THE EFFECTIVENESS OF A BESPOKE MOBILE LEARNING APPLICATION IN A LABORATORY-BASED, PRACTICAL SKILLS UNDERGRADUATE UNIT.

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DEDICATION

I dedicate this thesis to the memory of my close friend Lee Hughes who tragically died in December 2013.

ABSTRACT

Statement of Problem

The teaching of dental technology requires significant face-to-face teaching leading to high staff loading and variability in learning experience. Smartphones, which are now ubiquitous powerful and affordable with excellent communication capability offer the possibility of individualised learning.

Purpose

To design and evaluate a bespoke learning application for the teaching of partial denture manufacture.

Methods

The traditional learning process for partial denture construction was analysed and a database-driven mobile learning application using streaming video and text was designed and written using XCode software for Apple iOS devices to deliver student-directed learning in an undergraduate dental technology programme.

Results

The results indicated high student engagement with the App and a highly significant improvement in the performance of students in course work using the application. However, examination performance was unaffected. Student satisfaction surveys indicated an improvement.

Conclusions

Interactive video using mobile learning applications reduced staff time and improved student performance. However, students can develop dependence. The broader implications of the study indicate that mobile learning applications have a place in the learning environment whilst their global range offers great opportunities for the delivery of dental technology and other subjects in the future.

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LIST OF ABBREVIATIONS

ADA	American Dental Association
API	Application Programming Interface
BDA	British Dental Association
BDS	Bachelor of Dental Surgery
BELS	Blended E-Learning System
CDE	Council on Dental Education
CEO	Chief Executive Officer
CPD	Continuing Professional Development
DSC	Dental Schools Council
DRM	Digital Rights Management
GDC	General Dental Council
HIG	Human Interface Guidelines
ICT	Information Communication Technology
IOM	Institute of Medicine
ISP	Internet Service Provider
ISS	Internal Student Survey
JSON	JavaScript Object Notation
LDS	Licentiate of Dental Surgery
MCQ	Multiple-Choice Question
MIT	Massachusetts Institute of Technology
MVC	Model-View-Controller
NHS	National Health Service
PCD	Professional Complimentary to Dentistry
PHP	Pre-Hypertext Processor
QAA	Quality Assurance Agency (for Higher Education)
RCoS	Royal College of Surgeons
SDK	Software Development Kit
SLC	Student Loans Company
SMS	Short Messaging System
SSR	Staff Student Ratio
STP	Scientific Training Programme
UCAS	Universities and Colleges Admissions Service
URL	Universal Resource Locator
US	United States
USB	Universal Serial Bus
WIFI	Wireless Fidelity
XIB	XCode Interface Builder

1. INTRODUCTION

1.1 Dentistry

A dentist is defined as 'a person who is qualified to treat diseases and other conditions that affect the teeth and gums, especially the repair and extraction of teeth and the insertion of artificial ones' (Oxford English Dictionary, 2014). Dentistry is the collective noun for the science that encapsulates the work of all clinical personnel and those allied to it.

The earliest recorded mention of any kind of recognition of oral decay is attributed to a Sumerian clay tablet discovered 5000 years ago which suggests a tooth 'worm' as the source (Halvorsen, 2010). Herbal remedies were recommended and surprisingly, this notion was embraced up to the eighteenth century.

The 'Ebers Papyrus' from 1500BC, which was found in 1862, mentions many treatments for tooth decay yet none that are restorative or surgical. Any mention of restoration or extraction is absent until the time of Hippocrates (ca. 460-377 B.C.). Only then did the discussion begin to explore treatments using pharmacological and mechanical means in the prevention of tooth pain, decay and associated soft tissue ailments such as abscesses and swelling of the gums.

Of the thousands of extracted and inspected mummies from Egypt, none show evidence of any dentistry. However, many examples of extremely skilled restorative and decorative work involving gold and precious gemstones have

been recovered from the area which show that these skills were accessible yet never used on the entombed mummies (Halvorsen, 2010).

1.1.1 History of dentistry education

In the last century, the education of dentists has evolved from a model where courses were provided for-profit to a position where they are now based in universities at undergraduate and postgraduate level (DePaola, 2012).

The following shows the current names for institutions but some have been known by other titles over time.

