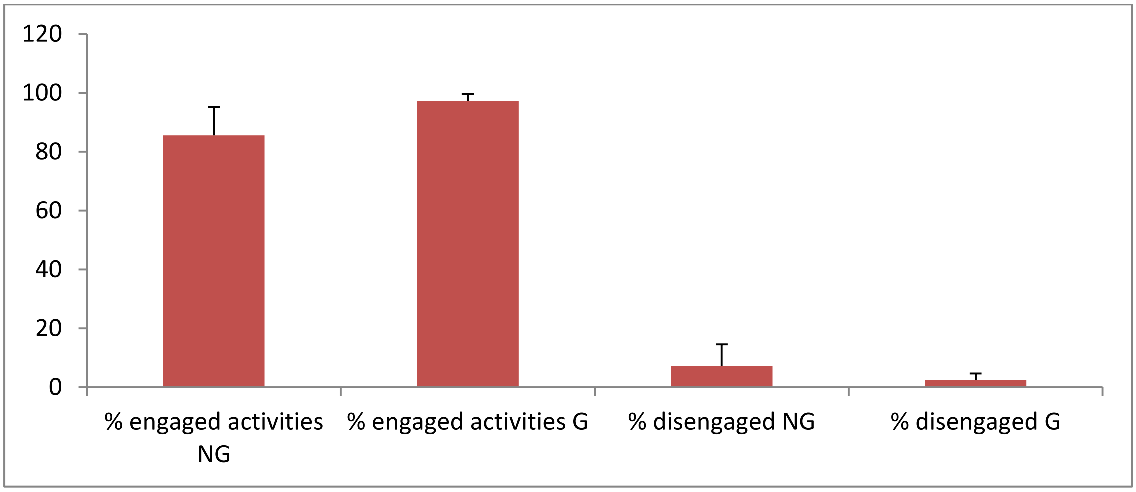

Figure 13: The percentage of time spent engaged and non-engaged in the seminar sessions for Games (G) and No Games (NG) sessions.

A paired t-test was performed revealing a significant reduction in the engaged activities in the NG week ($p<0.001$; $t= -5.346$). Time spent reading or writing and working alone decreased in the G session ($p<0.01$; $t=3.174$). Time spent on-task and talking to other students on task were significantly greater in the G session ($p<0.05$; $t=2.387$). There was no significant difference between sessions in talking to the tutor, listening or using the learning tools (for example, skeleton, iPad) ($p>0.05$). Bonferroni corrections were made based on 2 dependent variables, therefore p was set to 0.025 and therefore all significance levels remained valid.

Table 11: Mean percentage time for on and off-task behaviours in the Games (G) and No Games (NG) seminars.

Behaviour	% seminar time (NG)	% seminar time (G)
On task (device)	35.7	24.2
On task (talking to student)	17.1	30.4
On task (talking to teacher or SLA)	3.7	4.1
On task (listening, reading, writing)	29.1	38.5
Off task (using device)	2.2	1.4
Off task (talking to student)	7.2	0.3
Off task (other)	5.0	1.1

The behavioural observation of engagement was compared to the NSSE and Socrative scores using Pearson correlations. No significant correlations existed between the achievement scores and engagement levels ($p>0.05$). There were highly positive correlations seen between both G and NG seminars ($p<0.001$) and in both seminars for the NSSE statements ‘Used your smartphone or tablet device for learning’ and ‘Worked with other students on projects during class time’ as shown in Table 12. The engagement score in the G session positively correlated with the question ‘Synthesizing and organizing ideas information or experience’ ($p<0.05$) and negatively with the Cooperative learning score ($p<0.05$).

Table 12: Key Pearson correlation data investigating relationships between NSSE and observational engagement percentage.

		% engaged NG	% engaged G	1)Asked questions	Cooperative learning score	9) Analysing elements	10) synthesising	2) Worked with others	7) Used mLearning device	Cognitive score	Personal score	Engagement score
% Engagement NG	R	1	.886**	.118	-.204	.287	.336	.659**	.629**	-.060	-.004	-.026
	p		.000	.641	.388	.248	.173	.003	.005	.791	.985	.907
% Engagement G	R	.886**	1	-.501*	-.461*	.444	.547*	.601**	.654**	-.031	.046	.004
	p	.000		.034	.041	.065	.019	.008	.003	.890	.840	.986

The results from Study Two presented in this section are now discussed with respect to current literature, practice and the study aims in section 5.5.

5.5 Discussion

The aim of this study was to evaluate whether 15 minutes of gameplay prior to the start of an anatomy class increased student engagement in the class and knowledge acquisition (KA) and retention (KR). Section 5.5.1 discusses these factors but other factors that arose in the study results have been discussed in Section 5.5.2.

5.5.1 Student Engagement and Learning

Students showed a significant gain in knowledge in the G sessions based on the KA and KR scores but more so in the KR scores. KR was measured using the difference between plenary and recap scores of successive weeks revealing a highly significant increase following the G seminar compared to NG. Recap scores were measured prior to any intervention to give an indication of independent learning and knowledge retention since the previous seminar the week before. There is the argument that the testing process itself could increase knowledge retention as shown in research regarding formative testing (Roediger and Karpicke, 2006). It could also be student self-reflection impacting on their independent study focus during the week (Roediger and Butler, 2011; Lameris et al. (2015)). The plenary or KA scores were significantly greater in the G session compared to the NG suggesting that students had learned more or been able to learn more effectively following the G intervention. Independent of the mechanism, the gameplay prior to the session helped students acquire knowledge in the session and in knowledge retention for the week afterwards. Therefore, as a study aid for achievement and knowledge acquisition prior to class it is shown to be positive. Increases in knowledge acquisition following the gameplay could be as a result of many different learning factors including a greater fundamental knowledge to build on, increased engagement, psychological factors and group learning dynamics; all of which will now be discussed.

Gameplay could be viewed as a novelty inducing the Hawthorn effect, however, the study was conducted in weeks seven, eight and nine where students had regularly used quiz-games in class and some individually. Therefore, gameplay having a novelty effect was unlikely which is illustrated by the scores in the modified NSSE where in both sessions, the students responded positively to the question “Used your smartphone or tablet device for learning” indicating that they were not a novel learning device for them.

Perotti (2002) suggested that memorisation in anatomical sciences could be redundant because of more active learning techniques being utilised which facilitate integrated memorisation of information. Students showed that the subject still needs high levels of memorisation from the NSSE results but potentially, the gameplay is a different tool for this process to occur. Games and quiz-games can facilitate knowledge acquisition via the act of doing (Petty, 1998), increasing motivation, interest within the subject (Dominguez et al. 2013) and greater levels of engagement in class, the topic and their own learning journey (Hamari et al. 2014; Procci et al. 2012). Pre-class reading or activities are commonly advocated by educators to aid independent learning and encourage the development of learning autonomy. Many students, in practice do not do the required amount or quality of self-study needed to excel in their degree and since the introduction of the nine thousand pound fees many see themselves as consumers (Nixon et al. (2016)). Research discussed in chapter 2 suggests that the practice commonly termed "spoon feeding" is becoming more widely practised, particularly at FE levels (Nordin et al. (2016)). This, combined with the consumerism that university now attracts could be even more of a trigger for less autonomy of learning. If gameplay can stimulate interest in a subject as well as aid in knowledge acquisition then this could be an active alternative for those students who lack motivation or the skills for independent learning. This could be even more useful as a tool at level 4 where in the FHEQ the main element of Blooms' taxonomy is knowledge and understanding with limited higher level thinking skills.

Three measures of engagement were used in *Study Two*, the observational video data, the NSSE scores and achievement scores. This approach uses the holistic approach where the NSSE has a measure of Emotional, Behavioural and Cognitive engagements as defined by Fredricks et al. (2004). The holistic NSSE engagement scores were combined with the video analysis for actual behaviour and the success outcome of achievement, therefore all aspects highlighted by Fredricks et al. (2004) were measured. There was only one relationship identified between observational behavioural engagement and one of the NSSE indicators, cooperative learning, no other relationships were found. This would suggest that the NSSE does not provide a valid measure of behavioural engagement and should be used cautiously as a fully holistic approach (Kuh et al. 2005). It also suggests that behavioural engagement relates most strongly to group working and students' relationship with peers and educators compared to their emotive or cognitive engagement in the subject. This may be less apparent at level 4.

Scores for the NSSE agreed with the relationships found in Ahlfeldt et al. (2005) between the three sections, Cooperative, Personal, Cognitive that make up overall Engagement scores. The average NSSE overall engagement score in the USA was 38, in this sample it was 39 for NG and 39.9 for G indicating that this study was comparable, further enhancing the reliability of the current study. The G session was nearly two points greater than the US average further suggesting that using subject specific quiz-games prior to the session could help engagement.

The positive relationship found between NSSE engagement score and KA or plenary test score in the G session could suggest that engagement in class and therefore learning in class improved after gameplay and this was mirrored in the KR scores. Therefore the results of this study suggest gameplay prior to class increases engagement and knowledge acquisition in class and knowledge retention but the reasons for this remain largely unanswered.

Classroom behaviour can affect the learning environment both positively and negatively and subsequently have an effect on learning potential and achievement. Disruptive or negative behaviour can be a barrier to class learning outcome fulfilment and has been shown to reduce test scores (Akey, 2006). Studies in school aged children have found that students who exhibited inattentive, withdrawn or aggressive behaviours had low academic performance (Finn, Pannozzo, & Voelkl,1995; Ladd & Burgess, 1997). They suggest that these students are likely to gravitate to other students engaging in negative behaviours, face academic failure, and have trouble interacting with their peers (Akey, 2006; Barriga et al. 2002). It could be argued that the university classroom is very different compared to the school primarily because students have chosen and are paying to be there. However, for those students not engaged showing negative behaviours, it is likely that this literature could transcend the education levels. Negative behaviours observed in *Study Two* were recorded as off task and included talking to peer, looking away or not concentrating and distancing themselves from their group. Off task behaviours only accounted for 14.4% of time in the NG session and 2.8% in the G session suggesting that the majority of students were engaged for most of the session. This could have been affected by the presence of the video camera but students were aware that they were not being judged by the data and students did not seem aware of the camera during the sessions.

In anatomy, the subject is developed throughout the year where knowledge is built layer upon layer for each of the sections. Therefore, if students struggle to engage in a topic or not gain the basic knowledge needed every session this could impact on the whole class dynamics and behaviour. This can also feed into the cycle of failure described by Busch et al. (2015). Where failure can occur when the basics are not mastered, either by lack of understanding, absenteeism or lack of motivation self-efficacy, intrinsic motivation can further decline (Csikzentmihalyi, 2010). This can then negatively impact on future learning success where in anatomy this can also impact on the whole class. If gameplay can aid knowledge retention and acquisition as well as potentially being a viable substitute for pre-class reading or activities this may further positively impact on preventing students from entering this cycle of failure.

Engagement scores and all sub-categories measured using the NSSE did not improve in the G session, however, observational measures of student behaviour showed significantly less off task behaviour in the G session compared to the NG session. The NSSE questionnaire is primarily designed as a course evaluation not for individual sessions and therefore the questionnaires are not designed to be used as a week on week differentiator. In the future, another form of evaluation should be sourced but student evaluations are questioned regularly within the sector. The NSS questions have been reviewed for the upcoming TEF because they are not considered to represent engagement reliably (Neary, 2016). The questionnaire was completed at the end of the session whilst students were still in the seminar session so there would be no detachment from the session in question. This may help to explain the non-significance between the two sessions but potentially this is where the NSSE evaluates engagement with a course or subject but not how they engage with the topic or course in a classroom environment. This could suggest a difference between student perception of engagement and the measures of the NSSE with their actual actions of engagement measured in their behaviour.

The G session resulted in significantly less off-task behaviours recorded and higher achievement scores suggesting increased in-class engagement. The G session had greater levels of peer interaction and notetaking and less time interacting with the skeleton or iPad. Greater peer interaction on task suggests greater cooperative or group learning and potentially greater cognitive skills through peer based learning. Taking notes is a learned response to instruction developed through their primary and secondary education (Ahn et al. 2016). Notetaking can take different forms and functions but prior research indicates that notetaking in general facilitates students' learning (Kiewra, 1988; Kiewra, Dubois, Christian, McShane, Meyerhoffer, & Roskelley, 1991; Kobayashi, 2005). Increased notetaking combined with peer interactions suggest that potentially students are forming internal connections with the seminar material and external connections with previous knowledge. Sometimes notetaking is associated with copying down lecturer instruction or thoughts and therefore not seen as a measure of engagement but where it is in a peer led seminar session it should be more of a success outcome. Some educators suggest that active participation and reflection on using that information is part of the learning process in a class (Healey et al. 2013). In the NG seminar there is a greater level of interaction with the devices but less notetaking and less peer interaction suggesting that potentially their engagement with the devices is more superficial than in the G session.

The predominate off-task behaviours seen in the NG session were peer interaction (off task), using their phone or tablet (device) and others. Other behaviours included staring into space, not being in their group space (either seated or actively participating) or pretending to work (Wang et al. (2014)). Disengagement can stem from many things including finding a subject difficult or equally, lack of academic challenge (Shernoff, 2010). Anatomy is generally seen as a difficult subject within a Sports Science programme due to the large amount of new terminology and memorisation of origins, insertions and names. This makes it unlikely to be due to lack of academic challenge which is supported by the achievement scores (correlating to engagement) and the responses to the NSSE (Hamari et al. 2016). Competency in a subject is associated with motivation, therefore finding the subject difficult could lead to a lack of motivation and therefore potentially lead to negative engagement outcomes such as failure, drop out or disruptive behaviour. Academic challenge in anatomy is often related to ability to memorise names and facts rather than higher level thinking, but similar to language learning, the building blocks of the topic are a vital part of progressing to higher level learning processes.

Studies have positively related flow to gameplay (Hamari et al. 2014; Procci et al. 2012) and to achievement of learning outcomes (Chang et al. 2012; Liu et al. 2011). Elements of gamification that could positively affect classroom engagement following gameplay would be increased competency or knowledge, immersion in and enjoyment of the topic and instant feedback and rewards (Csikzentmihalyi, 1990; Fukuchi et al. 2000; Moy el al., 2000; Steinmen and Bladtos, 2002; Ballon and Silver, 2004; Eckert et al. 2004; da Rosa et al. 2006; Breylefeld and Struwig, 2007; Reece and Wells, 2007; Teyner et al. 2010; Sung et al. 2015). These elements could then feed forward into the class they are entering which could further enhance engagement by a continuation of active learning, challenge and peer or student led learning. It would be naïve to say that gameplay prior to any class will increase engagement because the teaching style and quality will of course impact on in-class engagement. However, the effect of increased knowledge or competency is shown to feed into motivation and the success cycle, which can lead to acute and subject engagement improvement (Busch et al. 2015). This study looked at the effect of gameplay prior to a seminar, which is designed to encourage active learning, cooperative, group based learning and elevated peer and facilitator interaction.

5.5.2 Discussion of other factors raised in *Study Two*

Other factors that impact on learning and could be affected by gameplay were identified in the results including gender and class and group learning dynamics, which are discussed in the next two paragraphs.

Gender has been discussed extensively in school aged children investigating why boys underperform compared to girls and how gender identity develops through their education pathway. However, it is less commonly investigated in UK Higher Education but success outcomes of engagement are published thoroughly. Kessels et al. (2014) found that the perception that displaying effort and engagement at school is feminine leads to a discourse between male gender identity and academic engagement in general. Much of the literature suggests that at lower achievement level there is a gender gap whereas at higher grades there is no difference (Kupczynski et al. 2014). This mirrors school aged children where at GCSE level females outperform male counterparts but the gap lessens and depending on the subjects, reverse by A-level (Jacob, 2002). On this evidence it would suggest that no difference would be expected in academic success in higher education but even more so in a STEM type subject such as anatomy where males tend to outperform females (Voyer and Voyer, 2014). These differences in male dominated subjects were shown to be not significant, however, in more equally distributed groups the gender affect became more significant. The cohort in Study Two is predominantly male and therefore based on the meta-analysis done by Voyer and Voyer (2014) a gender difference would not exist. Huang (2012) looked at self-efficacy and found that the gender gap existed favouring males but this was exacerbated in the STEM subjects and lessened (favouring females) in the arts.

The Cooperative learning score represents students' group learning preferences and their feelings towards its use. Machemer and Crawford (2007) suggest that active learning is doing whereas cooperative learning is doing with others. Herrman (2013) discusses cooperative learning as a way to increase social interaction and meeting both individual and peer learning outcomes. Positive interdependence in cooperative learning means that group members should perceive that the collective effort of the group is essential in order for the individual learners to achieve their goals (Johnson and Johnson, 2009). The cooperative learning scores were lower than those seen in Ahlfedt et al. (2005) and NSSE average scores where the mean was approximately 9 whereas in this study the mean was 12 suggesting that there is a high level of group and peer learning. Looking more closely at the Cooperative learning score questions, the students scored the in-class questions highly but the scores for those looking at independent cooperative study were much lower. This agrees with the idea that level four students in particular have not yet developed autonomy of learning and potentially need to be shown how to use group learning methods outside of the classroom environment to add them to their study toolkit rather than rely on self-discovery. The personal and cognitive scores are similar to published norms further reinforcing the validity of the study.

Study Two has demonstrated a positive increase in behavioural engagement and achievement following quiz-gameplay prior to a seminar class. The positive effect on knowledge acquisition and knowledge retention between classes has been discussed with the potential experimental effect of order being indicated as a possible co-factor. Therefore, in semester two a crossover design was chosen to ensure that a timing bias would be minimised and to remove a potential effect from the topic being easier or more favourably regarded. Order could not be eliminated as a factor in semester one and therefore repeating it as a crossover design in *Study Three* accounts for the effect of order and therefore can test the reliability of the semester one results.

6.0 Study Three: The use of mLearning quiz-games as a tool for pre-class preparation – a generalised approach.

Following evaluation and reflection on *Study Two,* parts of the study were repeated in *Study Three*. The aim of this was to increase generalisability and to try and account for the potential effect of time or order identified from the discussion of *Study Two*. Where the interventions were completed in the same order in study two there could have potentially been a learning effect or an additive effect of the learning tools used. *Study Three* therefore uses a randomised crossover design for the interventions allowing timing to be taken out of the effect equation.

The aim of this study is to evaluate whether quiz-game play prior to the start of an Anatomy class improved learning and achievement. The objectives of the study are:

1) To investigate the level of knowledge acquisition in classes where students participated in 15 minutes of quiz-game play, question generation or normal preparation.

2) To investigate the level of knowledge retention between classes where students participated in 15 minutes of quiz-game play, question generation or normal preparation

6.1 Method

In *Study Three*, the experiment was completed for the upper limb, shoulder joint, shoulder muscles, elbow joint and elbow muscles. This portion of the semester was chosen as the topics mimic those on the lower limb from the semester one, *Study Two* data collection period and although there are slight teaching differences, the level and type of content is similar (scheme of work, Appendix D). The randomised crossover design used is shown in Table 13 using three interventions, control (notes), Games (G) and Games plus question generation (G+).

I teach seven seminar groups over two days weekly, all completing the same seminar. These groups were randomly organised into a three week crossover design using a free app (Random Number) on the iPhone 6. The videoing of sessions for observational engagement was not completed as in *Study Two* because it was not required for the aims of the study to be met and therefore unethical. NSSE and Socrative scores were measured as per the method described in *Study Two,* chapter 5.3.

The same protocol of Socrative quizzes and gameplay was used as in semester one (Figure 15) with the same quality and reliability testing completed. The Games plus (G+) intervention consisted of 15 minutes of gameplay but during that time students generated five questions from the material to ask their peers. Alpha Cronbach's reliability score was 0.79 cross all of the Socrative quizzes allowing reliable comparison of scores (Santos, 1999).

Table 13: A Table showing the semester two crossover design interventions for the seven seminar groups.

Seminar Group	Week 1	Week 2	Week 3
1	15 minutes normal seminar (control)	15 minutes mLearning games + question generation	15 minutes mLearning games
2	15 minutes mLearning games	15 minutes normal seminar (control)	15 minutes mLearning games + question generation
3	15 minutes mLearning games + question generation	15 minutes normal seminar (control)	15 minutes mLearning games
4	15 minutes normal seminar (control)	15 minutes mLearning games	15 minutes mLearning games + question generation
5	15 minutes mLearning games + question generation	15 minutes mLearning games	15 minutes normal seminar (control)
6	15 minutes mLearning games	15 minutes mLearning games + question generation	15 minutes normal seminar (control)
7	15 minutes normal seminar (control)	15 minutes mLearning games	15 minutes mLearning games + question generation

The pre-seminar 15 minute intervention was incorporated into three taught two hour seminar sessions in the level four Anatomy module for seven of the eight groups as shown in Table 13. Each group had between twelve and twenty students but attendance varied throughout the semester. Students were included in the within-student analysis if they attended all of the data collection sessions or they had completed the control week plus one intervention week. All consenting student data was included in the between-subject analysis.

The data collected was part of the normal seminar structure (one two hour seminar once per week). Students were informed of the data collection when they were given informed consent forms and participant information sheets (Appendix A) at the beginning of semester one but not told what I was looking at or the nature of the interventions to ensure as naturalistic an approach as possible. Socrative quizzes are a normal part of the teaching toolbox for the module and used regularly in both lectures and seminars. The Socrative quizzes were done at the start of the session using students' own smartphones/tablet devices or the University iPads if that was not possible. They took approximately seven minutes and followed the 15 minute intervention each week shown in Figure 14.