Table 1: Current schools of dentistry in the United Kingdom (2013)

Year Established	Country	School / City / Region
1495	Scotland	Aberdeen
1583	Scotland	Edinburgh
1637	Scotland	Glasgow*
1821	Northern Ireland	Belfast
1828	England	Birmingham, Sheffield
1831	England	Leeds
1833	England	Bristol
1834	England	Newcastle, Liverpool
1874	England	Manchester
1931	Wales	Cardiff
1948	England	UCL / Eastman (London)
1967	Scotland	Dundee **
1988	England	Kings College (London)
1995	England	Queen Mary (London)
2000	England	Peninsula
2007	England	Central Lancashire #

** Dentistry first taught in 1637 but University founded in 1451*
*** Dentistry taught at University of St Andrews From 1899-1967*
 # Dentistry teaching began but institution founded in 1842

There are currently 18 dentistry courses in the United Kingdom; 12 in England, 4 in Scotland, 1 in Wales and 1 in Northern Ireland.

In the US, the first college for teaching dentistry opened in 1840 at the Baltimore College of Dentistry but is was a further 27 years before a dentistry college would be connected to a classic university; the Harvard School of Dental Medicine (DePaola, 2012). Dentistry was finding it difficult to find a foothold to establish itself, evidenced by the University of Maryland's refusal to include dental education in its curriculum and forcing the Maryland state to charter the Baltimore College of Dental Surgery. By 1865, only four US dental schools existed, none of which were attached to a university. Five years later, only 15% of practising dentists had diplomas from dental schools (Field, 1995). One explanation for this was that those who were interested in becoming a dentist found it easier to serve their apprenticeships locally with practitioners rather then undertake a more expensive programme of formal education at a distant institution. Today there are 64 schools across 36 states and Puerto Rico.

In 1848, Sir John Tomes of the Royal College of Surgeons (RCoS) brought about the introduction of the Dental Board. He convinced the Council that an examination in dentistry was needed which was realised in the Charter of 1859. A year later in 1860 saw the first candidates sitting the exam for the Licentiate of Dental Surgery (LDS). As a result of the 1878 Dentists Act, the very first register of dentists was produced. The RCoS continued to influence the training of undergraduate dentists but this gradually diminished due to the establishment of dental faculties in London and other institutions (Blandy and Lumley, 2000).

In 1859, the American Dental Association (ADA) was formed and existed as a standalone discipline. In the UK, the British Dental Association (BDA) was formed in 1880. This non-regulatory association was formed to promote good practice, patient care and higher standards. It also stood to represent dentists up to national level to ensure that their views and concerns were pushed up political and public agendas.

In the 1920s, William Gies advocated that dentistry should be intimately linked with science and medicine and housed in universities and academic health centres (Jeffcoat, 1995). In his 1926 report, Gies redefined dental education as a scientifically based health service. Furthermore, he advocated that the quality and support of dental education must be comparable to that of medicine (Gies, 1926). The nation's oral health was in a bad state, underlined by the fact that the majority of recruits for the Second World War were rejected due to dental problems (Field, 1995). Napoleons quote 'An army marches on its stomach' could not be possible if the soldiers could not eat the meagre and often-hard rations provided to them during conflict.

In the early 20th century, tooth extractions were routinely carried out by physicians who favoured a very slow and painful procedure whereas "lay" practitioners such as those working as barbers performed extractions quickly. This could be a reason why people who needed a tooth extraction chose treatment from non-physicians and ultimately contributed to the drift of dentistry from beneath the umbrella of medical care (Field, 1995). The red stripes on a barber's striped pole relate to when they performed 'bloodletting' and minor surgical procedures (Abel, 1970). Furthermore, Gies' 1926 report said that

many of the dental schools that were chartered since 1884 were ‘diploma mills’, ’conducted with the collusion of unworthy dentists’, ‘protected by unfaithful practitioners’ and led to the ‘disgrace of the profession and to the dishonour of dental education’. Strong statements but a gauge for the feeling of some towards dentistry at the time (Gies, 1926). Soon after, acts by state required dental school graduates to take examinations, and these were only offered to those who were graduates of ‘reputable’ schools. The word reputable was not defined but served as a cypher to mean ‘non-proprietary’ school. This had an immediate effect; new schools slowed rapidly (in Illinois alone, charters were lost to 22 schools in a three year period beginning 1902). The cost to fund the increase in educational requirements turned dental education clearly away from a profitable business opportunity (Gies, 1926).

The Dental Schools Council (DSC) was first established as ‘The Dental Education Advisory Committee of Great Britain and Ireland’ in 1932 and changed its name four times prior to the current title. The DSC is made up of the 18 Deans of UK dental schools who meet three times a year to ‘represent the interests and ambitions of UK dental schools as they relate to the generation of national health, wealth and knowledge acquisition through research and the profession of dentistry’ (The Dental Schools Council, 2008).

In 1936, the ADA Council on Dental Education (CDE) was established. Half way through the Second World War in 1942, all US Dental Schools were either ‘inspected and approved’ or ‘accredited’ under the backing and support of the CDE. Five years later, a review of the approved dental school curriculum found

that it was generally overcrowded and that clinics had an emphasis on income generation rather than teaching (Horner, 1947).

At the RCoS, due to the increase in number of surgical fellows who were practising dentistry within the college, a suggested revision of the governance and examination system was recommended in 1939. Four years later, Sir Cuthbert Wallace sought permission via the council for a higher qualification in dentistry titled the 'Fellowship in Dental Surgery of the Royal College of Surgeons'. Council recognised the need to foster the different surgical specialties, whose representatives took seats on the council in July 1944. A joint venture between the British Dental Association and the College established the first Faculty of Dental Surgery, coinciding with the formation of the National Health Service (NHS). The faculty worked to influence the NHS about dentistry's contribution to healthcare. Responding to joint working party recommendations, an application was made to the Privy Council to enable the college to create and regulate faculties. This was duly granted in the summer of 1947, forming the 'Board of the Faculty of Dental Surgery' and inaugurated two months later. This board was formed from a variety of different sources such as the Ministry of Health, the Armed Forces and general practice thereby drawing on a wide range of experience from the profession (Blandy and Lumley, 2000). For those seeking senior posts within universities and the NHS, the Fellowship examination that was introduced in 1948 became the accepted qualification; brought about by the recommendations of 1939. It was a postgraduate examination that was sat before the end of specialist training and drew dentists from beyond the shores of the United Kingdom and promoted the introduction of similar Fellowship examinations in Ireland and Scotland. Over time, the

examination was moved into earlier stages of a dentist's career where it eventually became the barometer by which selection for higher training was decided. This continued until 1995 when the examination was once again moved to the end of the final year of specialist training.

The General Dental Council held their first meeting on 4th July 1956, only three years after the end of 14 years of national rationing brought about by the Second World War (Basker, 2006). Under the watch of the General Medical Council, the then 'Dental Board' was tasked with the regulatory work recommended by Parliament in 1921 to ensure that dentistry should be limited only to those who were registered. Within three months, they had assessed that the UK required around 20,000 dentists. They had 16,000 on the dentists register and half of these were 'beyond middle age'. Recent data had shown that the UK would need an annual intake of 900 students but places were limited to 645. In stark contrast to today, dentistry did not seem attractive as a career as only 495 had applied to courses (Basker, 2006). This was partly affected by the public's perception of dentistry as a career and the general lack of awareness about the importance of oral health. This concern continued into the 1970's. The Charitable Trust arm of the GDC provided dentists with literature that they enthusiastically used to promote the profession and in 1977, the number of registered dentists passed 20,000.

The GDC also earlier tackled the issue of immigrants wishing to work as dentists in the UK, arriving as refugees following the global conflict. The GDC were responsible for the formation of rules, regulations and a statutory examination for people who had been educated in countries whose diplomas

were not at the time recognised by the council. The Fellowship examination amongst others was revised by the GDC to satisfy the criteria for Europe membership.

One overarching focus since reports of dental education began is that of where it actually belongs. Since its beginnings as an introduction to an apprenticeship and where self-taught and self-proclaimed competency were the majority to the position now where there are public and private schools; the question of where dentistry positions itself is one of conjecture and has been challenged by a number of reports and studies (Gies, 1926; Field, 1995). Early education was provided by independent practitioners who themselves were lacking an education. Nowadays, this is provided by a clinical practitioner, typically based in a university.