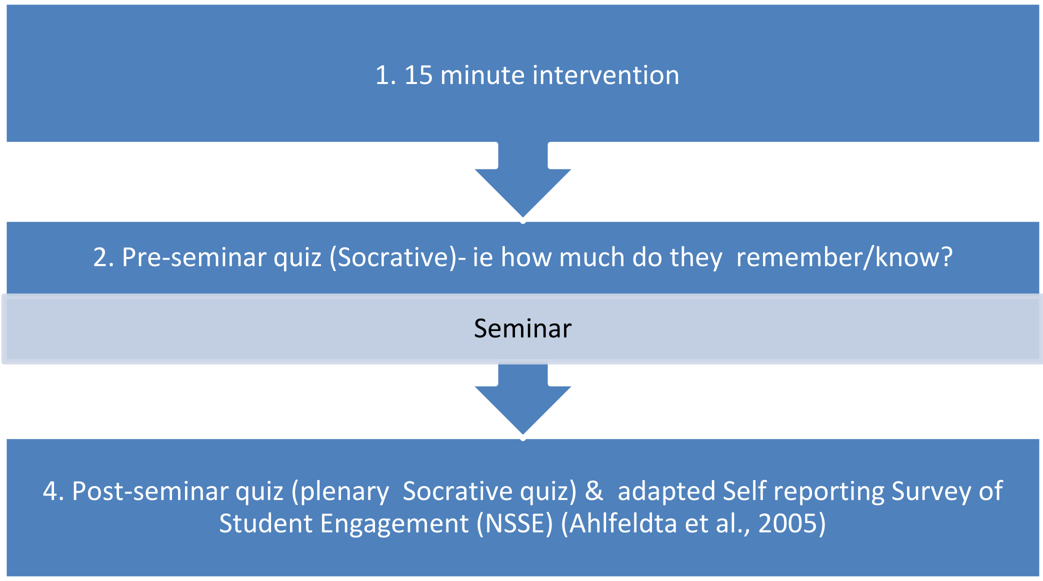

Figure 14: Study Three data collection flow diagram for the Socrative and NSSE

The Socrative quizzes were undertaken as described in chapter 5, *Study Two* but for the upper limb like for like by topic (Scheme of work, Appendix C). For example, the shoulder in semester two is comparable with the hip in semester one. The Socrative quizzes were completed as shown in Figure 15 below, where the plenary quiz from the previous week had the same questions as the recap quiz the following week to allow a measure of knowledge retention and the effect of the intervention. S1 represents the plenary quiz of week 0 (teaching week 14) and the recap quiz of week 1 and S2 is the recap quiz of week 2 and the plenary of week 1.

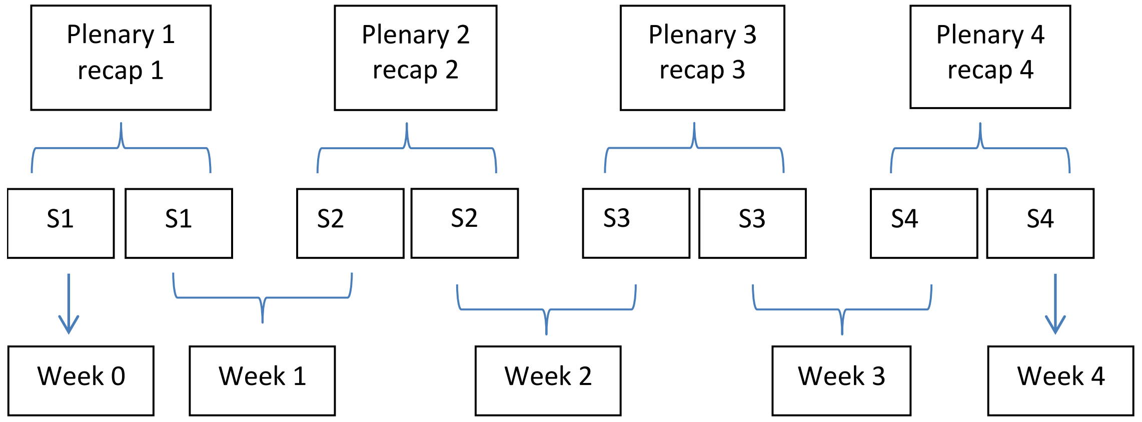

Figure 15: The Socrative testing schedule of the randomised crossover design where the same quiz is given as a plenary and the following week recap. Week 0 and week 4 did not have an intervention in class but were needed to allow Knowledge retention score to be calculated.

The Socrative quiz scores were emailed to the tutor each week as an Excel spreadsheet and they were integrated at the end of the four week collection period. Students were asked to provide student number instead of their name in the Socrative quiz to allow data matching and anonymity.

The NSSE is described in chapter 5 and it was administered in the same way for the current study. At the end of each session the modified NSSE was completed using the Bristol Online Survey. Students were emailed a link to the survey on the morning of the seminar and were asked to complete it before leaving class following the plenary Socrative quiz (https://mdxuni.onlinesurveys.ac.uk/national-student-engagement-class).

The quantitative data was tested for homogeneity of variance and normality suggesting it met the criteria for parametric statistical analysis. *Study Three* had three independent factors and therefore repeated-measures within and between-subject ANOVAs were used (Field, 2009). In the repeated measures statistical analysis, Mauchly's test of sphericity was used to test for equality of variance. Bonferroni post-Hoc pairwise corrections and analysis for both knowledge acquisition (KA) and knowledge retention (KR) Socrative scores were then applied.

6.2 Results

All students were included for between group analysis (N=196). There was N=71 for the control intervention, N=65 for the games intervention and N=60 for the Games+ intervention for within-student analysis.

The Socrative recap were compared between interventions. The mean for the control (C) weeks (N=71) was 55.0 ± 20.9%, the games (G) group (N=65) 63.9 ± 22.8% and for the games + (G+) group (N=60) 62.3 ± 20.0%. A One-way ANOVA revealed a significantly greater score in the games ($p<0.05$) and games+ ($p<0.01$) weeks compared to the control (Figure 16). The Knowledge acquisition mean scores were also compared between the groups, C (n=63) was 60.5 ± 18.4%., G (n=80) was 64.2 ± 19.0% and G+ (n=60) was 63.8.5 ± 16.3% revealing no significant difference between the groups.

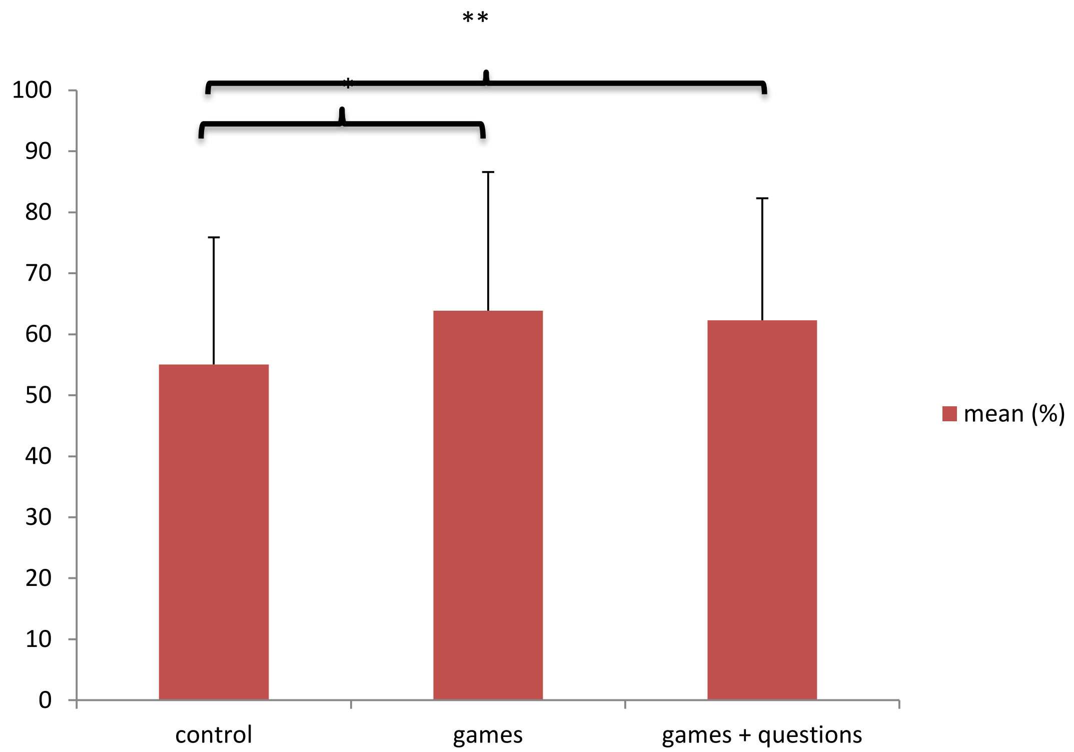

Figure 16: A comparison of Knowledge Acquisition (KA) in the three interventions between subjects (**) significant at 0.1% ($p<0.001$) (*) significant at 5% level ($p<0.05$)

The Knowledge retention (KR) scores ((recap week x) – (plenary week x -1)) had no significant difference between groups ($p>0.05$); the mean for the control week was -5.26 ± 25.4%, 3.13 ± 21.9% for the Games week and -3.56 ± 21.0% in the Games+ week.

A within-subject ANOVA was used to compare KR scores between the interventions (N=48) revealing a significant difference ((F(1.735, 5.302), $p <$ 0.01)). A Bonferroni pairwise comparison showed a significant increase in the G intervention compared to the control session (p<0.001). The mean for the control week was -8.5 ± 3.5%, Games week 4.0 ± 3.4% and the Games+ week -4.0 ± 3.4% shown in Figure 17. The KA scores were also tested (N=42) showing the mean for the control (C) weeks was 61.8 ± 20.9%., the games (G) group 72.1 ± 22.8% and for the games + (G+) group 61.5 ± 20.0% revealing a significant difference between the G and G+ and C and G groups (p<0.05).

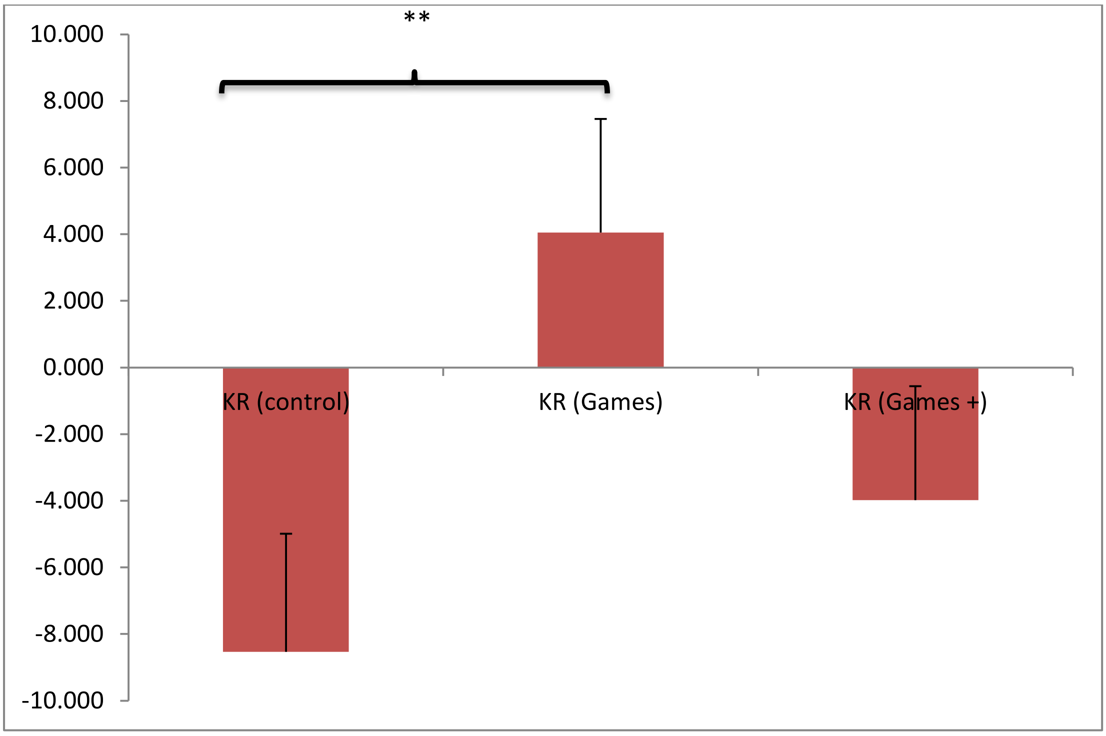

Figure 17: Knowledge Retention (KR) scores (%) showing a significant increase in the Games (G) group (p<0.01) compared to the control but no difference in Games + (G+) (**).

6.3 Discussion

Study Three looked at both knowledge acquisition and knowledge retention Socrative quiz scores in a randomised crossover design between seminar groups. For knowledge acquisition (KA) scores, there was a significant increase in the within-subject measure between the Games (G) and control (C) and the Games (G) and the Games plus (G+) interventions. There was no difference between the control and the Games plus sessions. Between groups analysis did not show a significant difference, but the difference between G and C was nearing significance at 0.062. The mean values also supported the within-subject trend. The data therefore suggests that knowledge acquisition in the seminar improved following the gameplay intervention but not the G+. The G+ intervention was designed to add an active learning element on top of the gameplay but it is possible that students may not have done as much gameplay due to the added task of devising five questions. Students therefore may not have had the same volume of information in the intervention compared to the G only intervention. This would mean that the time spent testing themselves and the amount of feedback received would be less and therefore according to Roediger and Karpicke, (2006) the potential learning effect may also decrease. It is possible that adding an additional level to the learning such as question development was detrimental to some students' learning. If the fundamental knowledge was not known then adding a higher learning layer could be premature and result in a negative learning effect but could be part of learning development through quiz-games as they progress (Biggs, 2014; Arnab et al. 2015). Arnab et al. (2015) discuss the hierarchy of learning and game mechanics, which can coexist alongside levels of learning discussed by Biggs (2014).

There are other possible reasons that may have existed for the increased knowledge acquisition or test score following the G intervention. The gameplay nature of testing themselves, visual stimulation and feedback could increase memorisation and learning. An increased knowledge of the required building blocks for the seminar can improve student confidence and therefore feed into the success cycle of learning. Lee and Hammer (2011) found that repetition of gameplay can frame failure into a motivational tool to maintain engagement in the topic. Feedback and overcoming failure in gameplay prior to a class could therefore motivate student participation and confidence to learn the new information in the class. Busch et al. (2015) describes the cycle of failure, reduction in self-efficacy and avoidance strategies of learning, which could be minimised by quiz-gameplay prior to class.

Quiz-gameplay had been shown to have a positive effect on engagement in class in *Study Two* and in previous research by Hamari et al. (2014). Quiz-games played prior to class could increase engagement and therefore improve achievement as shown in *Study One, Study Two* and by Perera et al. (2009). Elements of gameplay that feed into the concept of flow (Csikzentmihalyi, 1990) were identified as challenge and skill and shown to be positively affected after play (Hamari et al. 2014; Procci et al. 2012). Therefore, the recommendation of quiz-gameplay prior to class needs to have these elements as well as feedback in the form of rewards (leader board, level increases or equivalent) to be a success.

The knowledge retention (KR) scores improved significantly in the between-student analyses in the G and G+ sessions whereas the within-student analyses revealed a difference between the Control and G group only. The KR scores were calculated from a Socrative test performed at the beginning of each class prior to the seminar (recap) compared to the plenary score of the previous week. It was therefore designed as a measure of knowledge retention but there are other learning behaviours that would impact on the recap scores. Firstly, the knowledge retention could improve due to the increased knowledge acquisition in the previous class already shown to be positively affected by gameplay. An increased KA in class could lead to increased subject engagement, confidence, motivation and autonomy of learning as discussed in chapter 6. However, it could also be due to the Socrative testing and competitive nature of the gameplay act in the same way as formative testing (Roediger and Karpicke, 2006). Formative testing has been shown to increase knowledge retention in test scores supporting the theory that quizzing and testing can help the long term learning effect (Lameris et al. 2015).

The recap and therefore KR scores could also have improved if the students completed more independent learning between classes. The control group did not have a positive effect in the within-students analysis and therefore any effect may have been influenced by the gameplay in the session and subsequent increased engagement in the topic. Gameplay feedback and competition can help students' self-reflection and identification of weaker knowledge areas, which could lead to an increased autonomy of learning behaviours between classes (Van Nuland et al. 2014). This method of learning may have limitations depending on the depth of the game and in this instance be a tool for memorisation and learning the fundamental terms, muscle names and details. Other apps with quiz-games can be recommended to enable further depth and testing of understanding but this would have to be facilitated by the staff member because it is unlikely that all students will actively seek these out, particularly at level four.

Increases in KA and KR following quiz-gameplay prior to class suggest that this learning technique could be utilised by academics as part of learning and teaching toolboxes for students. The gamification of self-study strategies or as a pre-class recap tool could enable students to begin a class with increased knowledge, confidence and motivation in their own learning potential and engagement in the subject. This would require staff expertise in mLearning and gaming, investment in market knowledge or app awareness as well as a suitable model to integrate mLearning gamification alongside more traditional anatomical sciences teaching methods.

Study Three provides further evidence supporting *Study Two* showing that playing anatomy quiz-games prior to a seminar results in better knowledge acquisition in the session as well as knowledge retention the following week. The discussion has highlighted potential factors to explain these increases which can be in part triangulated in chapter 7. The results from all three studies are discussed together in chapter 7, which follows on from the individual discussions in the previous three chapters. Chapter 7 will attempt to bring the ideas together to show how the results can be used to form a framework of best practice for integrating mLearning quiz-games into teaching anatomical sciences.

7.0 A Framework for the Integration of mLearning quiz-games into HE

The discussions in chapters 4, 5 and 6 have focussed on the individual studies; this chapter will attempt to bring the findings together. Based on the knowledge gained from all three studies a practice-based framework for the integration of mLearning quiz-games into teaching practice is proposed. A summary of the key findings from the three studies is shown in Figure 18.

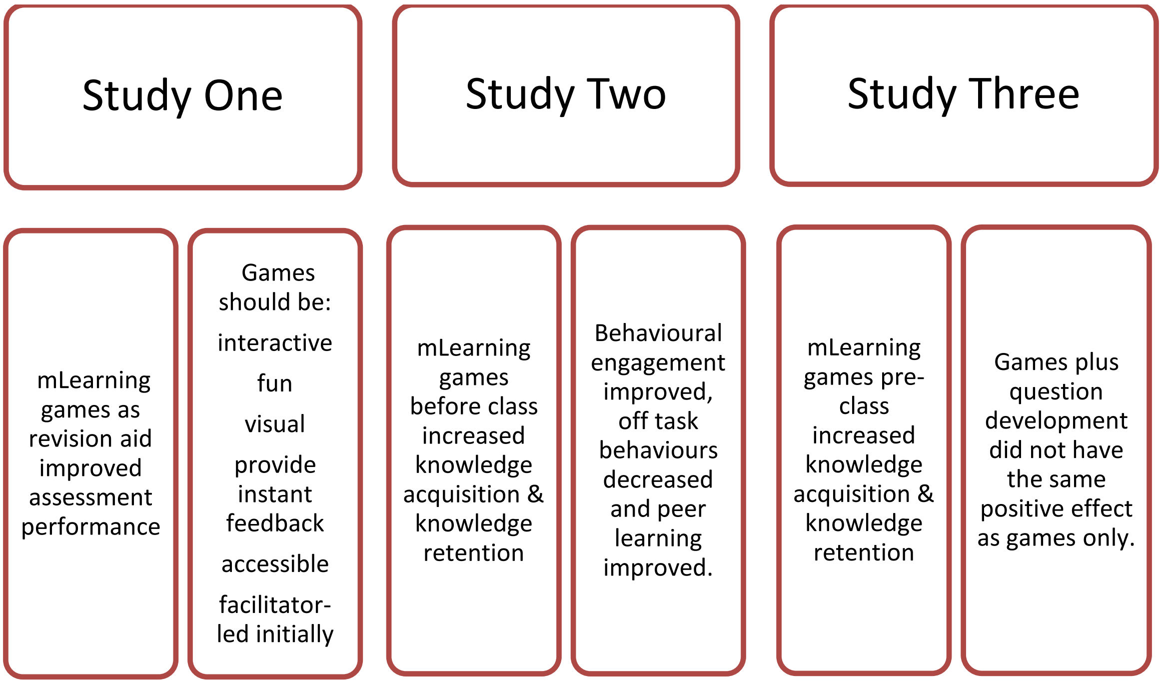

Figure 18: A summary of the key findings from *Studies One, Two and Three*

Study One found that using quiz-games as an acute revision tool prior to an assessment positively impacted on achievement; this was mirrored in the in-class knowledge acquisition effect in *Studies Two* and *Three*. The discussion of *Study One* suggested that this improved achievement could be more of a short term memory aid as opposed to an effective long-term learning tool for deeper understanding and application. *Studies Two* and *Three* showed the positive effect on learning that quiz-gameplay prior to class can have. Combining the three studies suggests that gameplay can have a positive effect on student knowledge acquisition but also have a longer term learning effect from the knowledge retention score analyses.

Study One also highlighted that those students who played quiz-games prior to the assessment not only outperformed the control group in labelling questions but also in the more applied, higher level thinking MCQs. This suggests that study aids to allow more effective learning of the fundamental knowledge or memorisation can also help deeper learning development of understanding and application according to the FHEQ.

The positive effect on engagement in the classroom found in *Study Two* potentially has a knock-on effect on learner psychology at both subject and course levels. Anatomy is often highlighted on medical, veterinary and Sports Science courses as a difficult topic with large volumes of information to learn (Noguera, 2013; Hopkins, 2011). If students' engagement level increases in anatomy their overall outlook on the course may also improve. Bassin (1974) noted poorer evaluations tended to be given to quantitative courses and Boland et al. (2001) and Darby (2006) found that students rate elective courses more favourably than required ones. Increased engagement, classroom behaviour achievement and innovative teaching methods could therefore have a positive impact on module evaluations and NSS scores, which feed into student satisfaction tables and comparison sites. Universities may therefore benefit from providing mLearning and gamification strategies on all programmes, particularly where there is an element of rote learning required. This would suggest that the findings of this project could impact on other subject areas such as STEM subjects and languages. Many educators view rote learning with disdain but higher-level critical thinking skills are often built on rote learning foundations. If mLearning gamification could make memorisation or knowledge acquisition more enjoyable and provide other positive elements identified in *Study One* then it could be a viable alternative or additional resource for those subjects and educators requiring some degree of memorisation.

Study Two revealed the positive effect that the pre-class gameplay intervention had on in-class knowledge acquisition, retention and observational, behavioural engagement. The experiment was performed in the order no games (NG) or control followed by games (G), which left the reason for the improved scores and engagement potentially affected by the previous weeks' learning and activities rather than the quiz-games themselves. *Study Three* therefore repeated the achievement measures of *Study Two* in a randomised repeated measures method. The two studies together further enhance the findings that gameplay helps knowledge acquisition in class and retention until the next week's class. Reasons for this were discussed in both chapter 5 and 6. The experimental repetition increases generalisability and validity of the study suggesting that the gameplay was the primary reason for the effect seen in Study Two, not the order or timing of the interventions.

From the qualitative results in *Study One*, instant feedback was identified as a positive for gamification agreeing with the research regarding game-informed learning (Kapp, 2012; Nicol, 2010). Other aspects of the gameplay found to have a positive effect on learning were the enjoyment factor, accessibility, visual stimulation and competition. All these factors can be linked to the increased engagement recorded in Study Two and the potential increased independent learning found in *Studies Two* and *Three* through the measure of knowledge retention. Therefore, integration of any mobile gamification should seek to ensure that quiz-games chosen meet the core values highlighted by the students.

Research and practice based evidence focussing on students as the consumer show that many students do not regularly complete all of the pre-class reading, activities or assignments unless they are graded (Nixon et al. 2016). By advocating mLearning quiz-games as a viable alternative, educators could provide more engaging, accessible learning tools, which have been shown to increase autonomy, motivation and confidence. All of these will impact on student achievement, which has a massive effect on student success and the prevention of a student entering the cycle of failure (Fredricks et al. 2004). Some educators believe that traditional methods are always the best and that quiz-games or mLearning apps are not as academic as these methods. Several studies have found that among academics there are a number of counterproductive beliefs about learning technologies and mLearning that might impede successful implementation (Handal et al. 2011; Moron-Garcıa, 2002; Newhouse, 1998; Niederhauser & Stoddart, 1994). Handal et al. (2013) conclude that staff development should focus on healthy trepidation and common misconceptions towards the adoption of mLearning. mLearning and gamification will not necessarily be suitable for all topics, students or levels but academics should be given training and case studies on pedagogical innovations in their own fields to highlight the potential relevance to them. Students have been shown to need help in the process of learning to use mLearning quiz-games and therefore knowledge or expertise in the area should not be assumed for staff either.

7.1 Framework development

Frameworks are primarily tools for organising and communicating findings or ideas to the wider community in your field (Carver, 2008). They provide an overarching structure for educators and policy makers to follow to bring about potential change. A framework for best practice in gamification using mLearning tools needs to incorporate previous frameworks suggested for play, gamification and the integration of mLearning into teaching discussed in chapter 2 as well as the findings reported from the studies in this thesis. Gamification models have commonly been based around the elements of gaming suggested by Bunchball (2010) in the list below. Games should:

- Allow repeated play cycles to reach a goal.
- Include rapid feedback
- Include different levels to achieve the main goal or cover a topic; this will allow a reward system and break each topic down into achievable sections to improve motivation and maintain engagement.
- Allow individualisation of study materials within game-informed learning.
- Allow recognition from teachers, peers, themselves through rewards or levels.

Simoes et al. (2012) suggest a social gamification framework for teachers at Key Stage 6 that agrees with the concepts suggested by Sung et al., (2015) (page 35), Hamari et al. (2014) and Lee and Hammer (2011). They suggest that gamification should be individualised, set simple objectives, have a reward system, use competition and recognition and be specific to the learning outcomes. mLearning frameworks generally agree that mLearning should be learner-centred, allow collaboration (Naismith et al. 2004) and acknowledge local and distant communities for learning. Pegrum (2014) described this as needing to link local to global, then episodic to the extended and the personal to the social, which is similar to the ideals of game-informed learning and gamification. Ozdamli (2012) suggests that mLearning frameworks should look at the pedagogical approach, the assessment techniques used (Competition Based Learning (CBL), self-assessment, peer assessment), integration of tools (support versus information) and teacher training (mLearning toolbox). Cochrane et al. (2010; 2012) describe six success factors for the use of iPads or iPadagogy and evaluate a number of case studies using this framework. The success factors in Cochrane et al. (2012) attempt to cover each aspect of the integration of iPads into teaching and learning but could appear to lack breadth of application to other mobile and tablet devices. In an attempt to address every aspect of iPadagogy, including support, communities, pedagogical integration, lecturer utilisation and pedagogical-andragogical shift continuum, the framework seems to aim to be an institutional tool from a purely social constructivist outlook rather than a practice-based tool for educators. Conceptual frameworks tend to be based around theory rather than practice with many focussing on the technical aspects of mobile devices in mLearning (Motiwalla, 2007; Park, 2011) but more recently there seems to be a more practice-based shift. Khaddage et al. (2015) suggested four challenges to the integration of mLearning; pedagogical, technological, policy and research and then went on to provide potential solutions in a follow-up paper based on discussions at a conference (Khaddage et al. 2016) agreeing that action research into the area is required to drive mLearning to the forefront of all education at all levels.

From an institutional perspective mLearning and gamification need to be sustainable, cost-effective, and accessible to meet both quality and ethical pedagogical standards. This requires staff to be able to access development opportunities and be encouraged via pedagogical strategy to explore potential mobile gamification opportunities.

In universities there is an increasing drive for scholarship and pedagogical research to underpin teaching quality, which could be emphasised even further in the upcoming TEF and potential fee increases. Action research could therefore be given greater academic rigour and acceptance in the academic community. Action research allows the dynamic nature of pedagogy and student learning to be accounted for. The current study had three cycles (Figure 1) and built on a previous study on mLearning (Wilkinson and Barter, 2016) allowing the development of a mixed methods approach that aimed to provide some degree of generalisability and a move towards the experimental approach so increasing reliability and validity of the studies.

7.2 A framework for integrating mLearning quiz-games into HE anatomical sciences teaching

A framework for integrating mLearning quiz-games into teaching anatomical sciences should be adaptable for both in-class and independent learning to meet the requirements of Higher Education and to develop autonomy of learning whilst remaining learner-centred. The framework builds on Bunchball's (2010) suggestions for gamification to incorporate the results from the current studies and ensure it is bound within the HE model. The framework will be explained from both teacher and learner perspectives to remain consistent with the ontological naturalistic approach to this research. The proposed Mobigames framework that I have developed from the study findings is outlined in Figure 19 and the key aspects expanded on in Table 14 using the information from the current studies and reflecting on previous literature.

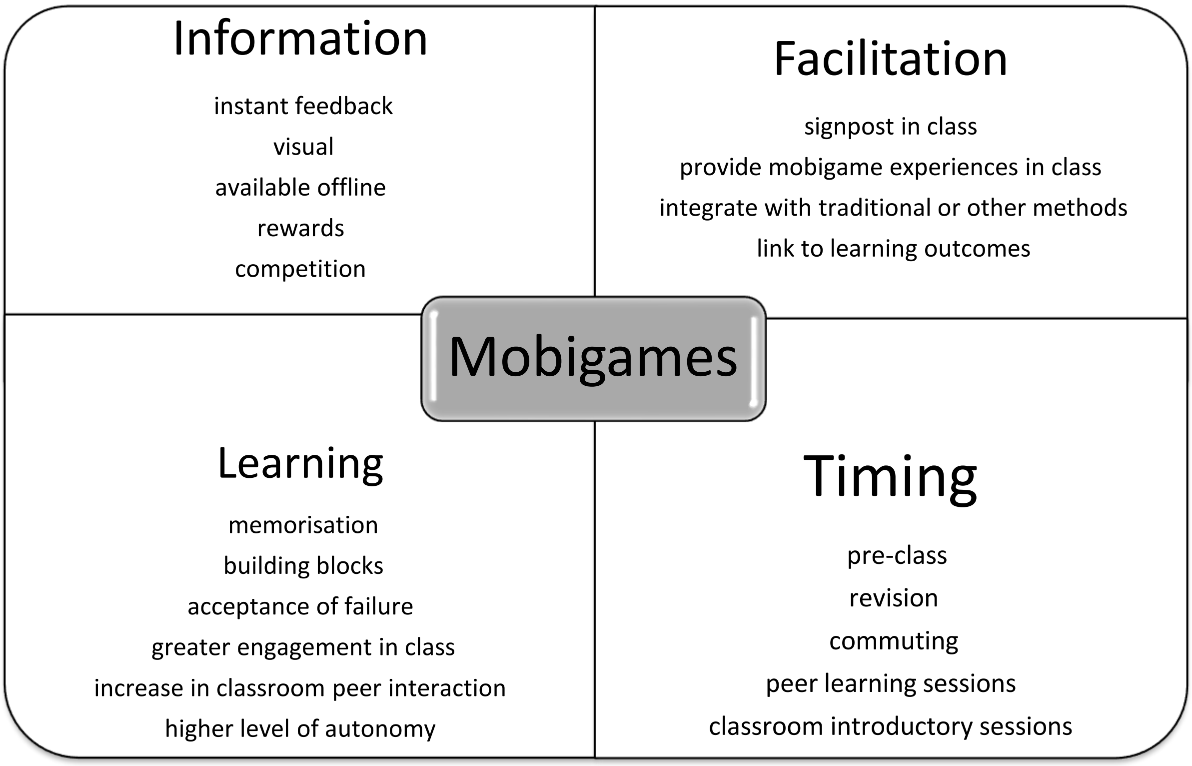

Figure 19: The proposed Mobigames framework for the integration of mLearning games in HE anatomical sciences teaching.

The framework highlights four key components of the research findings of this doctorate and the important features of each. The generalisability of the framework is clear for subjects requiring an element of rote learning for the fundamental building blocks of knowledge acquisition. The four sections fit into the spatial dimensions of What? How? Why? and When? and sit within a social constructivist, naturalistic and collaborative learning perspective. The results have been mapped to the framework in Table 14 showing the relevant study.

Table 14: Teacher and Learner explanations from the current Studies for the Mobigames framework suggested in Figure 19.

Dimension	**Study**	**Teacher**	**Learner**
Facilitation	Study 1 (Figure 5, 6)	Apps and quiz-games should be tested and their utilisation recommended for specific subjects or classes. Facilitation of quiz-gameplay should be advocated as a complementary tool for revision and learning, not as an alternative. Invest time in playing those quiz-games advocated to ensure they meet the core elements of successful gamification and learning or assessment outcomes. Gameplay should be initiated in class and regularly revisited to maintain engagement and progression.	Will need signposting initially to suitable quiz-games that meet learning outcomes and are at the correct level. Visual, fun and rewards are important in quiz-games for learning but most important factor identified is instant feedback.

Information	Study 1 (Figure 6) Study 1 (figure 5,6, Table 4)	Quiz-games should be available offline to allow play whilst commuting (eg. London underground), be inexpensive and available on Apple, Windows and Android platforms to ensure nobody is disadvantaged. Students are shown to appreciate the comparison of cost to textbooks. Discounts may be available for course-adopted apps so the faculty or educator should investigate this possibility. Competition-based learning (CBL) can help motivation and self-reflection in the learning cycle individually and with peers. Teachers should consider how they facilitate this and encourage failure within the learning cycle in class to be overcome by independent learning so that students learn that failure is a part of their experience.	Mostly play is at home, commuting or in breaks from classes and therefore facilitation and recommendations should take this into account. Potentially staff could facilitate a CBL league or group leader board or challenge to further encourage independent practice.

Timing	Study 1,2,3 (Figure 4, 11, 12, 13, 16,17) Study 1 (Figure 6,7)	Quiz-games can be an effective learning tool for knowledge acquisition and retention; they should therefore be integrated at appropriate times including before class, daily short periods to increase longer term knowledge retention and as a revision aid.	Need to be informed of different ways of using mLearning quiz-games before, during and after class as well as in assessment preparation. They may not be suitable for all individuals, alternatives should be available. Students most frequently used quiz-gameplay during their commute, in timetable breaks and at home.
Learning	Study 2,3 Table 11,12; Figure 13, 14	mLearning quiz-games can help engagement in class or in the subject, and can be considered as an alternative for more traditional tasks and where rote learning or memorisation of facts is required. In particular, gamification of pre-class reading and activities increase participation rate and have a positive effect on the subsequent class behaviour and engagement.	Students found quiz-games useful for learning if they were shown how to and were positive about their role as an electronic flashcard, as a revision tool and as an aid to learn facts.

	Study 1 Figure 4,5	Social interactions between peers increased following pre-class quiz-gameplay, which is linked to positive learning experiences. Greater interaction results in more peer feedback and a more active, collaborative learning environment.	

The framework is designed to give educators a set of guidelines for the integration of mLearning quiz-games for optimal achievement, engagement and behaviour in classes. The framework is informed by the results of the three studies in this project building on a concrete pedagogical foundation. Current pedagogical research in HE highlights the need for methods to encourage student engagement, autonomy of learning and highly employable graduates. There is an increased requirement for innovative teaching methods utilising current technologies and resources, however, the benefits of these methods is commonly not identified or studied resulting in sometimes ineffective fashionable methods.

It is envisaged that the framework should be used in HE practice and be incorporated into wider teaching and learning strategies. Following on from the proposed framework, the areas requiring future research should start with the scrutiny and validation of Mobigames by testing their effectiveness across a range of subjects and levels within HE. The origins are from anatomical sciences and therefore evaluation of the Mobigames framework could be tested for generalisability in other subjects, initially for STEM type subjects followed by those requiring different learner types, further discussed in section 7.4. The next section, 7.3 will look at the limitations of the project and then 7.4 will identify areas for future research based on the discussions in chapters 3, 4, 5, and 6.

7.3 Limitations

In pedagogical research, particularly in action research there are methodological limitations, some of which are discussed in chapter 3. Although many of these common issues were taken into account in the methods used to minimise any limitations the studies are still subject to potential sources or error or bias. All three studies used only one module for data collection where the module leader was also the insider researcher. The resulting potential bias was discussed in chapter 3 and efforts were made to minimise the effects but as the module leader and lecturer students may have been influenced by the teaching methods and values shown (Chapelle, 2007). Kirkwood (2013) discusses the limitations of conducting pedagogical research further positioning the importance of the chosen epistemological position and assumptions made. Although only one module was investigated, both *Study One* and *Study Two* involved a repetition to increase reliability and generalisability. Each cohort will change depending on the entry criteria and admissions for the year in question but no significant differences were found in baseline measures at A1 and therefore student level of knowledge and previous education was assumed to be comparable.

The use of the NSSE, SPQ and behavioural observation coding criteria were discussed in the relevant study chapters. The use of existing, validated questionnaires and methods is more reliable but they can also not be the most effective specific measure with limitations identified in their application to the scenarios seen in the current studies. For example, the NSSE did not correlate with the behavioural engagement scores and is not meant for in-class use over consecutive weeks. This may be a reason as to why the results for the NSSE were not significantly different between weeks and a more effective measure would be required in the future. The SPQ has been critically discussed in chapter 3 and in the research but was seen as the optimal measure for Study One. A questionnaire specifically designed and validated for *Study One* may have given more accurate data on the motives and strategies of student learning but it was beyond the scope of this project. However, data was triangulated with the use of focus groups and semi-structured interviews to overcome this potential limitation.

Measures for knowledge acquisition in *Study two* and *three* used the plenary Socrative scores as an indication of information learned. Socrative scores were deemed reliably comparable using alpha Cronbach's coefficient but different tests were used to reflect the nature of what was taught week by week. The baseline level of knowledge could also be different, although in *Study Three* the repeated measures design eliminated this effect.

Other methodological aspects affected by the action research and the ethics in a pedagogical setting were equality of group sizes and the ethical inability to repeat experiments with an allocated control group where an intervention was previously shown to be positive. Groups were determined by choice in *Study One* and therefore there were unequal group sizes in this study, however, in *Study Two* and *Three* the designs incorporated the interventions into the normal teaching and environment and therefore the group sizes were fairly equal. The studies have addressed most of the common assumptions and limitations identified by Kirkwood (2013), therefore increasing the quality of action research in this case.

7.4 Future Research

Although attempts were made to triangulate findings to allow possible explanations to be put forward in the current studies, further evaluation of the reasons identified need to be examined. This will allow greater depth of understanding on how students learn using quiz-games and the true extent of their gameplay learning. *Study One* identified that gameplay was an effective revision tool and revealed student perceptions of mLearning quiz-games but further research comparing different types of game and assessment would allow a greater understanding of the type of learning benefit and potential application to level of study and learning. The literature behind using quiz-games as well as other types of games has been reviewed in chapter 2.

There are not currently mobile anatomical games available that would be classified as being for gamed based learning as opposed to game informed learning. There are many more games available across different topics that are designed to instigate a deeper learning response such as augmented reality in anatomy but these are expensive, in their infancy and the benefits require research. For example an immersive platform game or a problem based game based on anatomy and/or fitness. Collaborative development of such a mobile game would enable further study into whether it is the quizzing aspect, the play or the learning-failure cycle and gamification aspects of gameplay that benefit learning. The next stage of the research will in fact be the addition of timing to *Study One* where revision timing and frequency can be investigated. The students will use the quiz-games just before, 24 hours before and 72 hours prior to an assessment.

Study One also investigated the factors associated with and student perceptions of mobile learning quiz-games using the focus groups and interviews. The student answers revealed valuable information about how and why they played the quiz-games and labelling games on the apps. This information should be mirrored to investigate the teacher perceptions. The student information will also be empirically tested to see whether their thoughts mirror their application. Information is needed on what they look for in a quiz-game and therefore a study testing their perceptions on different available app based quiz-games and self-reporting of their play habits would enable further evaluation of the qualitative data.

The study will also be repeated using different topics, for example physiology where there is appropriate apps and using a non-sports cohort in anatomical sciences. This will allow further generalisability, effect size and enable further conclusions on whether quiz-games can help different subjects and types of students. Teaching methods change depending on the level being taught and the learning outcomes require much deeper learning as the level increases. Gameplay has been identified as being a good learning tool for repetition, memorisation and knowledge acquisition at level 4 but the potential benefits at higher levels remain under-researched.

Study Two and *Three* highlighted the benefit of pre-class gameplay on both knowledge acquisition in class and retention between classes as well as a positive effect on engagement in seminar sessions. A key teaching method in higher education remains the large group lecture, which is commonly highlighted as an area requiring teaching improvements and innovation (Smith and Cardaciotto 2012). Investigation of mLearning gameplay prior to a large group lecture will be the subject of future study to determine whether any activity prior to the seminar would increase engagement or by gameplay alone.

The method used in Study Two for observational behavioural engagement measurement will be validated in the 2017-18 academic year using a number of different cohorts in a wider Teaching Fellows study following the use in my thesis is similar to Blatchford, 2006 did in school children. The video analysis method will be tested using a number of different cohorts and the on task-off task behaviours will be further developed to have sub scales for a large group lecture, seminar and practical session. This will allow a comparison of engagement at HE to be more repeatable and comparable between different classrooms which could be further highlighted due to TEF.

One of the key areas of mLearning research is to investigate whether mobile teaching innovation truly transcends the formal to informal learning environments to allow independent learning outside of the classroom. To allow this to be evaluated, student use of the quiz-games outside of the classroom should be investigated in the following scenarios:

- with and without facilitation from the teacher

- normal habitual use (timing, location, duration)

- as part of an individualised learning environment.

This will use self-reporting to log app use and therefore student numbers will have to be as large as possible and a method of self-reporting used to maximise reliability. The approach to the studies used action research and therefore continues to be dynamic and evolving, as with all pedagogical research this will depend on my teaching timetable, responsibilities and collaborations.

7.5 Self Reflection

The professional doctorate aims to encourage practitioner reflection and practice based research in the field of study. Throughout the process I have been using a logbook to detail my doctoral journey and additional Teaching Fellow collaborative writing activities and a summary of meta-reflection is provided briefly. I started the doctorate as a purely scientific, experimental researcher in the field of sports science, specifically physiology. I had never done a PhD in over ten years of teaching because I did not want to do it in a sports field. As my role as an educator evolved and my interests in education and HE quality increased so did my future career plans and direction. The professional doctorate gave me the opportunity to do my thesis on teaching and learning and more specifically in mLearning, an area I am invested in and believe is an important aspect of future HE.

The research process from a practical level has presented me with potential boundary issues where my role as the module leader and lecturer has conflicted with the research process. This has not been a regular occurrence but where sessions were to be compared and a more strict structure was adhered to in class I felt at times I could not facilitate the additional learning opportunities I would normally include as a reaction to student questions or level of knowledge shown in class. This became less of an issue from a professional perspective because it was only for small periods of time in the term where this was needed; for example, *Study Two* required three weeks and *Study Three* required four weeks out of 24 learning weeks. If any students were identified as requiring additional help they were invited to student learning assistant sessions or a tutorial after the period of data collection. The process did make me critically reflect on my teaching methods and the video analysis of engagement revealed some useful feedback to take forward for the future. For example, I now ensure that my activities in class are equally spaced wherever possible and the principles of gamification are heavily integrated into normal teaching, maybe only suiting Sports students to the extent I find!

In terms of research, I have surpassed any expectation I had. My theoretical knowledge of the ontological and epistemological aspects now allows me to discuss papers, approaches and potential experiments with experienced colleagues and students I am supervising. I have grown in confidence within my department and in my role as a supervisor, something which I had previously self-doubted. My research for my doctorate has also given me the opportunities to present at BETT as an invited speaker, two international conferences and be a team leader in collaborative groups within the University teaching fellows community. It has also encouraged me to publish more within my subject specific field of public health, again presenting at two Public Health England conferences and the British Heart foundation conference earlier this year.

The writing up process has been hard at times, particularly in the last few months when pregnancy meant the self-imposed deadline was brought forward. However, this has actually made it easier and suited my work ethic and the valuable use of the summer period to write up. I have made it my primary goal at work and therefore have felt that my input into some health projects I am involved in has decreased, however, my colleagues have been very supportive and I have still been involved in all aspects, I have just had to step back from being the lead. Overall, I have learned so much about the subject I am most passionate about, teaching and learning but also about myself, my inner strength to focus and be channelled towards a goal and how much you can keep learning through action research and enquiry based learning. Generalised lessons I will take forward are;

1) Pedagogical research is not necessarily less valuable than experimental subject research.

2) Acceptance that some things are out of your control.

3) I am a teacher first, but also a researcher.

4) A professional doctorate is a doctorate no matter what some people think.

5) I am highly efficient and goal orientated when I need to be.

6) Learning can occur through teaching, reading, writing, feedback and not constricted by the environment that you are in.