Medical schools were reluctant to welcome dentistry into their environment due to the presumed physical space that would be required, together with the expensive equipment needed to support dentist training (Sissman, 1971). Dentistry as a discipline had problems within, even when the medical community did eventually seek them; “dentistry is altogether too large to be made the tail end of the kite of medical practice,” said one (quoted in McCluggage, 1959, p. 171).

Since the shortage of dentists on the register up until the late 1970’s, there have been many changes that affected the profession. Tooth decay and tooth loss have been reduced due to improvements in technology, science and the general health of the public (Field, 1995). One such public health example is the

fluoridation of the water supply using calcium fluoride. Far from widespread, only 10% of the UK population receive fluoridated water, mainly in the North East and West Midlands according to the British Fluoridation Society's report, 'One in a million' from 2012. Compare this to the US, where 74% of the population receive fluoridated water (The British Fluoridation Society, 2012).

The opinion that 'the mouth is connected to the body' supports reason to ally dentistry education with medicine, research and science, since some dental conditions may need a combination of treatment modalities in order to provide the best patient care. Dentistry has been punctuated by clear stages over time where teeth were first removed and replaced, followed by the first age of prevention (which included fluoridation of water) then restoration and repair. There has been a slight shift more recently to a focus on prevention rather than cure, using a collaborative approach to encourage a more holistic treatment that may involve input from disciplines outside the immediate shell of dentistry (Jeffcoat, 1995).

These reports also raise another significant point in that changes in dental education move, at best, glacially. Breakthroughs in science and technology and changes in the curriculum design take far too long to filter into the curriculum as underlined in a survey of US dental schools in 2002-3 (Kassebaum et al., 2004). This survey echoed the findings of Solomon and Brown's paper from 1989 (Solomon and Brown) that in the past 50 years, only half of the curriculum areas in dentistry education had grown to within 1% of the hours recommended by proponents such as Gies. His vision of change by gentle transformation has still to become a reality in the 21st century due to the

ways in which dental education fails to embrace it. There was an emphasis on honing technique rather than critical and scientific thinking (Field, 1995).

The Kassebaum et al. study found that in the survey they undertook, a mere 7% of US dental schools indicated their curriculum was arranged around themes of topics that were interrelated. This is sometimes known as an educational 'silo' and is a common trademark of education in the health professions (DePaola, 2012). If dentistry education is to change, it needs to implement long-standing recommendations made in the mid 1920's, to integrate itself within science and medicine and the health care system at large.

The 1995 study by the Institute of Medicine (IOM) raised some interesting statements that further support the recommendations made many times previously (Field, 1995). Amongst the key points were that learning should not stop when the degree is awarded but that it should be a continuous part of ones professional career and overwhelmingly, that dentistry should integrate itself closer with medicine.

1.1.2 Regulation

In the UK, The General Dental Council regulates all dental personnel. Courses that exist to educate such personnel have to align with the GDC defined outcomes required to gain membership and are contained within the document 'The First Five Years' (The General Dental Council, 2008). This document serves as a template of responsibilities that are expected from the council and its registrants. It is built around a theme of three key phrases, which simply stated, explain what the registrant should be able to do: -

- ‘Be competent at’ - Expects that students should have a thorough understanding and knowledge of the subject, adequate clinical experience and should be able to solve clinical problems themselves.
- ‘Have knowledge of’ – As above but with only limited clinical / practical experience.
- ‘Be familiar with’ – Means that they need not work independently, have any clinical experience but should possess a basic understanding.

The document encapsulates the changes that have taken place since 1997 and embed the benchmarked academic standards that were set out by the report by the Quality Assurance Agency for Higher Education (QAA). Amongst these are IT skills, Ethics, Law, Professionalism and integrating with other Professionals Complimentary to Dentistry (PCD). The report also encourages that these be embedded in the curriculum rather than offered as optional ‘side-dishes’ (The General Dental Council, 2008).

The GDC’s outcomes essentially define what is the product of the dentists’ undergraduate education. Albert Einstein’s quote ‘Education is what is left after you’ve forgotten everything you’ve learned’ sits comfortably within the goals of the GDC in that education should be lifelong and that we also learn through experience; and part of the undergraduate experience should be ‘learning how to learn’.

Already, medicine is looking to move towards international agreement on what their outcomes should be, just as dentistry begins to catch up with them by

concentrating on the educational product rather than its process (Clark et al., 2003).