8.0 Conclusion

As a practitioner my thesis is practice driven and therefore can hopefully be embraced by fellow educators, particularly in HE. Pedagogical research conducted as the insider results in potential bias which can impact on forming generalizable results and therefore increasing potential reach. Both myself and the students I have taught have gained valuable skills and tools for our continued development in education and employment. It is hoped that the thesis can be used to inform others' practice to enhance other learner experiences.

Study One found that mLearning quiz-games used as a revision tool prior to an exam resulted in greater student achievement. Assessment is a key part of HE and although steps have been taken to move away from assessment driven learning environments it is a requirement for awarding bodies and a necessary part of study at this level. Many students, particularly on applied courses do not thrive on examination based assessment, therefore engaging methods to improve preparation could transform student perception and success whilst maintaining course integrity. Study One also contributed to our knowledge of student perception of both mLearning and app based quiz-games. The student focus groups and interviews provided knowledge to inform the elements of the how, where and what elements of the Mobigames framework. There is an increasing trend to use the "student voice" in teaching and therefore any practice driven framework should utilise both teacher and student perspectives.

Study Two and Three findings show mLearning quiz-games before class improve seminar engagement and social interaction as well as knowledge acquisition and retention. This information should be used by teachers as a practical tool to facilitate learning in classroom environments. They could also utilise gameplay in other forms and as in-class activities to help engagement and behavioural management. All studies can be used to inform practice and teaching and learning strategies, particularly to help integrate mobility or mLearning. Staff development opportunities should be provided to communicate the project findings and encourage idea sharing communities in different subject areas. The increased behavioural engagement could, in time have more of an impact on cognitive engagement but this would have to be sustained by continuous use of quiz-games prior to class.

The Mobigames Framework developed in this project for integrating mLearning quiz-games into the teaching of anatomical sciences in HE is designed to provide a model of best practice for educators. The framework may be able to help teachers use mLearning quiz-games effectively in class and encourage independent learning opportunities between classes. It is based upon the findings of the doctoral project, as mapped in Table 14 showing that using mLearning quiz-games can positively affect revision and be used as a pre-sessional tool to improve engagement and learning in and between classes. It incorporates previous work on both mLearning and gamification with the current quantitative and qualitative findings and should be integrated into current teaching methods to enhance the student experience, success and to develop student autonomy in Higher Education. The framework provides the teacher with the tools to be able to integrate app-based quiz-games into their teaching adding to the current frameworks available in both gamification, play and mLearning by integrating the areas in an applied manner based on empirical research not using conceptual basis.

Although this framework has been designed around the anatomical sciences, it has application potential for a wide array of disciplines. Many subjects are built upon fundamental knowledge acquisition, which requires some degree of memorisation of facts. *The Mobigames Framework has proved to be most successful for such learning. The Mobigames Framework can thus be put into practice with a much wider target audience as it has been derived from studies designed for generalisability.*

mLearning and gamification are increasingly being identified as areas on which educators should focus; student perceptions and feedback support their combined use. The increases seen in achievement and engagement should not be ignored particularly when teaching quality is becoming a focal point for student satisfaction, fees and University rankings. The first full TEF evaluation will take place this year, 2016/17 and therefore teaching innovation and underpinning research will take centre stage, justifying the implementation of the Mobigames framework into subjects which require large volumes of knowledge acquisition and retention. Such subjects should include Sports Science, Veterinary, Medical and Nursing subjects and potentially Language learning and other STEM subjects.

The Mobigames Framework should be discussed in PG CertHE programmes for new HE educators and be disseminated via teaching and learning conferences within institutions. Mobigames should be integrated into teaching and learning strategies alongside more traditional or current methods, not as a substitute, so reinforcing the teacher's toolbox and the learner experience. Facilitation pathways for using mLearning quiz-games via staff development and sharing experiences or case studies should be advocated from an institutional level down to ensure potential barriers to the unknown are lowered.

App developers could also use the framework to ensure the teaching and learning dimension is highlighted in their product development in order to appeal to the students in terms of gamification but also to be an efficient tool from an academic practice perspective. For example, in the Anatomy apps used in this study further development could build on the gaming aspects to increase social interaction or recognition via local (class or module) leader boards. Improvements to progress gamification learning from surface to deep or to reach the taxonomy layers of application and understanding rather than just knowledge acquisition would further enable this learning transition further. mLearning gaming apps have the potential to revolutionise access and engagement in HE; further collaboration between app developers and Universities would increase future impact.

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Appendix A

Ethical Approval Letter

School of Science and Technology
The Burroughs
London NW4 4BT

www.mdx.ac.uk
Main switchboard:
020 8411 5000

To Kate Wilkinson

Date: 15 December 2014

Dear Kate

RE: Application 273 "The pedagogical effect of different smartphone app games as revision tools for anatomy exams." Supervisor: Stuart Miller Category: A5

Thank you for the response which adequately answers the ethics committee's queries. On behalf of the London Sport Institute Ethics sub-Committee, I am pleased to give your project its final approval. Please note that the committee must be informed if any changes in the protocol need to be made any stage.

Yours sincerely

[redacted]

Dr. Rhonda Cohen
Chair of Ethics Sub-committee (London Sport Institute)

Middlesex University
London Sport Institute

School of Science and Technology
The Burroughs
London NW4 4BT

www.mdx.ac.uk
Main switchboard:
020 8411 5000

To: Kate Wilkinson

Date: 16 October 2015

Dear Kate

RE: Application 438 "The pedagogical effect on engagement and learning of mLearning games prior to anatomy class based seminars." Supervisor: Hemda Garelick/Chris Huyck
Category: A2 & A3 & A5

Thank you for the response which adequately answers the ethics committee's queries. On behalf of the London Sport Institute Ethics Subcommittee, I am pleased to give your project its final approval. Please note that the committee must be informed if any changes in the protocol need to be made at any stage.

Yours sincerely

[redacted]

Dr. Rhonda Cohen
Chair of Ethics Sub-committee (London Sport Institute)

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Middlesex University
London Sport Institute

Ethical Approval Application response

MIDDLESEX UNIVERSITY

SCHOOL OF HEALTH AND EDUCATION

REVIEW FORM FOR ALL ETHICS APPLICATIONS

Name of Lead Researcher (i.e. student or PI): Kate Wilkinson

Name of Supervisor (if applicable): Hemda Garelick

Project Title

The pedagogical effect on engagement and learning of mLearning games prior to anatomy class based seminars

CORE PART I: TO BE COMPLETED FOR ALL APPLICATIONS	YES	NO
1. Is the form completed correctly?		x
2. Is the supervisor identified?	x	
3. Is the participant information sheet and consent form comprehensive enough?	x	
4. Is anyone likely to be disadvantaged or harmed?		x

5. Is the subject being respected?	x	
6. What are the benefits of this research? Please Specify:		

Reviewer Recommendation

Please indicate your overall assessment of the merits of the project:

APPROVE:	APPROVE WITH: MINOR AMENDMENTS	RESUBMIT AFTER: AMENDMENTS	REJECTED

(minor amendments can be signed off by the supervisor and then returned to Colin who will send out the approval letter)

Comments

Please provide any comments you wish to make on the proposal, particularly any suggestions as to how the project should be amended or could be improved:

Comments to Supervisor Only: I would like to thank the applicant for a well presented document that was well written and logical

Following Re-submission (if appropriate)

Reviewer Comments	**Responses to Reviewer**
Section3.1-3.3: You need to respond to whether you agree or not.	
The student supervisor signature needs to be added to the risk assessment.	

Ethics form 2015

Section 1 – Applicant details

1.1 Details of Principal Investigator o☐ **upervisor** (tick ☐ appropriate)		
1.1a Name: Kate Wilkinson	1.1b Department/role: Senior Lecturer LSI (student DProf in Health & Education)	
1.1c Qualifications: B.Sc, MSc, mSMA, REPS, fHEA	1.1d Email: K.S.Wilkinson@mdx.ac.uk	1.1e Tel: [redacted]
1.2 Details of Supervisors (if applicable)		
1.2a Name: Chris Huyck	1.2b Department/role: Professor in Artificial Intelligence	
1.2c Qualifications: PhD	1.2d Email: C.Huyck@mdx.ac.uk	1.2e [redacted]
1.2a Name: Hemda Garelick	1.2b Department/role: Professor in Environmental Science and Public Health education	
1.2c Qualifications: PhD	1.2d Email: H.Garelick@mdx.ac.uk	1.2e [redacted]
1.2a Name: George Dafoulas	1.2b Department/role: Science and Technology	
1.2c Qualifications: PhD	1.2d Email: G.Dafoulas@mdx.ac.uk	1.2e [redacted]
1.3 Details of any co-investigators (if applicable)		
1.3a Name:	1.3b Organisation:	
1.3c Role:	1.3d Email:	
1.3e Name:	1.3f Organisation:	
1.3g Role:	1.3h Email:	
1.4 Details of External Funding:		

Identify which of the Categories this proposal can be classified:

A1 ☐ **For information only (approved externally i.e. MoD) or public data**

(If yes, *please state the name of the external ethics committee)*…………………………………..

A2 v☐ Questionnaire A3 v☐ Discussion/Focus Groups A4 ☐ Observations

A5 v☐Interventions A6 ☐ Invasive e.g. Protein/Omega 3 tablets

A7 ☐Random Controlled Trials

NB: If A7 is ticked you will also need to tick A2, A3, A4 or A5 as appropriate

NB : Start date must be after approval letter has been released

Section 2 – Details of proposed study

2.1 Research project title:	**The pedagogical effect on engagement and learning of mLearning games prior to anatomy class based seminars**		
2.2 Proposed start date	01/10/15	**2.3 Proposed end date**	31/08/16
2.4 Main aims of the study			

The study is designed as part of a DProf in Education which focusses on the area of mobile learning in HE students. Smartphones and tablets are becoming increasingly popular in pedagogical practise but there is limited research into their effects on student learning, optimal strategies and achievement. Games in particular have been used successfully in secondary education to help engagement and are commonly advocated for students learning anatomy but there is no research on the use of games in HE anatomy learning.

Aim: To investigate the efficacy of mobile based anatomy games as a pre-seminar preparation tool for Undergraduate Sport and Exercise Science students.

Objectives:

- Investigate whether mobile learning experience influence efficacy in a pedagogical environment.
- Evaluate the effect on student engagement within the seminar compared to traditional pre-classroom reading.
- Evaluate the effect on student learning within the seminar.

2.5 Details of data collection procedures (Methodology – Participants, material and procedure):

Students will be undertaking the module as part of their normal academic study. Students will undertake the following assessments as per the module descriptor.

Participants:

Approximately 140 students SES1240 Students enrolled in 2014-15 and 2015-16 level 4 cohorts on BSc Sport and Exercise Science (SES) and BSc Sports and Exercise Rehabilitation (SER) students at Middlesex University. Currently the module is taught in nine seminar groups (seven SES; two SER), for this study only the SES groups will participate due to staff differences and teaching approaches. There will be approximately 140 students participating in the study but it is expected that a 80% completion rate will be achieved based on attendance and voluntary involvement in the study resulting in approximately 112 participants.

Procedure:

The study will be completed in the autumn term of semester one and then repeated in semester two. It is a crossover design where students will participate in all three conditions completing the same measures but these measures will be topic and seminar specific. A crossover design has been chosen to ensure that there is not bias due to one topic being easier or more favourably regarded or possibly even different teaching standards – although this will be minimised by the same experienced tutor completing all sessions. Students will be given an informed consent to sign which will allow the videoing of sessions for observational analysis to be completed after the seminar. Although real time analysis is shown to be better in school aged children I think this would disrupt the session too much and effect the learner experience. The recruitment is voluntary and no incentives will be offered. Students can opt out of the study at any time without informing the module leader, just by non-attendance. The 15 minute intervention will be integrated into the two hour seminar to ensure maximal participation and so as to not impinge on any other timetabling or travel commitments.

The proposed method is outlined in Table 1 and figure 1, showing the crossover nature of the pre-seminar conditions and the proposed data collection. Week 0 will act as the baseline for each student and seminar group to allow for normative comparisons to be drawn to a control measure. Normal module data will also be collected and students will be asked to complete an online focus group at the end of each semester to see whether participation in the study impacted on their normal behaviour.

The data collected is part of the normal seminar structure whereby students participate in a recap quiz and a plenary quiz – these may be on Socrative or moodle depending on the topic, however for the testing weeks the same platform will be utilised – Socrative which will allow data to be saved as an Excel spreadsheet for each student and organised into seminar groups.

Table 1.0 Crossover design

Seminar Group	Week 0	Week 1	Week 2	Week 3

1	Normal seminar	15 minute pre seminar games	15 minute pre seminar notes	Active Learning – 5 questions from the notes.
2	Normal seminar	15 minute pre seminar games	Active Learning – 5 questions from the notes.	15 minute pre seminar notes
3	Normal seminar	15 minute pre seminar notes	Active Learning – 5 questions from the notes.	15 minute pre seminar games
4	Normal seminar	15 minute pre seminar notes	15 minute pre seminar games	Active Learning – 5 questions from the notes.
5	Normal seminar	Active Learning – 5 questions from the notes.	15 minute pre seminar games	15 minute pre seminar notes
6	Normal seminar	Active Learning – 5 questions from the notes.	15 minute pre seminar notes	15 minute pre seminar games
7	Normal seminar	Active Learning – 5 questions from the notes.	15 minute pre seminar games	15 minute pre seminar notes

One seminar, either number 1 or 7 will be excluded from the crossover design due to numbers – but until timetabling is final this cannot be finalised. Data will be collected as detailed in Figure 1 below.

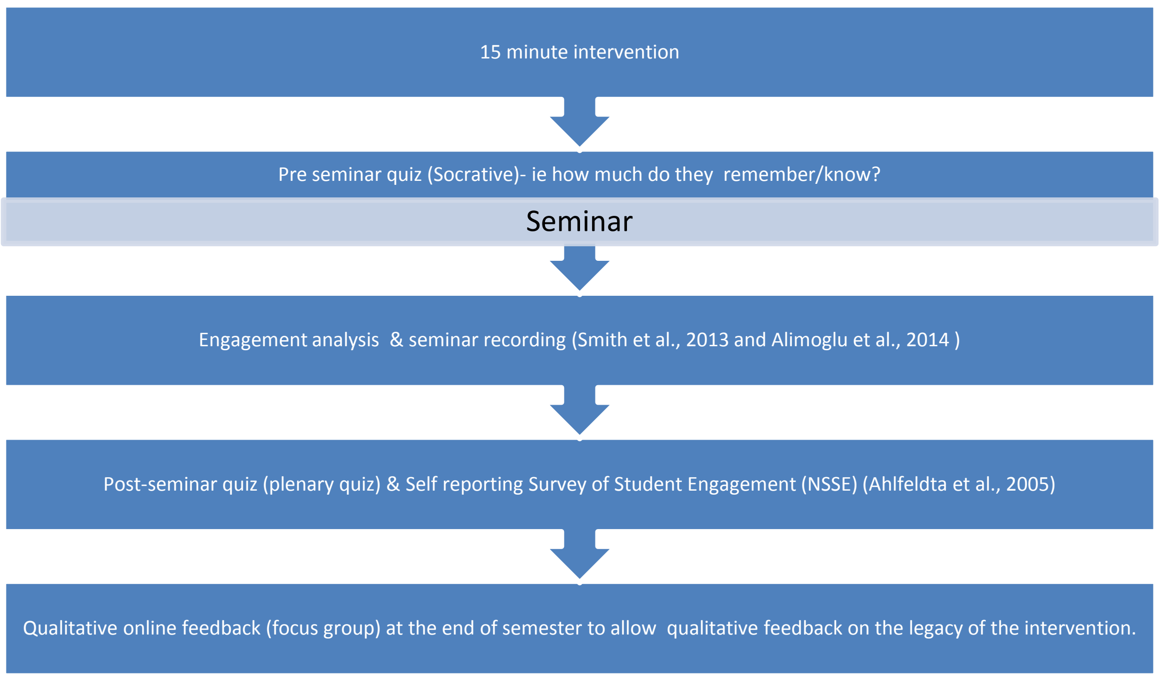

Figure 1

Proposed measures of the study with approximate timings.

Engagement data will consist of scale data based on observational behavioural engagement of number of on-task/off-task, student-student, student-staff, student-SLA interactions and will be analysed alongside other parametric data (quiz scores, module data, Unihub stats) in a MANOVA using SPSS. The engagement behavioural coding has been adapted from Smith et al., 2013 and Alimoglu et al., 2014 consisting of a mixed lecturer/facilitator and student method. Coding will take place as follows using interval observational analysis because of the continuous nature of student engagement using focus software or an alternative educational app.

The instructor is

1. talking to entire class while all the students are passive receivers (1)

2. telling/asking one or a group of students, or teaching/showing an application on a student (e.g., demonstration) while the rest of the class is listening or following their required work.

(2)

3. starting or conducting a discussion open to whole class, or assigning some students for some learning tasks (e.g., creating student groups to discuss different aspects of the subject matter) (3)

4. listening/monitoring active discussion with one or a group of students (4)

5. listening/monitoring active discussion with entire class (5)

Student behaviour scale:

Student is

1. engaged with non-educational material such as mobile phone, hand bag etc.; browsing a book,

notes (1)

2. reading or writing something on task (maybe following the lecture from a published material or taking notes)

(2)

3. listening to the instructor or a talking student/ looking at slides or board, eye contact, look of interest (3)

4. talking to the instructor (questioning, answering, discussing, etc.), reading something (e.g., seminar notes) to entire class or writing something (e.g., major signs of a disease) on the board, flip-chart etc. (4)

5. talking/discussing (asking, answering, explaining, etc.) with one or a group of students on the subject matter (5)

6. Interacting with mobile phone or tablet for a learning task as an individual/as a group. (6)

7. Student is interacting with another student off task. (7)

8. Student is working alone rather than in the required group situation. (8)

9. Student is talking/discussing (asking, answering, explaining, etc.) with one or a group of students using a model, skeleton to interact.

Students will also complete the National Survey of Student Engagement (NSSE) (Ahlfeldta et al., 2005) after each seminar during data collection (three occasions) which measures self-reporting cognitive engagement and emotional engagement to allow all proposed aspects of engagement to be measured. The NSSE is an established instrument that was developed to measure engagement in educationally relevant activities and the desired outcomes of Universities in the USA (Pascarella &Terenzini 2005; Kuh 2009). The NSSE is suggested to exhibit acceptable psychometric properties (Kuh, 2002) and items focusing on good practices in undergraduate education consistently predict development during the first year of college based on multiple objective measures (Pascarella et al. 2009) aligned to Blooms taxonomy of levels. Items from the larger NSSE have been used to develop shorter scales to measure engagement in educationally relevant practices and engagement in online courses (Kuh et al. 2008; Chen et al. 2010) including the chosen version used by Ahlfeldta et al., 2005 with an additional question, no 15 which will be working by playing games on a tablet/smartphone.

A Survey of Student Engagement

Course Number:____________________ **Instructor:**_____________

Please cross (X) your answers.

A. During your class, about how often have you done each of the following?
Scale: 4: very often; 3: often; 2: occasionally; 1:never

1. **Asked questions** during class or contributed to class discussions	4	3	2	1
2. **Worked with other students** on projects during class time	4	3	2	1
3. **Worked with classmates outside** of class to complete class assignments	4	3	2	1
4. **Tutored or taught** the class materials to other students in the class	4	3	2	1

B. To what extent has this course emphasized the mental activities listed below?
Scale: 4: very much; 3: quite a bit; 2: some; 1: very little

5. **Memorizing** facts, ideas or methods from your course and readings so you can repeat them in almost the same form	4	3	2	1
6. **Analyzing** the basic elements of an idea, experience or theory such as examining a specific case or situation in depth and considering its components	4	3	2	1
7. **Synthesizing and organizing** ideas, information, or experiences into new, more complicated interpretations and relationships	4	3	2	1
8. **Evaluating** the value of information, arguments, or methods such as examining how others gathered and interpreted data and assessing and accuracy of their conclusions	4	3	2	1
9. **Applying** theories and/or concepts to practical problems or in new situations	4	3	2	1

C. To what extent has this course contributed to your knowledge, skills, and personal development in the following ways?
Scale: 4: very much; 3: quite a bit; 2: some; 1: very little

10. **Acquiring job or career related** knowledge and skills	4	3	2	1
11. **Writing** clearly, accurately, and effectively	4	3	2	1
12. **Thinking** critically and/or analytically	4	3	2	1
13. **Learning effectively on your own,** so you can identify, research, and complete a given task	4	3	2	1
14. **Working effectively with other individuals**	4	3	2	1

An online focus group will be carried out to allow for further qualitative data collection to occur via moodle. It will be facilitated by myself and organised for the last week in the semester, week 12 to allow for questions and discussion to be raised about their attitude and response to the intervention. It will be anonymised for analysis but not for the student discussion to encourage a true reflection and has been suggested to encourage dialogue.

It is envisaged that 2 levels of coding will occur; at the first level there will be discussions on general themes about mLearning and at the second level, these themes will be further broken down into sub-themes. The specific sub-levels will be smartphones, games and pre-seminar reading/independent learning (Kinsash et al., 2012). Focus group data will be analysed using Nvivo.

Section 3 –Initial Checklist to be completed by all applicants (A1)	**Agree**
3.1 The research **DOES NOT involve human participants** or **animals** (e.g., it is a theoretical discussion, review of existing literature, analytical, simulation modelling and analysing media from televised sports events)	n/a
3.2 The research involves **secondary data analysis*** where the researcher can provide evidence that they have the necessary **approval to access*** the data *(please provide evidence of approval)* and **DOES NOT involve** access to records of **personal or sensitive information** concerning **identifiable individuals**, or **internet research involving visual images or discussion of sensitive issues**, or **research which may involve sharing of confidential information beyond the initial consent given**. Example, please provide a letter of permission for the use of Club and Team data. **If there is data linkage or it may be otherwise possible to identify participants, please complete all sections of this form.*	n/a
3.3 The research **already has ethical approval from another UK Ethics Committee** (e.g., a UK HEI, NHS NRES and MoD) and the liability insurance is provided by the other body/institution*. *(Please provide evidence of approval)* **If MU liability sponsorship is required please complete all sections of this form.*	n/a

If you have answered **AGREE** to any of the questions above, then **no further information is required**. Please complete **Section 9** and **sign the declaration in Section 10.** **(E-signature required)**

....
....
....

Section 4 – Research Methods and Design

4.1 Please detail **ALL methods of data collection** for this research:

Students will be undertaking the module as part of their normal academic study. Students will undertake the following assessments as per the module descriptor.

Participants:

Approximately 140 students SES1240 Students enrolled in 2014-15 and 2015-16 level 4 cohorts on BSc Sport and Exercise Science (SES) and BSc Sports and Exercise Rehabilitation (SER) students at Middlesex University. Currently the module is taught in nine seminar groups (seven SES; two SER), for this study only the SES groups will participate due to staff differences and teaching approaches. There will be approximately 140 students participating in the study but it is expected that a 80% completion rate will be achieved based on attendance and voluntary involvement in the study resulting in approximately 112 participants.

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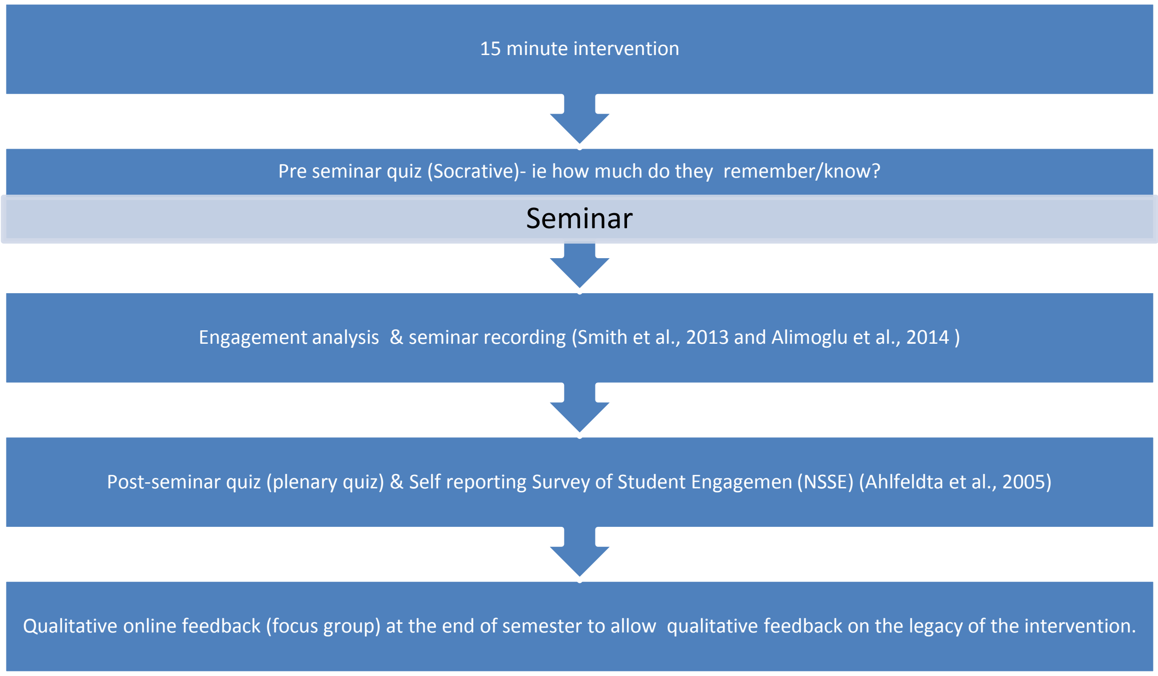

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Alimoglu, M. K., Sarac, D. B., Alparslan, D., Karakas, A. A., & Altintas, L. (2014). An observation tool for instructor and student behaviors to measure in-class learner engagement: a validation study. Medical Education Online, 19, 10.3402/meo.v19.24037. doi:10.3402/meo.v19.24037

Smith, M. K., Jones, F. H., Gilbert, S. L., & Wieman, C. E. (2013). The Classroom Observation Protocol for Undergraduate STEM (COPUS): a new instrument to characterize university STEM classroom practices. CBE-Life Sciences Education, 12(4), 618-627.

4.2 Will it be necessary for **participants to take part in the study without their knowledge and consent** at the time, e.g., covert observation? ~~Yes~~ No

If 'yes', please provide justification and details of how this will be managed to respect the participants/third parties involved to respect their privacy, values and to minimise any risk of harmful consequences:

4.3 Will you **audio or video record** interviews and/or observations? Yes No

The sessions will be recorded for analysis of behavioural engagement using Focus observational analysis software. Students will be aware of the recording and any student not wishing to participate in the study will be able to sit outside of the video field of view.

4.4 Will the research involve **respondents to the internet** or **other visual of vocal methods** where respondents may be identified? Yes ~~No~~

If 'yes' please provide details:

Online survey and module evaluation via moodle.

Eviva and online quiz assessments

Smartphone apps for revision.

Focus groups

4.5 Will the research involve the **sharing of data or confidential information beyond the initial consent** given?

If 'yes' please provide details: ~~Yes~~ No

4.6 How will you ensure compliance with the **Data Protection Act*** in terms of **anonymous data collection, maintaining confidentially**, sharing and secure storage, through research dissemination plans and disposure of research data? (*see DPA checklist)

All data will be stored electronically with participants identified by a student number only. The electronic data will be stored on a secure laptop and the consent forms will be stored separately in a locked cupboard.

4.7 Will you use an **experimental research design** (ie., implement a specific plan for assigning participants to conditions and noting consequent changes? Yes No

If 'yes', please provide details of treatment/intervention (and specify is these are intrusive interventions such as the use of hypnosis or physical exercise) and required resources:

The proposed method is outlined in Table 1 and figure 1, showing the crossover nature of the pre-seminar conditions and the proposed data collection. Week 0 will act as the baseline for each student and seminar group to allow for normative comparisons to be drawn to a control measure. Normal module data will also be collected and students will be asked to complete an online focus group at the end of each semester to see whether participation in the study impacted on their normal behaviour.

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2	15 minute pre	Active Learning – 5	15 minute pre

	seminar games	questions from the notes.	seminar notes
3	15 minute pre seminar notes	Active Learning – 5 questions from the notes.	15 minute pre seminar games
4	15 minute pre seminar notes	15 minute pre seminar games	Active Learning – 5 questions from the notes.
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One seminar, either number 1 or 7 will be excluded from the crossover design due to numbers – but until timetabling is final this cannot be finalised. Data will be collected as detailed in Figure 1 below. **Although the students will be doing the same sessions and interventions as part of their normal seminar including the pre and post quizzes (normal in my classses) they will give consent and therefore can opt out of any data collection and being a participant in the study.**

4.8 Will the study involve **discussion of sensitive topics**? (e.g., sexual activity, drug use etc) ~~Yes~~ No

If 'yes' please provide details:

4.9 Is **pain or more than mild discomfort** likely to result from the study? ~~Yes~~ No

If 'yes' please provide details:

4.10 Could the study induce **psychological stress or anxiety** or **cause harm or negative consequences** beyond the risks encountered in normal life? ~~Yes~~ No

If 'yes' please provide details:

4.11 Avoiding harm: what has been done to assess, obviate/remove or minimise potential risks and how will participants/third parties be supported?

4.12 Will participants receive any **reimbursements or payments**? ~~Yes~~ No

If 'yes' please provide details:

4.13 Will the research involve the participation and/or observation of **animals***? ~~Yes~~ No

**Please see MU Statement on the Use of Animals in Research*

If 'yes' please provide details:

Section 5 – Research Participants

5.1 Please indicate the **types of participants** that will be included in this research:

(e.g., under 16yrs; patients; MU students; general public; specific group(s) or team(s); vulnerable adults unable to give informed consent etc) *All research that falls under the auspices of the Mental Capacity Act must be reviewed by NHS NRES.*

SES1240 Students enrolled in 2015-16 level 4 cohorts on BSc Sport and Exercise Science and BSc Sports and Exercise Rehabilitation students at Middlesex University.

5.2 Number of participants: *(for each type of participant, if applicable)*

140 (approximately) cohort is approx 160 students but allowing for non participants

5.3 Briefly decribe how **access** will be gained to participants:

The students will be those enrolled on SES1240, Fundamentals of Anatomy and Movement. As the module leader I am in charge of the module administration, content and delivery of the module. All students will be asked for consent prior to using their data in the study.

5.4 Length of each **data collection session**, number of sessions and location of data collection *i.e., will the study involve prolonged and repetitive testing? If so, please justify and state how participants will be supported?*

Table 1.0 Crossover design

Seminar Group	Week 0	Week 1	Week 2	Week 3

1	Normal seminar	15 minute pre seminar games	15 minute pre seminar notes	Active Learning – 5 questions from the notes.
2	Normal seminar	15 minute pre seminar games	Active Learning – 5 questions from the notes.	15 minute pre seminar notes
3	Normal seminar	15 minute pre seminar notes	Active Learning – 5 questions from the notes.	15 minute pre seminar games
4	Normal seminar	15 minute pre seminar notes	15 minute pre seminar games	Active Learning – 5 questions from the notes.
5	Normal seminar	Active Learning – 5 questions from the notes.	15 minute pre seminar games	15 minute pre seminar notes
6	Normal seminar	Active Learning – 5 questions from the notes.	15 minute pre seminar notes	15 minute pre seminar games
7	Normal seminar	Active Learning – 5 questions from the notes.	15 minute pre seminar games	15 minute pre seminar notes

One seminar, either number 1 or 7 will be excluded from the crossover design due to numbers – but until timetabling is final this cannot be finalised. Data will be collected as detailed in Figure 1 below.

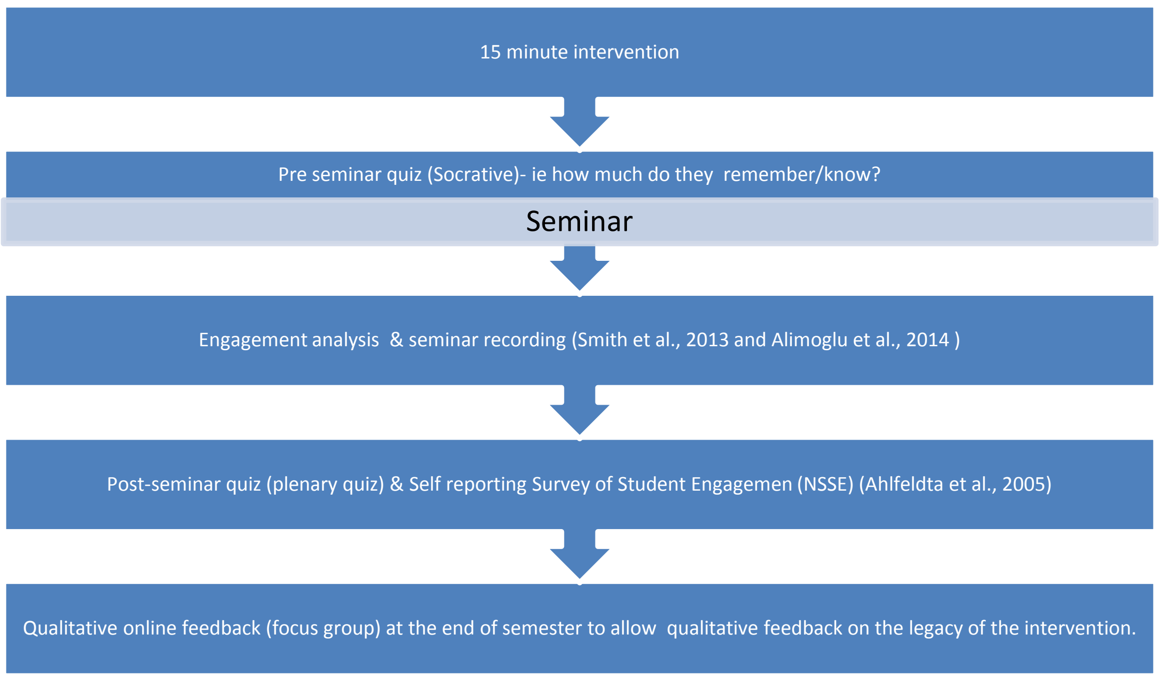


Figure 1

Proposed measures of the study with approximate timings.

5.5 Does this research require **External Ethics Approval**? ~~Yes~~ No

If 'yes' please provide details:

Section 6 – Safety and legal issues

6.1 Will you **be alone** with a participant or group of participants? Yes ~~No~~

Yes – teaching as per normal (although usually with SLA's and GTA's)

6.2 What **safety issues*** does your methodology raise for you and for your participants and what mitigating actions will be taken? *While researchers have a duty to not cause harm to participants, some research requires judgements to be made about what are acceptable/justifiable levels of harm in accordance with the potential benefits of the research. *If relevant to this research, please specify*:

none

6.3 What **legal issues** does your methodology raise for you and for your participants and what mitigating actions will be taken? *Please specify*:

N/A

6.4 Do you hold a current **Disclosure and Barring Service** (DBS) Certificate*? Yes ~~No~~

*Needed when working with children or in healthcare.

Section 7 – Research Collaboration

7.1 Does the research involve an international collaborator or research conducted **overseas**? ~~Yes~~ No

If 'yes', what ethical review procedures must this research comply with for that country, and what steps have been taken to comply with

these:

Section 8 – Protocols for ethical research	**Yes**	**No**
8.1 Will you ensure compliance with the **Data Protection Act**? (See DPA Checklist)	YES	
8.2 Will you provide a **<u>Participant Information Sheet</u>***?	YES	
8.3 Will you obtain **<u>Written Informed Consent</u>*** directly from research participants?	YES	
8.4 Will you obtain **<u>Written Informed Consent</u>*** directly from gatekeepers (if applicable) Registry – student data This has been requested by Phil Barter through student records. Awaiting response.	YES	
8.5 Will you inform participants that their participation is **voluntary** and that they have a **right to withdraw** from the research at any time?	YES	
8.6 Will you tell participants that their data will be treated **confidentially** and the limits of confidentiality will be made clear in your Participant Information Sheet?	YES	
8.7 Will you inform participants of the limits of **anonymity** they will be afforded as participants? (e.g., their identities as participants will be concealed in all documents resulting from the research)	YES	
8.8 Will you aim to **avoid harm** to your participants?	YES*	
8.9 Will you ensure your research is **independent and impartial**?	YES	
8.10 Will you provide a **<u>Written Debriefing Sheet</u>***? (if applicable) N/A		

*Please **submit copies of these forms** with this application

If you have answered **No** to any of the questions above, please explain below:

Section 9 – Other Ethical Issues – to be completed by all applicants

Does the study involve any **other ethical issues** not covered above? Yes No *If 'yes' please give details:*

Section 10: Declaration – to be completed by all applicants

Applicants should read and sign the following declaration before submitting the application.

Please ensure that you have read and understood the relevant Code(s) of Ethics appropriate to your research field and topic.

In signing this research ethics declaration I am confirming that:

1. I have read and understood the relevant Code(s) of Ethics appropriate to my research field and topic.
2. The research ethics application form is accurate to the best of my knowledge and belief.
3. I have read and understand the University's *Code of Practice For Research: Principles and Procedures*
4. I agree to abide by the research ethics applicable to the project and which are listed above.
5. I understand that it is my responsibility to ensure that the research is conducted in accordance with my professional/statutory/regulatory body Code of Conduct/Code of Ethics/Research Governance Framework.
6. There is no potential material interest that may, or may appear to, impair the independence and objectivity of researchers conducting this project.
7. I have received and will submit evidence of authorisation from the relevant authorities to carry out the research with this application – if applicable.
8. I agree to inform my Supervisor/School/Institute or Departmental Research Ethics Committee of any adverse effects.
9. I understand that the project, including research records and data, may be subject to inspection for audit purposes at any time in the future.
10. I understand that personal data about me contained in this form will be held by those involved in the ethics approval procedure and that it will be managed according to Data Protection Act principles.
11. I will notify my Supervisor/School/Institute or Departmental Research Ethics Committee of any proposed changes to this methodology. Use Amendment form D, or Extension form E where appropriate.
12. I have seen and signed a risk assessment for this research study (if applicable).

For supervisors:

1. I confirm that I have reviewed all the information submitted with this research ethics application.
2. I also accept responsibility for guiding the applicant so as to ensure compliance with the terms of the protocol and with any applicable Code(s) of Ethics.
3. I understand that research/data may be subject to inspection for audit purposes and I agree to participate in any audit procedures required by the University Ethics Committee (UEC) if requested.
4. I confirm that it is my responsibility to ensure that students under my supervision undertake a risk assessment to ensure that health and safety of themselves, participants and others is not jeopardised during the course of this study.
5. I have seen and signed a risk assessment for this research study (if applicable).

Principle Investigator/Supervisor signature:

.... .

Print name: ....K Wilkinson.......

Date: ....07/09/15.....(dd/mm/yyyy)

Print name: ....

Date: .... (dd/mm/yyyy)

Student's signature (if applicable):

...[redacted]

Principle Investigator/Supervisor signature:

.... . [redacted]

Print name: ...Hemda Garelick

Date: .... (dd/mm/yyyy)

Principle Investigator/Supervisor signature:

.... .

Print name: ....

Date: .... (dd/mm/yyyy)

Please submit to your relevant School/Institute or Departmental Research Ethics Committee.

Please attach the following documents:

1. Participant Information Sheet
2. Written Informed Consent Sheets
3. Written debriefing Sheet (if applicable)
4. Completed risk assessment form (if applicable)
5. Copy of questionnaire/interview guide/details of materials for data collection

Participant Information Sheet 2015

MIDDLESEX UNIVERSITY
SCHOOL OF HEALTH AND EDUCATION

LONDON SPORT INSTITUTE ethics SUB-committee

PARTICIPANT SHEET (PS)

1. Study title

The pedagogical effect on engagement and learning of mLearning games prior to anatomy class based seminars

2. Invitation paragraph

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

3. What is the purpose of the study?

The study is designed as part of a DProf in Education which focusses on the area of mobile learning in HE students. Smartphones and tablets are becoming increasingly popular in pedagogical practise but there is limited research into their effects on student learning, optimal strategies and achievement. Games in particular have been used successfully in secondary education to help engagement and are commonly advocated for students learning anatomy but there is little research on the use of games in HE anatomy learning.

Aim: To investigate the effect of mobile based anatomy games as a pre-seminar engagement and learning tool in Undergraduate Sport and Exercise Science students.

4. Why have I been chosen?

You have been chosen because you are a student registered on SES1240, Fundamentals of Human Anatomy and Movement.

5. Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason.

A decision to withdraw at any time, or a decision not to take part, will not affect your academic studies at any time.

6. What will I have to do?

You will complete the module as normal during the 2015-16 academic year, but in three seminars in semester one you will be given a 15 minute activity at the beginning of each seminar. You will be doing all three activities in class time as part of the normal learning environment. Students will be asked to complete the normal learning activities (recap quiz, learning exercise, plenary quiz) and a short questionnaire on student engagement. The questionnaire is adapted from the Self reporting Survey of Student Engagement (NSSE) consisting of 14 questions using a rating system (Likert Scale). Four seminar classes will be recorded using video for the student engagement analysis. Any students opting out of the investigation will be grouped outside of the video field of view or excluded from analysis depending on your preference.

Data to be collected and analysed will also include your achievement data for the module, SES1240 and interaction statistics for MyUnihub.

Please note that in order to ensure quality assurance and equity this project may be selected for audit by a designated member of the committee. This means that the designated member can request to see signed consent forms. However, if this is the case your signed consent form will only be accessed by the designated auditor or member of the audit team.

7. What are the possible disadvantages and risks of taking part?

There is no known risk in participating in this project.

8. What are the possible benefits of taking part?

We hope that participating in the study will help you. However, this cannot be guaranteed. The information we get from this study may help us to inform the teaching and learning strategy of the LSI and give us valuable information about the effect of different learning methods on student engagement.

9. Will my taking part in this study be kept confidential?

All information that is collected about you during the course of the research will be kept strictly confidential. Any information about you which is used will have your name and address removed so that you cannot be recognised from it.

All data will be stored, analysed and reported in compliance with the Data Protection Legislation of the UK.

10. What will happen to the results of the research study?

This research will be published as part of a professional Doctorate dissertation. A copy of the results can be obtained from the library following submission or you can contact Kate Wilkinson for an executive summary of the results.

11. Who has reviewed the study?

The study has been reviewed and approved by the Middlesex University, School of Science and Technology, London Sport Institute Ethics sub-Committee.

12. Contact for further information

Please contact myself using K.S.Wilkinson@mdx.ac.uk.

If necessary you can contact my supervisors;

Chris Huyck C.Huyck@mdx.ac.uk

Hemda Garelick H.Garelick@mdx.ac.uk

George Dafoulas G.Dafoulas@mdx.ac.uk

You will be given a copy of this form and the Informed consent form to keep.
Thank you for participating in the study

CONSENT FORM

Title of Project:. The pedagogical effect on engagement and learning of mLearning games prior to anatomy class based seminars

Name of Researcher: Kate Wilkinson

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

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

3. I agree that this form that bears my name and signature may be seen by a designated auditor.

4. I agree that my non-identifiable research data may be stored in National Archives and be used anonymously by others for future research. I am assured that the confidentiality of my data will be upheld through the removal of any personal identifiers.

5. I agree to take part in the above study.

____________________________ ________________ ___________________________

Name of participant Date Signature

______________________________ _________________

____

Name of person taking consent (if different from researcher) Date Signature

___Kate Wilkinson__________ _20/08/15________________ ___[redacted]

Researcher Date Signature

1 copy for participant; 1 copy for researcher;

INDEPENDENT FIELD/LOCATION WORK RISK ASSESSMENT FRA1

This proforma is applicable to, and must be completed in advance for, the following field/location work situations:

1. *All field/location work undertaken independently by individual students, either in the UK or overseas, including in connection with proposition module or dissertations. Supervisor to complete with student(s).*
2. *All field/location work undertaken by postgraduate students. Supervisors to complete with student(s).*
3. *Field/location work undertaken by research students. Student to complete with supervisor.*
4. *Field/location work/visits by research staff. Researcher to complete with Research Centre Head.*
5. *Essential information for students travelling abroad can be found on www.fco.gov.uk*

FIELD/LOCATION WORK DETAILS

Name …Kate Wilkinson………….

Student No
Research Centre (staff only)……KW671……………..

Supervisor ……Chris Huyck, Hemda Garelick, George Dafoulad….

Degree course ……DProf Education………………….

Telephone numbers and name of next of kin who may be contacted in the event of an accident

NEXT OF KIN

Name …[redacted]……………………..

Phone [redacted]………………………………………..

Physical or psychological limitations to carrying out the proposed field/location work

…N/A……..…………..…………...…………………………………….

……….………….………….…………...……………………………………….

Any health problems (full details) Which may be relevant to proposed field/location work activity in case of emergencies.

………N/A.……………..…………...……………………………………….

……….………….………….…………...……………………………………….

Locality (Country and Region)

…Allianz Park, Middlesex University, London, UK

Travel Arrangements

……Driving/cycling to work as normal…………………………………………..

……….………….………….…………...……………………………………….

NB: Comprehensive travel and health insurance must always be obtained for independent overseas field/location work.

……….………….………….…………...……………………………………….

…………………………………………………………………………………..

Dates of Travel and Field/location work	…October 2014-September 2017……..…………..…………………………
	………..………..………..…………...………………………………………

PLEASE READ THE FOLLOWING INFORMATION VERY CAREFULLY

Hazard Identification and Risk Assessment

List the localities to be visited or specify routes to be followed **(Col. 1).** For each locality, enter the potential hazards that may be identified beyond those accepted in everyday life. Add details giving cause for concern **(Col. 2).**

Examples of Potential Hazards :
Adverse weather: exposure (heat, sunburn, lightening, wind, hypothermia)
Terrain: rugged, unstable, fall, slip, trip, debris, and remoteness. Traffic: pollution.
Demolition/building sites, assault, getting lost, animals, disease.
Working on/near water: drowning, swept away, disease (weils disease, hepatitis, malaria, etc), parasites', flooding, tides and range.
Lone working: difficult to summon help, alone or in isolation, lone interviews.
Dealing with the public: personal attack, causing offence/intrusion, misinterpreted, political, ethnic, cultural, socio-economic differences/problems. Known or suspected criminal offenders.
Safety Standards (other work organisations, transport, hotels, etc), working at night, areas of high crime.
Ill health: personal considerations or vulnerabilities, pre-determined medical conditions (asthma, allergies, fitting) general fitness, disabilities, persons suited to task.
Articles and equipment: inappropriate type and/or use, failure of equipment, insufficient training for use and repair, injury.
Substances (chemicals, plants, bio- hazards, waste): ill health - poisoning, infection, irritation, burns, cuts, eye-damage.
Manual handling: lifting, carrying, moving large or heavy items, physical unsuitability for task

If no hazard can be identified beyond those of everyday life, enter 'NONE'.

1. LOCALITY/ROUTE	2. POTENTIAL HAZARDS
Allianz Park	**None**

The University Field/location work code of Practice booklet provides practical advice that should be followed in planning and conducting field/location work.

Risk Minimisation/Control Measures

PLEASE READ VERY CAREFULLY

For each hazard identified **(Col 2),** list the precautions/control measures in place or that will be taken **(Col 3)** to **"reduce the risk to acceptable levels",** and the safety equipment **(Col 5)** that will be employed.

Assuming the safety precautions/control methods that will be adopted **(Col. 3),** categorise the field/location work risk for each location/route as negligible, low, moderate or high **(Col. 4).**
Risk increases with both the increasing likelihood of an accident and the increasing severity of the consequences of an accident.

An acceptable level of risk is: a risk which can be safely controlled by person taking part in the activity using the precautions and control measures noted including the necessary instructions, information and training relevant to that risk. The resultant risk should not be significantly higher than that encountered in everyday life.

Examples of control measures/precautions:

Providing adequate training, information & instructions on field/location work tasks and the safe and correct use of any equipment, substances and personal protective equipment. Inspection and safety check of any equipment prior to use. Assessing individuals fitness and suitability to environment and tasks involved. Appropriate clothing, environmental information consulted and advice followed (weather conditions, tide times etc.). Seek advice on harmful plants, animals & substances that may be encountered, including information and instruction on safe procedures for handling hazardous substances. First aid provisions, inoculations, individual medical requirements, logging of location, route and expected return times of lone workers. Establish emergency procedures (means of raising an alarm, back up arrangements). Working with colleagues (pairs). **Lone working is not permitted where the risk of physical or verbal violence is a realistic possibility.** Training in interview techniques and avoiding /defusing conflict, following advice from local organisations, wearing of clothing unlikely to cause offence or unwanted attention. Interviews in neutral locations. Checks on Health and Safety standards & welfare facilities of travel, accommodation and outside organisations. Seek information on social/cultural/political status of field/location work area.

Examples of Safety Equipment: Hardhats, goggles, gloves, harness, waders, whistles, boots, mobile phone, ear protectors, bright fluorescent clothing (for roadside work), dust mask, etc.

If a proposed locality has not been visited previously, give your authority for the risk assessment stated or indicate that your visit will be preceded by a thorough risk assessment.

3. PRECAUTIONS/CONTROL MEASURES	**4. RISK ASSESSMENT** (low, moderate, high)	**5. SAFETY/EQUIPME**

PLEASE READ THE FOLLOWING INFORMATION AND SIGN AS APPROPRIATE

DECLARATION: The undersigned have assessed the activity and the associated risks and declare that there is no significant risk or that the risk will be controlled by the method(s) listed above/over. Those participating in the work have read the assessment and will put in place precautions/control measures identified.

NB: Risk should be constantly reassessed during the field/location work period and additional precautions taken or field/location work discontinued if the risk is seen to be unacceptable.

Signature of Field/location worker (Student/Staff)	[redacted]	**Date**	20/08/15…
Signature of Student Supervisor	[redacted] ………..………….………	**Date**	…….……………

APPROVAL: (ONE ONLY)

Signature of Director of Programmes (undergraduate students only)	………..……………..………..…………..……………	**Date**	………..…………
Signature of Research Degree Co-ordinator or Director of Programmes (Postgraduate)	………..……………..………..…………..……………	**Date**	………..…………
Signature of Research Centre Head (for staff field/location workers**)**	………..……………..………..…………..……………	**Date**	……..………

FIELD/LOCATION WORK CHECK LIST

1. Ensure that **all members** of the field party possess the following attributes (where relevant) at a level appropriate to the proposed activity and likely field conditions:

- ☐ Safety knowledge and training?
- ☐ Awareness of cultural, social and political differences?
- ☐ Physical and psychological fitness and disease immunity, protection and awareness?
- ☐ Personal clothing and safety equipment?
- ☐ Suitability of field/location workers to proposed tasks?

2. Have all the necessary arrangements been made and information/instruction gained, and have the relevant authorities been consulted or informed with regard to:

- ☐ Visa, permits?
- ☐ Legal access to sites and/or persons?
- ☐ Political or military sensitivity of the proposed topic, its method or location?
- ☐ Weather conditions, tide times and ranges?
- ☐ Vaccinations and other health precautions?
- ☐ Civil unrest and terrorism?
- ☐ Arrival times after journeys?
- ☐ Safety equipment and protective clothing?
- ☐ Financial and insurance implications?
- ☐ Crime risk?
- ☐ Health insurance arrangements?
- ☐ Emergency procedures?
- ☐ Transport use?

☐ Travel and accommodation arrangements?

Important information for retaining evidence of completed risk assessments:

Once the risk assessment is completed and approval gained the **supervisor** should retain this form and issue a copy of it to the field/location worker participating on the field course/work. In addition the **approver** must keep a copy of this risk assessment in an appropriate Health and Safety file.

RP/cc August 2011

Appendix B

The modified SPQ

Study Process questionnaire

1 * I find that at times studying gives me a feeling of deep personal satisfaction.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

2 * I find that I have to do enough work on a topic so that I can form my own conclusions before I am satisfied.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

3 * My aim is to pass the course while doing as little work as possible.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

4 * I only study seriously what's given out in class or in the course outlines.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

5 * I feel that virtually any topic can be highly interesting once I get into it.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

6 * I find most new topics interesting and often spend extra time trying to obtain more informatioı about them.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

7 * I do not find my course very interesting so I keep my work to the minimum.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

8 * I learn some things by rote, going over and over them until I know them by heart even if I do not understand them.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

9 * I find that studying academic topics can at times be as exciting as a good novel or movie.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

10 * I test myself on important topics until I understand them completely.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

11 * I find I can get by in most assessments by memorising key sections rather than trying to understand them.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

12 * I generally restrict my study to what is specifically set as I think it is unnecessary to do anything extra.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

13 * I work hard at my studies because I find the material interesting.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

14 * I spend a lot of my free time finding out more about interesting topics which have been discussed in different classes.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

15 * I find it is not helpful to study topics in depth. It confuses and wastes time, when all you need is a passing acquaintance with topics.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

16 * I believe that lecturers shouldn't expect students to spend significant amounts of time studying material everyone knows won't be examined.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

17 * I come to most classes with questions in mind that I want answering.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

18 * I make a point of looking at most of the suggested readings that go with the lectures.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

19 * I see no point in learning material which is not likely to be in the examination.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

20 * I find the best way to pass examinations is to try to remember answers to likely questions.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

21 * I use my phone to help me study in my spare time.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

22 * I enjoy using games and quizzes to help me remember things.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

23 * I need to be told how to use my phone or tablet to help me study otherwise I will not bother.

this item is never or only rarely	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

24 * I cannot see the point in playing games to learn it doesn't help me academically.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

25 * I would rather read a book than use my phone or tablet for learning.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

26 * My interaction with the tablet or smartphone is clear and understandable.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

27 * Learning to use the tablet or smartphone for learning is easy for me.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

28 * It is easy for me to remember how to perform tasks when using the tablet or smartphone.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

29 * Using the tablet or smartphone helps me a lot in anatomy learning.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

30 * The tablet or smartphone enables me to accomplish learning tasks more quickly.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

31 * Using the tablet or smartphone enhances my effectiveness of study outside of the classroom.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

32 * Using the tablet or smartphone makes it easier to study to study outside of class.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

33 * I have started to use my tablet/smartphone in other modules for studying.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

34 * I like using the tablet/smartphone to play anatomy games when I have a free moment.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

35 * Games on the tablet/smartphone enhance my learning.

this item is never or only rarely true of me	this item is sometimes true of me	this item is true of me about half the time	this item is frequently true of me	this item is always or almost always true of me
○	○	○	○	○

36 * Please describe your experience of using your smartphone or tablet for learning whilst at Middlesex University.

37 * Please describe your feelings towards using games to help learning in anatomy and other modules.

38 If you use your smartphone or tablet to study for anatomy, where abouts do you do so on a regular basis?

NSSE

bos

National Student Engagement class

Showing 132 of 132 responses

Showing **all** responses

Showing **all** questions

Response rate: 132%

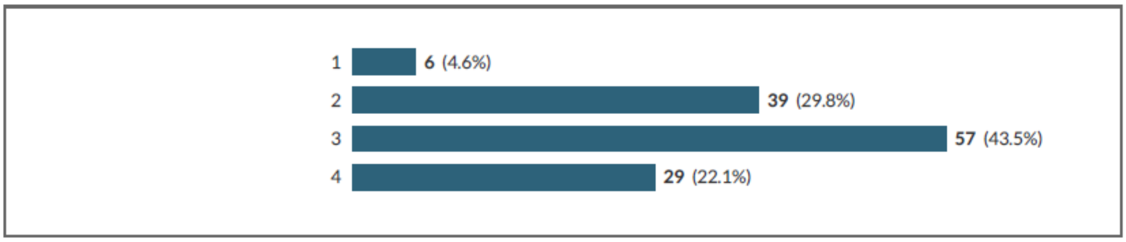
1 You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this. The study is designed as part of a DProf in Education which focusses on the area of mobile learning in HE students. Smartphones and tablets are becoming increasingly popular in pedagogical practise but there is limited research into their effects on student learning, optimal strategies and achievement. Games in particular have been used successfully in secondary education to help engagement and are commonly advocated for students learning anatomy but there is little research on the use of games in HE anatomy learning. Aim: To investigate the effect of mobile based anatomy games as a pre-seminar engagement and learning tool in Undergraduate Sport and Exercise Science students. Please choose agree or disagree to consent to using your anonymised data for the study.

2 Please give your student number

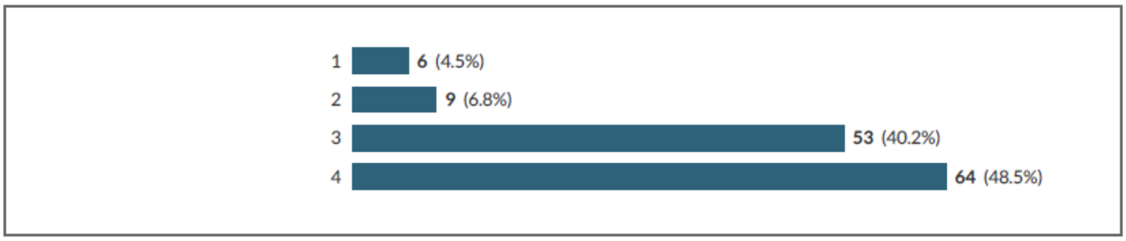
Showing 5 of 132 responses	
M00538315	165418-165412-10257537
M00521924	165418-165412-10258800
M00519984	165418-165412-10258799
M00522386	165418-165412-10258813
M00522015	165418-165412-10258863

3 During your class, about how often have you done each of the following? Scale: 4: very often; 3: often; 2: occasionally; 1:never

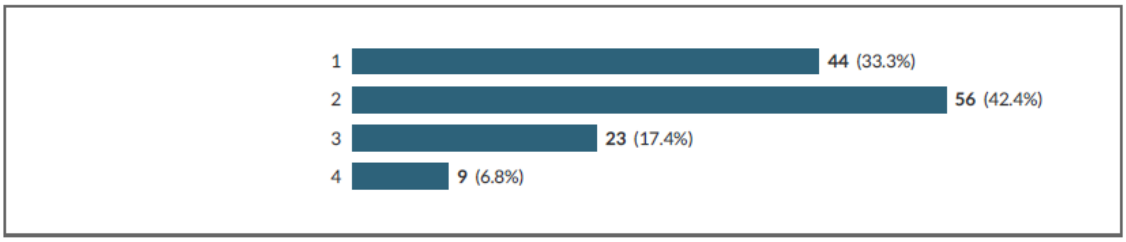
3.1 Asked questions during class or contributed to class discussions



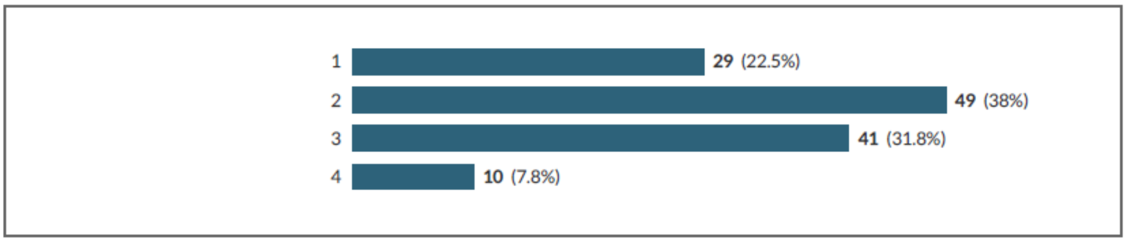
3.2 Worked with other students on projects during class time



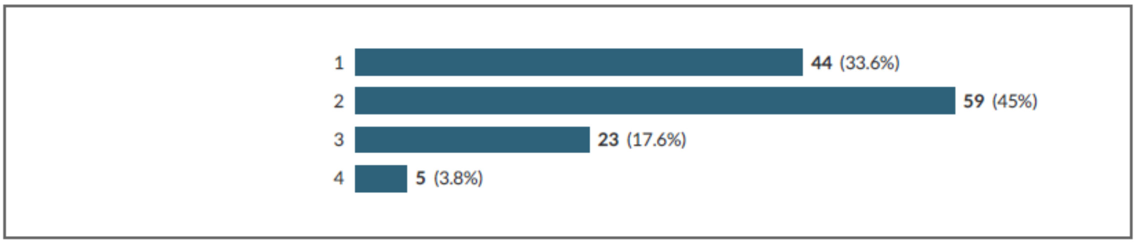
3.3 Worked with classmates outside of class to complete class assignments



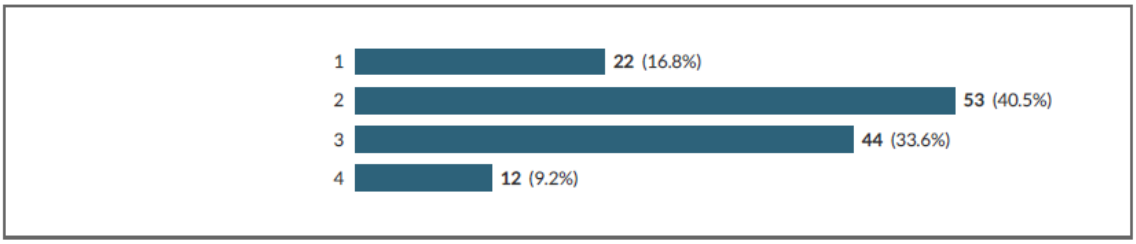
3.4 Tutored or taught the class materials to other students in the class



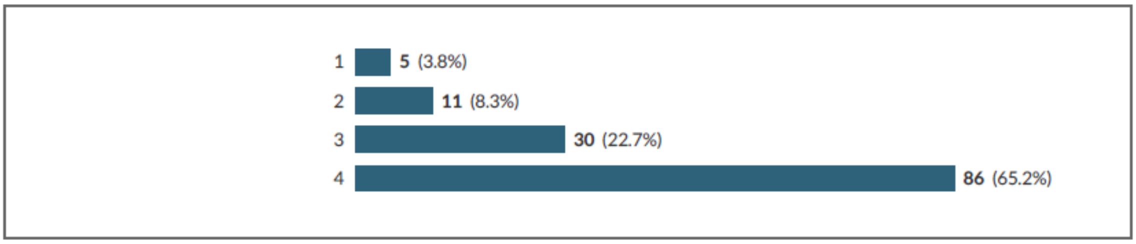
3.5 Come to class without completing readings or assignments



3.6 Discussed ideas from your readings or classes with others outside of class (students, family members, co-workers, etc.

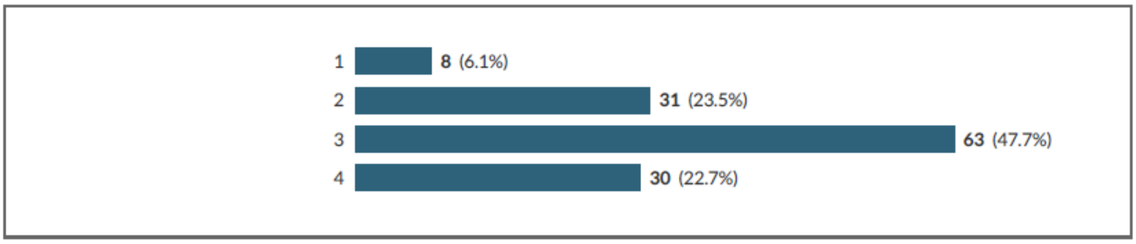


3.7 Used your smartphone or tablet device for learning.

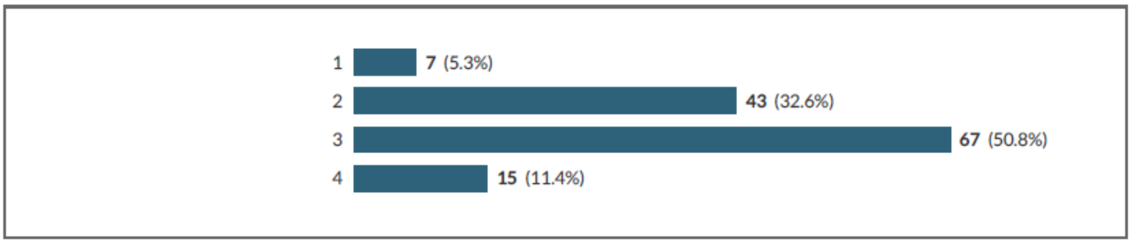


4 To what extent has this course emphasized the mental activities listed below? Scale: 4: very much; 3: quite a bit; 2: some; 1: very little

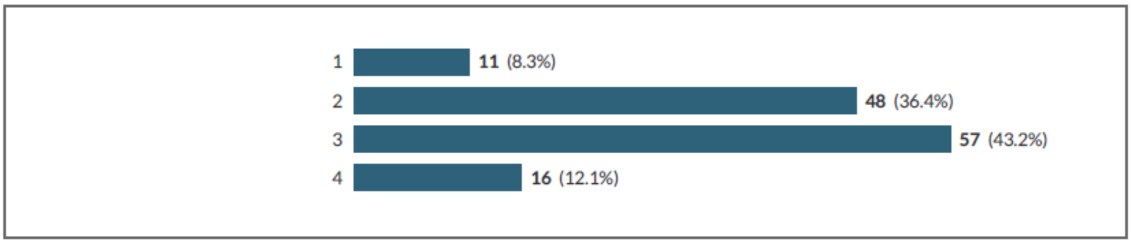
4.1 Memorizing facts, ideas or methods from your course and readings so you can repeat them in almost the same form



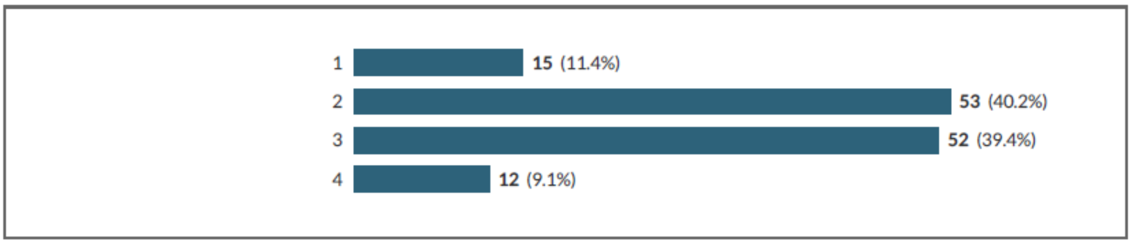
4.2 Analyzing the basic elements of an idea, experience or theory such as examining a specific case or situation in depth and considering its components



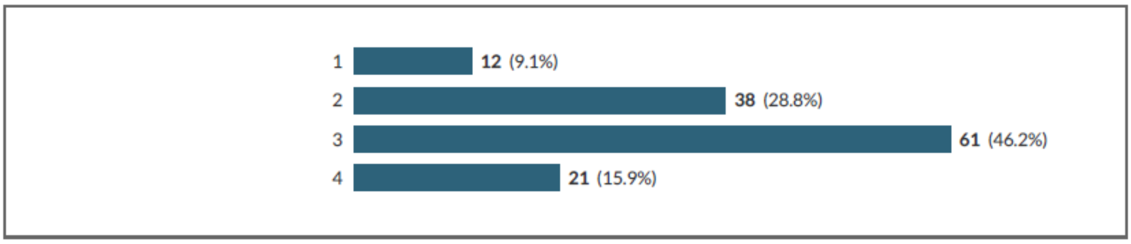
4.3 Synthesizing and organizing ideas, information, or experiences into new, more complicated interpretations and relationships



4.4 Evaluating the value of information, arguments, or methods such as examining how others gathered and interpreted data and assessing and accuracy of their conclusions

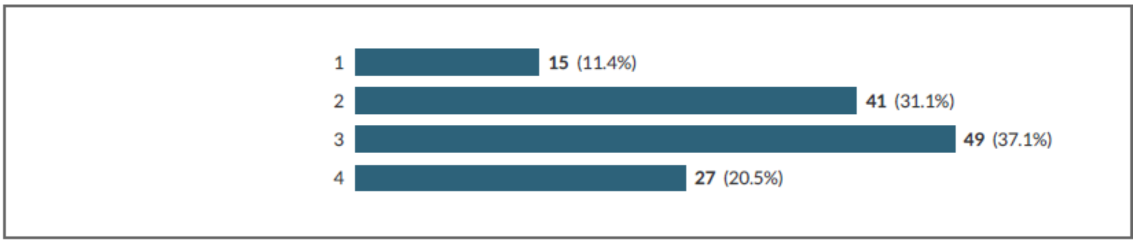


4.5 Applying theories and/or concepts to practical problems or in new situations

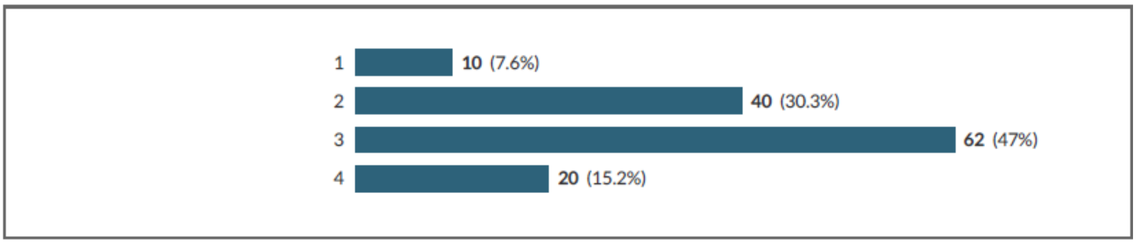


5 To what extent has this course contributed to your knowledge, skills, and personal development in the following ways? Scale: 4: very much; 3: quite a bit; 2: some; 1: very little

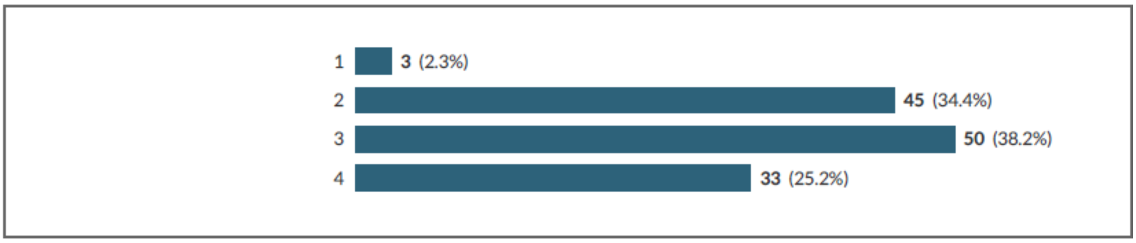
5.1 Acquiring job or career related knowledge and skills



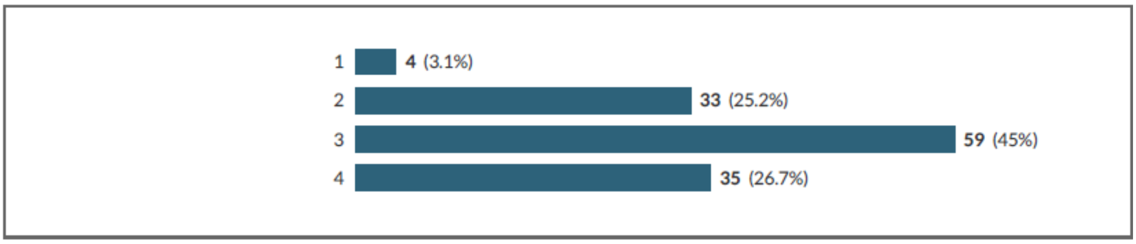
5.2 Writing clearly, accurately, and effectively



5.3 Thinking critically and/or analytically

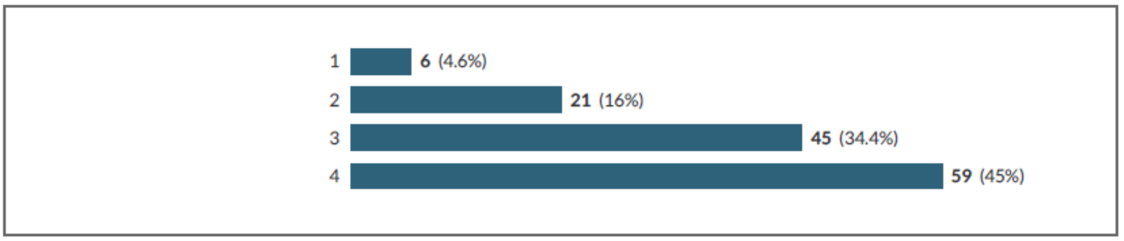


5.4 Learning effectively on your own, so you can identify, research, and complete a given task



5 / 6

5.5 Working effectively with other individuals



Appendix C

Scheme of Work

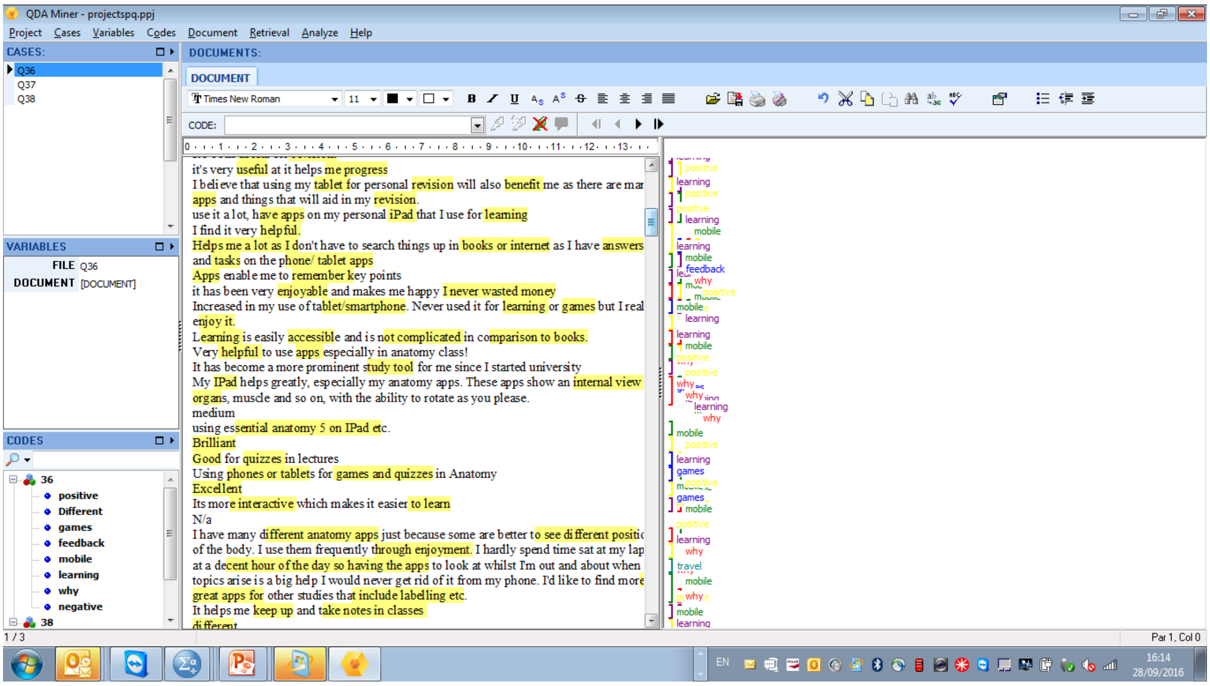
Week 1 5th Oct	Introduction to the module & the language of anatomy	KW	H &S, planes of motion	4	1,2,3,4	Read module information and assessment diary.
Week 2 12th Oct	Bone & skeleton	KW	The skeleton	4	1,2,3,4	Online quiz
Week 3 19th Oct	Joints	KW	Joints	4	1,2,3,4	Online quiz
Week 4 26th Oct	Tendon, ligament	KW	The knee joint	1	1	Online quiz
Week 5 2nd Nov	Muscle structure 1	KW	Knee muscles & Ligaments	1	1	Online quiz
Week 6 9th Nov	Reading week	KW	Reading Week			
Week 7 16th Nov	Muscle function	KW	The knee revision & Hip intro	1	1	Online quiz
Week 8	The nervous system	KW	The hip	1	1	Lecture

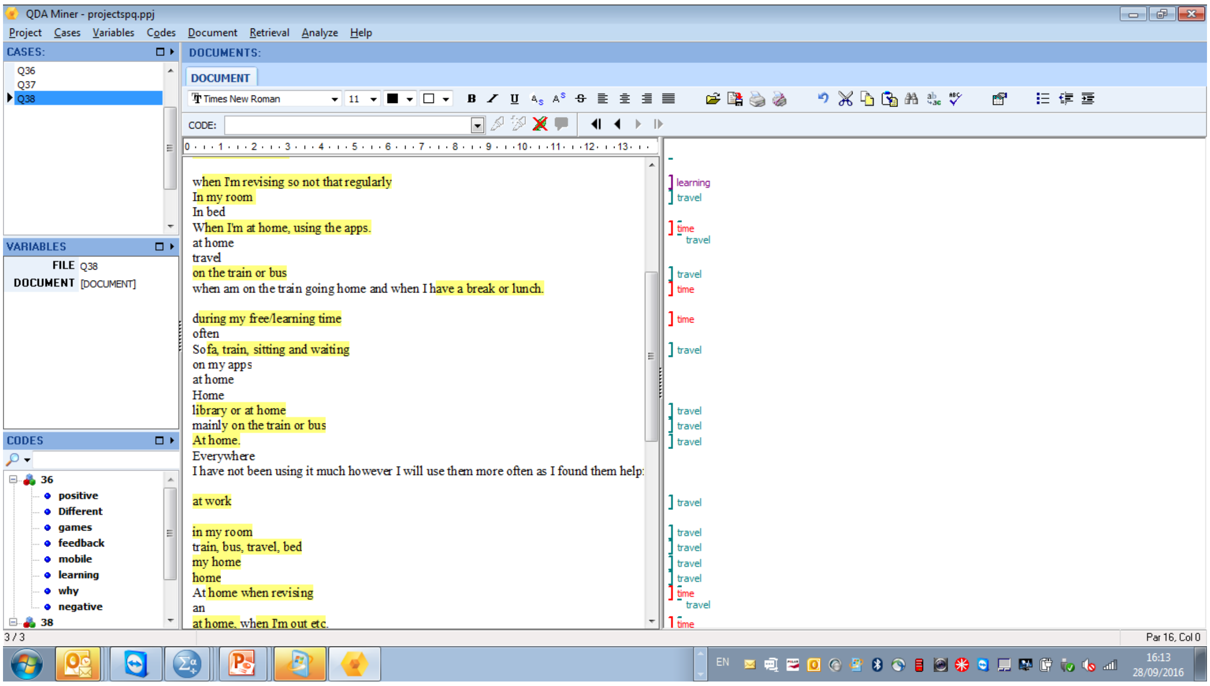
23rd Nov						formative quiz
Week 9 30th Nov	N/A	KW	Hip Muscles	4	1,2,3,4	feedback
Week 10 7th Dec	N/A		The ankle & foot	1	1	Online quiz
Week 11 14th Dec	Applied anatomy – Hip and knee		Muscles and ligaments of the ankle	1	1	Viva help
Week 12 11th Jan	Applied anatomy – The lower limb		Revision of the lower limb	1	1,2,3,4	
Week 13 18th Jan	Drop in – exam questions		The shoulder joints - Introduction			
Week 14 25th Jan	Exam prep online		The shoulder joint & ligaments	2	2	Online quiz
Week 15 1st Feb	Applied anatomy – the shoulder		Shoulder muscles	2	2	Online quiz
Week 16 8th Feb	Applied anatomy – the upper limb		The elbow joint	2	2	Online quiz
Week 17	Reading Week- revision		REVISION – DL	2	2	Online

15th Feb						Quiz
Week 18 22nd Feb	Applied anatomy – the upper limb		The wrist	2	2	Online quiz
Week 19 29th Mar	The spine		The hand			eViva 2
Week 20 7th Mar	Applied anatomy – the spine		The spine & vertebrae	3	3	Online quiz
Week 21 14th Mar	Applied anatomy – the spine		Muscles of the trunk	3	3	Online quiz
Week 22 11th April	N/A		Trunk Revision	3	3	Online quiz
Week 23 18th April	Trunk VIVA (Assessment 4)					
Week 24 20th April	Trunk VIVA (Assessment 4)					

Appendix D

Coding – QDA minor





Appendix E

Study One

1) Paired Analysis

Whole Group data

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	A2	52.8620	255	15.30902	.95869
	A3	49.8956	255	17.48557	1.09499

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	A2 & A3	255	.595	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	A2 - A3	2.96643	14.87647	.93160	1.13179	4.80108	3.184	254	.002

No Games

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	A2	53.0532	164	14.80307	1.15593
	A3	46.9054	164	17.78760	1.38898

Paired Samples Correlations

	N	Correlation	Sig.

Pair 1	A2 & A3	164	.671	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	A2 - A3	6.14787	13.49387	1.05369	4.06722	8.22852	5.835	163	.000

Games

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	A2	53.5406	87	14.45385	1.54961
	A3	57.1897	87	12.05232	1.29214

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	A2 & A3	87	.652	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	A2 - A3	-3.64908	11.27414	1.20871	-6.05193	-1.24624	-3.019	86	.003

2) Between-subject Analysis

Group Statistics

	games	N	Mean	Std. Deviation	Std. Error Mean
A1	no	164	64.0089	17.29349	1.35039
	yes	87	63.6554	16.89486	1.81132
A2	no	164	53.0532	14.80307	1.15593
	yes	87	53.5406	14.45385	1.54961
A3	no	164	46.9054	17.78760	1.38898
	yes	87	57.1897	12.05232	1.29214
A3A2diff	no	164	-6.2932	13.29593	1.03824
	yes	87	3.6491	11.27414	1.20871

Games v No Games

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
A1	Equal variances assumed	.161	.688	.155	249	.877	.35350	2.27558	-4.12835	4.83535
	Equal variances not assumed			.156	178.994	.876	.35350	2.25930	-4.10479	4.81179
A2	Equal variances assumed	.008	.928	-.250	249	.803	-.48734	1.94752	-4.32305	3.34837
	Equal variances not assumed			-.252	179.080	.801	-.48734	1.93325	-4.30223	3.32755
A3	Equal variances assumed	11.267	.001	-4.834	249	.000	-10.28429	2.12749	-14.47445	-6.09413
	Equal variances not assumed			-5.421	234.428	.000	-10.28429	1.89708	-14.02179	-6.54679

A3A2diff	Equal variances assumed	.777	.379	-5.933	249	.000	-9.94225	1.67574	-13.24267	-6.64183
	Equal variances not assumed			-6.240	201.769	.000	-9.94225	1.59340	-13.08411	-6.80040

3) SPQ Analysis

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	engagementG	37.9200	50	11.43721	1.61747
	engagementNG	36.8000	50	11.54583	1.63283
Pair 2	CooperativelearningscoreNG	6.982	113	6.4573	.6074
	CooperationscoreG	7.434	113	6.6934	.6297
Pair 3	cognitivelearningscoreNG	7.009	114	6.4403	.6032
	CognitivescoreG	7.175	114	6.4551	.6046
Pair 4	PersonalscoreNG	8.009	114	7.5146	.7038
	personalscoreG	8.219	114	7.5220	.7045
Pair 5	@31Askedquestionsduringclassorcontributedtoclassdiscus	2.844	45	.9282	.1384
	@31Askedquestionsduringclassorcontributedtoclassdiscus	2.889	45	.7752	.1156
Pair 6	@32Workedwithotherstudentsonprojectsduringclasstime	3.178	45	.8865	.1321
	@32Workedwithotherstudentsonprojectsduringclasstime	3.467	45	.6252	.0932
Pair 7	@33Workedwithclassmatesoutsideofclasstocompleteclassa	1.889	45	.8040	.1199
	@33Workedwithclassmatesoutsideofclasstocompleteclassa	1.933	45	.8634	.1287
Pair 8	@34Tutoredortaughttheclassmaterialstootherstudentsin	2.156	45	.8779	.1309
	@34Tutoredortaughttheclassmaterialstootherstudentsin	2.356	45	.8569	.1277
Pair 9	@36Discussedideasfromyourreadingsorclasseswithotherso	2.250	44	.8925	.1345
	@36Discussedideasfromyourreadingsorclasseswithotherso	2.364	44	.9667	.1457
Pair 10	@35Cometoclasswithoutcompletingreadingsorassignments	1.867	45	.7568	.1128
	@35Cometoclasswithoutcompletingreadingsorassignments	1.978	45	.8115	.1210
Pair 11	@4Towhatextenthasthiscourseemphasizedthementalactiviti	.	0[a]	.	.
	@37Usedyoursmartphoneortabletdeviceforlearning	.	0[a]	.	.
Pair 12	@41Memorizingfactsideasormethodsfromyourcourseandrea	2.111	45	.8040	.1199
	@41Memorizingfactsideasormethodsfromyourcourseandrea	1.956	45	.8779	.1309
Pair 13	@42Analyzingthebasicelementsofanideaexperienceortheo	2.733	45	.7804	.1163
	@42Analyzingthebasicelementsofanideaexperienceortheo	2.800	45	.7862	.1172
Pair 14	@43Synthesizingandorganizingideasinformationorexperien	2.600	45	.8090	.1206
	@43Synthesizingandorganizingideasinformationorexperien	2.667	45	.7687	.1146

Pair 15	@44Evaluatingthevalueofinformationargumentsormethods	2.400	45	.8893	.1326
	@44Evaluatingthevalueofinformationargumentsormethods	2.622	45	.8605	.1283
Pair 16	@45Applyingtheoriesandorconceptstopracticalproblemsor	2.689	45	.8208	.1224
	@45Applyingtheoriesandorconceptstopracticalproblemsor	2.622	45	.8865	.1321

a. The correlation and t cannot be computed because there are no valid pairs.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	engagementG - engagementNG	1.12000	12.83115	1.81460	-2.52657	4.76657	.617	49	.540
Pair 2	CooperativelearningscoreNG - CooperationscoreG	-.4513	7.6788	.7224	-1.8826	.9799	-.625	112	.533
Pair 3	cognitivelearningscoreNG - CognitivescoreG	-.1667	7.5210	.7044	-1.5622	1.2289	-.237	113	.813
Pair 4	PersonalscoreNG - personalscoreG	-.2105	8.6080	.8062	-1.8078	1.3867	-.261	113	.794
Pair 5	@31Askedquestionsduringclassorcontributedtoclassdiscus - @31Askedquestionsduringclassorcontributedtoclassdiscus	-.0444	.6727	.1003	-.2465	.1577	-.443	44	.660
Pair 6	@32Workedwithotherstudentsonprojectsduringclasstime - @32Workedwithotherstudentsonprojectsduringclasstime	-.2889	.9914	.1478	-.5867	.0090	-1.955	44	.057
Pair 7	@33Workedwithclassmatesoutsideofclasstocompleteclassa - @33Workedwithclassmatesoutsideofclasstocompleteclassa	-.0444	.7965	.1187	-.2837	.1948	-.374	44	.710
Pair 8	@34Tutoredortaughttheclassmaterialstootherstudentsin - @34Tutoredortaughttheclassmaterialstootherstudentsin	-.2000	.9195	.1371	-.4762	.0762	-1.459	44	.152

Pair 9	@36Discussedideasfromyourreadingsorclasseswithotherso - @36Discussedideasfromyourreadingsorclasseswithotherso	-.1136	.9205	.1388	-.3935	.1662	-.819	43	.417
Pair 10	@35Cometoclasswithoutcompletingreadingsorassignments - @35Cometoclasswithoutcompletingreadingsorassignments	-.1111	.8318	.1240	-.3610	.1388	-.896	44	.375
Pair 12	@41Memorizingfactsideasormethodsfromyourcourseandrea - @41Memorizingfactsideasormethodsfromyourcourseandrea	.1556	.8516	.1270	-.1003	.4114	1.225	44	.227
Pair 13	@42Analyzingthebasicelementsofanideaexperienceortheo - @42Analyzingthebasicelementsofanideaexperienceortheo	-.0667	1.0745	.1602	-.3895	.2561	-.416	44	.679
Pair 14	@43Synthesizingandorganizingideasinformationorexperien - @43Synthesizingandorganizingideasinformationorexperien	-.0667	.9630	.1435	-.3560	.2226	-.464	44	.645
Pair 15	@44Evaluatingthevalueofinformationargumentsormethods - @44Evaluatingthevalueofinformationargumentsormethods	-.2222	.9017	.1344	-.4931	.0487	-1.653	44	.105
Pair 16	@45Applyingtheoriesandorconceptstopracticalproblemsor - @45Applyingtheoriesandorconceptstopracticalproblemsor	.0667	.8634	.1287	-.1927	.3261	.518	44	.607

Study Two

1) Knowledge Acquisition

Tests of Between-Subjects Effects

Measure: score

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	534692.571	1	534692.571	2040.667	.000
Error	10742.762	41	262.019		

Mauchly's Test of Sphericity[a]

Measure: score

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
intervention	.927	3.051	2	.218	.932	.974	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept

Within Subjects Design: intervention

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: score

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
intervention	Sphericity Assumed	3026.333	2	1513.167	6.668	.002
	Greenhouse-Geisser	3026.333	1.863	1624.291	6.668	.003
	Huynh-Feldt	3026.333	1.948	1553.260	6.668	.002
	Lower-bound	3026.333	1.000	3026.333	6.668	.013
Error(intervention)	Sphericity Assumed	18608.333	82	226.931		
	Greenhouse-Geisser	18608.333	76.390	243.596		
	Huynh-Feldt	18608.333	79.883	232.944		
	Lower-bound	18608.333	41.000	453.862		

Estimates

Measure: score

intervention	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	61.833	2.643	56.496	67.170
2	72.071	1.938	68.158	75.985
3	61.524	2.511	56.452	66.595

Pairwise Comparisons

Measure: score

(I) intervention	(J) intervention	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-10.238*	3.098	.006	-17.971	-2.505
	3	.310	3.704	1.000	-8.937	9.556
2	1	10.238*	3.098	.006	2.505	17.971
	3	10.548*	3.017	.003	3.017	18.078
3	1	-.310	3.704	1.000	-9.556	8.937
	2	-10.548*	3.017	.003	-18.078	-3.017

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

2) Knowledge Retention

Within-Subjects Factors

Measure: score

intervention	Dependent Variable
1	KRControl
2	KRGames
3	KRGamesplus

Descriptive Statistics

	Mean	Std. Deviation	N
KRControl	8.53	23.227	43
KRGames	-4.05	22.403	43
KRGamesplus	3.98	21.504	43

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
intervention	Pillai's Trace	.257	7.082[b]	2.000	41.000	.002
	Wilks' Lambda	.743	7.082[b]	2.000	41.000	.002
	Hotelling's Trace	.345	7.082[b]	2.000	41.000	.002
	Roy's Largest Root	.345	7.082[b]	2.000	41.000	.002

a. Design: Intercept
Within Subjects Design: intervention

b. Exact statistic

Tests of Within-Subjects Effects

Measure: score

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
intervention	Sphericity Assumed	3489.318	2	1744.659	5.548	.005
	Greenhouse-Geisser	3489.318	1.720	2028.897	5.548	.008
	Huynh-Feldt	3489.318	1.786	1953.395	5.548	.007
	Lower-bound	3489.318	1.000	3489.318	5.548	.023
Error(intervention)	Sphericity Assumed	26416.682	84	314.484		
	Greenhouse-Geisser	26416.682	72.232	365.720		
	Huynh-Feldt	26416.682	75.024	352.110		
	Lower-bound	26416.682	42.000	628.969		

Tests of Within-Subjects Contrasts

Measure: score

Source	intervention	Type III Sum of Squares	df	Mean Square	F	Sig.
intervention	Linear	446.698	1	446.698	1.757	.192
	Quadratic	3042.620	1	3042.620	8.118	.007
Error(intervention)	Linear	10675.302	42	254.174		

	Quadratic	15741.380	42	374.795		

Tests of Between-Subjects Effects

Measure: score

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	1027.101	1	1027.101	1.174	.285
Error	36742.899	42	874.831		

Estimates

Measure: score

intervention	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	8.535	3.542	1.387	15.683
2	-4.047	3.416	-10.941	2.848
3	3.977	3.279	-2.641	10.595

Pairwise Comparisons

Measure: score

(I) intervention	(J) intervention	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	12.581*	3.396	.002	4.114	21.049
	3	4.558	3.438	.576	-4.016	13.132
2	1	-12.581*	3.396	.002	-21.049	-4.114
	3	-8.023	4.531	.252	-19.322	3.275
3	1	-4.558	3.438	.576	-13.132	4.016
	2	8.023	4.531	.252	-3.275	19.322

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

3) NSSE

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	engagementG	37.9200	50	11.43721	1.61747
	engagementNG	36.8000	50	11.54583	1.63283
Pair 2	CooperativelearningscoreNG	6.982	113	6.4573	.6074
	CooperationscoreG	7.434	113	6.6934	.6297
Pair 3	cognitivelearningscoreNG	7.009	114	6.4403	.6032
	CognitivescoreG	7.175	114	6.4551	.6046
Pair 4	PersonalscoreNG	8.009	114	7.5146	.7038
	personalscoreG	8.219	114	7.5220	.7045
Pair 5	@31Askedquestionsduringclassorcontributedtoclassdiscus	2.844	45	.9282	.1384
	@31Askedquestionsduringclassorcontributedtoclassdiscus	2.889	45	.7752	.1156
Pair 6	@32Workedwithotherstudentsonprojectsduringclasstime	3.178	45	.8865	.1321
	@32Workedwithotherstudentsonprojectsduringclasstime	3.467	45	.6252	.0932
Pair 7	@33Workedwithclassmatesoutsideofclasstocompleteclassa	1.889	45	.8040	.1199
	@33Workedwithclassmatesoutsideofclasstocompleteclassa	1.933	45	.8634	.1287
Pair 8	@34Tutoredortaughttheclassmaterialstootherstudentsin	2.156	45	.8779	.1309
	@34Tutoredortaughttheclassmaterialstootherstudentsin	2.356	45	.8569	.1277
Pair 9	@36Discussedideasfromyourreadingsorclasseswithotherso	2.250	44	.8925	.1345
	@36Discussedideasfromyourreadingsorclasseswithotherso	2.364	44	.9667	.1457
Pair 10	@35Cometoclasswithoutcompletingreadingsorassignments	1.867	45	.7568	.1128
	@35Cometoclasswithoutcompletingreadingsorassignments	1.978	45	.8115	.1210
Pair 11	@4Towhatextenthasthiscourseemphasizedthementalactiviti	.	0[a]	.	.
	@37Usedyoursmartphoneortabletdeviceforlearning	.	0[a]	.	.

Pair 12	@41Memorizingfactsideasormethodsfromyourcourseandrea	2.111	45	.8040	.1199
	@41Memorizingfactsideasormethodsfromyourcourseandrea	1.956	45	.8779	.1309
Pair 13	@42Analyzingthebasicelementsofanideaexperienceortheo	2.733	45	.7804	.1163
	@42Analyzingthebasicelementsofanideaexperienceortheo	2.800	45	.7862	.1172
Pair 14	@43Synthesizingandorganizingideasinformationorexperien	2.600	45	.8090	.1206
	@43Synthesizingandorganizingideasinformationorexperien	2.667	45	.7687	.1146
Pair 15	@44Evaluatingthevalueofinformationargumentsormethods	2.400	45	.8893	.1326
	@44Evaluatingthevalueofinformationargumentsormethods	2.622	45	.8605	.1283
Pair 16	@45Applyingtheoriesandorconceptstopracticalproblemsor	2.689	45	.8208	.1224
	@45Applyingtheoriesandorconceptstopracticalproblemsor	2.622	45	.8865	.1321

a. The correlation and t cannot be computed because there are no valid pairs.

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	engagementG & engagementNG	50	.377	.007
Pair 2	CooperativelearningscoreNG & CooperationscoreG	113	.319	.001
Pair 3	cognitivelearningscoreNG & CognitivescoreG	114	.320	.001
Pair 4	PersonalscoreNG & personalscoreG	114	.345	.000
Pair 5	@31Askedquestionsduringclassorcontributedtoclassdiscus & @31Askedquestionsduringclassorcontributedtoclassdiscus	45	.702	.000
Pair 6	@32Workedwithotherstudentsonprojectsduringclasstime & @32Workedwithotherstudentsonprojectsduringclasstime	45	.175	.250
Pair 7	@33Workedwithclassmatesoutsideofclasstocompleteclassa & @33Workedwithclassmatesoutsideofclasstocompleteclassa	45	.546	.000

Pair 8	@34Tutoredortaughttheclassmaterialstootherstudentsin & @34Tutoredortaughttheclassmaterialstootherstudentsin	45	.438	.003
Pair 9	@36Discussedideasfromyourreadingsorclasseswithotherso & @36Discussedideasfromyourreadingsorclasseswithotherso	44	.512	.000
Pair 10	@35Cometoclasswithoutcompletingreadingsorassignments & @35Cometoclasswithoutcompletingreadingsorassignments	45	.439	.003
Pair 12	@41Memorizingfactsideasormethodsfromyourcourseandrea & @41Memorizingfactsideasormethodsfromyourcourseandrea	45	.490	.001
Pair 13	@42Analyzingthebasicelementsofanideaexperienceortheo & @42Analyzingthebasicelementsofanideaexperienceortheo	45	.059	.699
Pair 14	@43Synthesizingandorganizingideasinformationorexperien & @43Synthesizingandorganizingideasinformationorexperien	45	.256	.090
Pair 15	@44Evaluatingthevalueofinformationargumentsormethods & @44Evaluatingthevalueofinformationargumentsormethods	45	.469	.001
Pair 16	@45Applyingtheoriesandorconceptstopracticalproblemsor & @45Applyingtheoriesandorconceptstopracticalproblemsor	45	.491	.001

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			

Pair 1	engagementG - engagementNG	1.12000	12.83115	1.81460	-2.52657	4.76657	.617	49	.540
Pair 2	CooperativelearningscoreNG - CooperationscoreG	-.4513	7.6788	.7224	-1.8826	.9799	-.625	112	.533
Pair 3	cognitivelearningscoreNG - CognitivescoreG	-.1667	7.5210	.7044	-1.5622	1.2289	-.237	113	.813
Pair 4	PersonalscoreNG - personalscoreG	-.2105	8.6080	.8062	-1.8078	1.3867	-.261	113	.794
Pair 5	@31Askedquestionsduringclassorcontributedtoclassdiscus - @31Askedquestionsduringclassorcontributedtoclassdiscus	-.0444	.6727	.1003	-.2465	.1577	-.443	44	.660
Pair 6	@32Workedwithotherstudentsonprojectsduringclasstime - @32Workedwithotherstudentsonprojectsduringclasstime	-.2889	.9914	.1478	-.5867	.0090	-1.955	44	.057
Pair 7	@33Workedwithclassmatesoutsideofclasstocompleteclassa - @33Workedwithclassmatesoutsideofclasstocompleteclassa	-.0444	.7965	.1187	-.2837	.1948	-.374	44	.710
Pair 8	@34Tutoredortaughttheclassmaterialstootherstudentsin - @34Tutoredortaughttheclassmaterialstootherstudentsin	-.2000	.9195	.1371	-.4762	.0762	-1.459	44	.152
Pair 9	@36Discussedideasfromyourreadingsorclasseswithotherso - @36Discussedideasfromyourreadingsorclasseswithotherso	-.1136	.9205	.1388	-.3935	.1662	-.819	43	.417
Pair 10	@35Cometoclasswithoutcompletingreadingsorassignments - @35Cometoclasswithoutcompletingreadingsorassignments	-.1111	.8318	.1240	-.3610	.1388	-.896	44	.375
Pair 12	@41Memorizingfactsideasormethodsfromyourcourseandrea - @41Memorizingfactsideasormethodsfromyourcourseandrea	.1556	.8516	.1270	-.1003	.4114	1.225	44	.227

Pair 13	@42Analyzingthebasicelementsofanideaexperienceortheo - @42Analyzingthebasicelementsofanideaexperienceortheo	-.0667	1.0745	.1602	-.3895	.2561	-.416	44	.679
Pair 14	@43Synthesizingandorganizingideasinformationorexperien - @43Synthesizingandorganizingideasinformationorexperien	-.0667	.9630	.1435	-.3560	.2226	-.464	44	.645
Pair 15	@44Evaluatingthevalueofinformationargumentsormethods - @44Evaluatingthevalueofinformationargumentsormethods	-.2222	.9017	.1344	-.4931	.0487	-1.653	44	.105
Pair 16	@45Applyingtheoriesandorconceptstopracticalproblemsor - @45Applyingtheoriesandorconceptstopracticalproblemsor	.0667	.8634	.1287	-.1927	.3261	.518	44	.607

4) Behavioural Observational Engagement

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Week1DeviceOnTask	2000000000000 0022000000000 000000.000	20	8944271909999 1590000000000 000000.0000	2000000000000 0000000000000 000000.0000
	Week2Deviceontask	56.350	20	84.2635	18.8419
Pair 2	Week1skeletonpeerinteraction	243.900	20	139.9556	31.2950
	Week2skeletonpeerinteraction	129.900	20	138.0476	30.8684
Pair 3	ontaskweek1	282.95	20	138.945	31.069
	ontaskweek2	186.25	20	166.036	37.127
Pair 4	week1TalkingtoTutor	30.500	20	39.2234	8.7706
	week2TalkingtoTutor	31.750	20	51.6933	11.5590
Pair 5	week1TalkingtoStudent	134.650	20	113.5134	25.3824
	week2TalkingtoStudent	235.40	20	123.117	27.530
Pair 6	week1workingsolo	27.650	20	61.0265	13.6460
	week2workingsolo	2.00	20	6.156	1.376
Pair 7	week1Listening	237.40	20	201.962	45.160
	week2Listening	298.90	20	161.870	36.195
Pair 8	week2Listening	298.90	20	161.870	36.195
	week1Listening	237.40	20	201.962	45.160
Pair 9	week1ReadingWriting	38.35	20	48.755	10.902

	week2ReadingWriting	8.55	20	13.040	2.916
Pair 10	week1offtask	16.90	20	24.976	5.585
	week2offtask	10.30	20	15.590	3.486
Pair 11	week1engaged	685.5000	20	103.33415	23.10622
	week2engaged	752.3000	20	41.98509	9.38815
Pair 12	week1disengaged	55.2500	20	55.78518	12.47395
	week2disengaged	18.8500	20	16.83754	3.76499

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Week1DeviceOnTask - Week2Deviceontask	200000000000000220000000000000000.0000	894427190999915900000000000000000.0000	200000000000000000000000000000000.0000	-218604810881647530000000000000000.0000	618604810881648000000000000000000000.0000	1.000	19	.330
Pair 2	Week1skeletonpeerinteraction - Week2skeletonpeerinteraction	114.0000	213.5753	47.7569	14.0437	213.9563	2.387	19	.028
Pair 3	ontaskweek1 - ontaskweek2	96.700	218.751	48.914	-5.678	199.078	1.977	19	.063
Pair 4	week1TalkingtoTutor - week2TalkingtoTutor	-1.2500	64.8820	14.5081	-31.6157	29.1157	-.086	19	.932

Pair 5	week1TalkingtoStudent - week2TalkingtoStudent	-100.7500	123.4972	27.6148	-158.5485	-42.9515	-3.648	19	.002
Pair 6	week1workingsolo - week2workingsolo	25.6500	62.1088	13.8879	-3.4178	54.7178	1.847	19	.080
Pair 7	week1Listening - week2Listening	-61.500	260.925	58.345	-183.616	60.616	-1.054	19	.305
Pair 8	week2Listening - week1Listening	61.500	260.925	58.345	-60.616	183.616	1.054	19	.305
Pair 9	week1ReadingWriting - week2ReadingWriting	29.800	50.761	11.351	6.043	53.557	2.625	19	.017
Pair 10	week1offtask - week2offtask	6.600	22.258	4.977	-3.817	17.017	1.326	19	.201

Pair 11	week1engaged - week2engaged	-66.80000	101.60843	22.72034	-114.35421	-19.24579	-2.940	19	.008
Pair 12	week1disengaged - week2disengaged	36.40000	55.24434	12.35301	10.54485	62.25515	2.947	19	.008

Correlations

		Week1DeviceOnTask	Week2Deviceontask	ontaskweek1
Week1DeviceOnTask	Pearson Correlation	1	.262	.283
	Sig. (2-tailed)		.265	.227
	N	20	20	20
Week2Deviceontask	Pearson Correlation	.262	1	.399
	Sig. (2-tailed)	.265		.082
	N	20	20	20
ontaskweek1	Pearson Correlation	.283	.399	1
	Sig. (2-tailed)	.227	.082	
	N	20	20	20
ontaskweek2	Pearson Correlation	.005	.558*	-.021
	Sig. (2-tailed)	.982	.011	.929
	N	20	20	20
week1TalkingtoStudent	Pearson Correlation	.154	.197	-.118
	Sig. (2-tailed)	.516	.404	.620
	N	20	20	20
week2TalkingtoStudent	Pearson Correlation	-.007	-.149	.002
	Sig. (2-tailed)	.978	.530	.993
	N	20	20	20
week1offtask	Pearson Correlation	.029	-.168	-.203
	Sig. (2-tailed)	.903	.478	.390
	N	20	20	20
week2offtask	Pearson Correlation	-.156	-.136	-.018
	Sig. (2-tailed)	.513	.568	.940

	N	20	20	20
CooperativelearningscoreNG	Pearson Correlation	.036	.075	.569**
	Sig. (2-tailed)	.882	.754	.009
	N	20	20	20
cognitivelearningscoreNG	Pearson Correlation	.065	.188	.546*
	Sig. (2-tailed)	.785	.428	.013
	N	20	20	20
PersonalscoreNG	Pearson Correlation	.021	.109	.555*
	Sig. (2-tailed)	.932	.648	.011
	N	20	20	20
EngagementscoreNG	Pearson Correlation	.042	.132	.596**
	Sig. (2-tailed)	.861	.580	.006
	N	20	20	20
week1disengaged	Pearson Correlation	-.149	-.343	-.463*
	Sig. (2-tailed)	.531	.139	.040
	N	20	20	20
week2disengaged	Pearson Correlation	-.264	-.158	-.031
	Sig. (2-tailed)	.262	.507	.898
	N	20	20	20

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	percentageengagedNG	82.181	22	18.5967	3.9648
	percentageengagedG	92.941	22	20.3586	4.3405
Pair 2	percentdisengagedNG	7.198	22	7.0272	1.4982
	percentdisengagedG	2.472	22	2.1382	.4559

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	percentageengagedNG & percentageengagedG	22	.886	.000
Pair 2	percentdisengagedNG & percentdisengagedG	22	.173	.442

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	percentageengagedNG - percentageengagedG	-10.7599	9.4403	2.0127	-14.9455	-6.5743	-5.346	21	.000
Pair 2	percentdisengagedNG - percentdisengagedG	4.7261	6.9833	1.4888	1.6298	7.8223	3.174	21	.005

Study Three

1) Knowledge Acquisition

Tests of Between-Subjects Effects

Measure: score

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	534692.571	1	534692.571	2040.667	.000
Error	10742.762	41	262.019		

Mauchly's Test of Sphericity[a]

Measure: score

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound

intervention	.927	3.051	2	.218	.932	.974	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept
Within Subjects Design: intervention

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: score

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
intervention	Sphericity Assumed	3026.333	2	1513.167	6.668	.002
	Greenhouse-Geisser	3026.333	1.863	1624.291	6.668	.003
	Huynh-Feldt	3026.333	1.948	1553.260	6.668	.002
	Lower-bound	3026.333	1.000	3026.333	6.668	.013
Error(intervention)	Sphericity Assumed	18608.333	82	226.931		
	Greenhouse-Geisser	18608.333	76.390	243.596		
	Huynh-Feldt	18608.333	79.883	232.944		
	Lower-bound	18608.333	41.000	453.862		

Estimates

Measure: score

intervention	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	61.833	2.643	56.496	67.170
2	72.071	1.938	68.158	75.985
3	61.524	2.511	56.452	66.595

Pairwise Comparisons

Measure: score

(I) intervention	(J) intervention	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-10.238*	3.098	.006	-17.971	-2.505

	3	.310	3.704	1.000	-8.937	9.556
2	1	10.238*	3.098	.006	2.505	17.971
	3	10.548*	3.017	.003	3.017	18.078
3	1	-.310	3.704	1.000	-9.556	8.937
	2	-10.548*	3.017	.003	-18.078	-3.017

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

2) Knowledge Retention

Within-Subjects Factors

Measure: score

intervention	Dependent Variable
1	KRControl
2	KRGames
3	KRGamesplus

Descriptive Statistics

	Mean	Std. Deviation	N
KRControl	8.53	23.227	43
KRGames	-4.05	22.403	43
KRGamesplus	3.98	21.504	43

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
intervention	Pillai's Trace	.257	7.082[b]	2.000	41.000	.002
	Wilks' Lambda	.743	7.082[b]	2.000	41.000	.002
	Hotelling's Trace	.345	7.082[b]	2.000	41.000	.002
	Roy's Largest Root	.345	7.082[b]	2.000	41.000	.002

a. Design: Intercept

Within Subjects Design: intervention

b. Exact statistic

Tests of Within-Subjects Effects

Measure: score

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
intervention	Sphericity Assumed	3489.318	2	1744.659	5.548	.005
	Greenhouse-Geisser	3489.318	1.720	2028.897	5.548	.008
	Huynh-Feldt	3489.318	1.786	1953.395	5.548	.007
	Lower-bound	3489.318	1.000	3489.318	5.548	.023
Error(intervention)	Sphericity Assumed	26416.682	84	314.484		
	Greenhouse-Geisser	26416.682	72.232	365.720		
	Huynh-Feldt	26416.682	75.024	352.110		
	Lower-bound	26416.682	42.000	628.969		

Tests of Within-Subjects Contrasts

Measure: score

Source	intervention	Type III Sum of Squares	df	Mean Square	F	Sig.
intervention	Linear	446.698	1	446.698	1.757	.192
	Quadratic	3042.620	1	3042.620	8.118	.007
Error(intervention)	Linear	10675.302	42	254.174		
	Quadratic	15741.380	42	374.795		

Tests of Between-Subjects Effects

Measure: score

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	1027.101	1	1027.101	1.174	.285
Error	36742.899	42	874.831		

Estimates

Measure: score

intervention	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	8.535	3.542	1.387	15.683
2	-4.047	3.416	-10.941	2.848

3	3.977	3.279	-2.641	10.595

Pairwise Comparisons

Measure: score

(I) intervention	(J) intervention	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	12.581*	3.396	.002	4.114	21.049
	3	4.558	3.438	.576	-4.016	13.132
2	1	-12.581*	3.396	.002	-21.049	-4.114
	3	-8.023	4.531	.252	-19.322	3.275
3	1	-4.558	3.438	.576	-13.132	4.016
	2	8.023	4.531	.252	-3.275	19.322

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.