As of 2013, individuals who wish to train as a dentist must complete a five-year Bachelor of Dental Surgery (BDS) course at an approved dental academic institution. The practical training in the clinics is combined with theoretical work in all the main areas of practice. Some dental schools offer an accelerated course ('fast-track') that reduces the BDS to four years for applicants who already possess a minimum 2:1 degree with significant core science (NHS Careers, No date)

1.2 Technical education

In the mid nineteenth century, the United Kingdom considered itself the pinnacle of the industrial age after building on foundations laid from around 1760. Manufacturing then had been done mainly by hand by skilled craftsmen but was gradually replaced by a revolution in machines, machine tools, chemical manufacturing and increased efficiency through the use of coal to power the steam engines instead of wood. The average income of the nations 'ordinary people' witnessed quick and then sustained growth. What had begun in England was gradually adopted around the world.

Unfortunately what followed was a gradual industrial decline, which was greatly attributed to the time it took for the country to accept the importance of technical education and training, and a strategy for the development of technical education institutions around the nation. The expanding industrial revolution had been met and treated differently in countries such as France and Germany

who were quick to establish technical universities in the early 1800s. In England, the Oxford and Cambridge universities concentrated purely on classical education (Literature, poetry, drama, philosophy, history, art and languages) to the neglect of science and technology (D. Evans, 2007).

1.2.1 The Great Exhibition of 1851

The Great Exhibition was the first of the 'World's Fair' exhibitions intended to showcase national progress and innovation in machinery, manufacturing, raw materials and the Fine Arts. A third of the British population (6 million) attended. The 'Crystal Palace' was a structure that was built in record time from cast iron and plate glass to house the exhibition that was opened by Queen Victoria on 1st May 1851.

Many famous architects pitched for the building's contract, which was to provide a cheap, simple building that could be built quickly in less than a year. 38 submissions were received from across the world and the building committee rejected all. Surprisingly, the contract was eventually awarded to renowned gardener of the time Joseph Paxton who had impressed many with his work at Chatsworth House and Birkenhead Park; most notably committee member Henry Cole who backed him and his design strongly. Paxton had been experimenting with glasshouse construction using a modular technique where mass-produced prefabricated cast-iron components were united with plate glass, inspired by the organic structure of the massive floating leaves of the 'Victoria amazonica' giant lily that he had rescued from Kew Gardens and restored to good health. His design was accepted on a budget of £85,800, with a 19-acre footprint and with less than a year to build it. The building opened on time, on budget and to the awe of the population who had never seen so much

glass in a building. Taxes on glass had been abolished only 6 years earlier in 1845 by then Prime Minister Sir Robert Peel. It must be remembered here that a gardener achieved this. Not a trained or educated architect or scientist but the seventh son of a farming family who could not afford him a fine education. This is very indicative of the time where people trained and learned through direct experience on site or in the workshop; the same applying to famous engineers Telford (roads) and Stephenson (engines) (D. Evans, 2007).

1.2.2 Observations from The Great Exhibition

Britain dominated the exhibition by occupying half of the floor space with exhibits from home and the Empire. However, it was observed that many products on display from other countries were superior in both their quality and range. Countries such as France, Germany and the US had invested heavily in the education of its people as well as newer technologies. Despite England being the host country for the exhibition, it was one of only a few that lacked a system of organised education in technical disciplines. Research and development lacked investment and soon, main industries such as shipbuilding started to fall behind due to inefficient and dated machinery. However there was an apparent lack of government response. 17 years after the exhibition, to highlight the lethargy of progress to act on the observations, the Schools Enquiry Royal Commission quoted "*…evidence appears to show that our industrial classes have not even that basis of sound general education on which alone technical education can rest…. our deficiency is not merely a deficiency in technical education but in general intelligence and unless we remedy this want we shall gradually but surely find our undeniable superiority in wealth... and vigour will not save us from decline*" (Quoted in (D. Evans, 2007).

This lack of progress in technical education varied nationally. Scotland had Glasgow and Edinburgh universities where science, medicine and engineering flourished and had produced some outstanding scientists and engineers as a result. Telephone inventor Alexander Graham Bell was a product of the University of Edinburgh and James Watt revolutionised steam engines whilst working as an instrument maker at the University of Glasgow (Lira, 2013).

The introduction of science and technology into a formal education system also had one further barrier, that of the dynamic between science and religion. Early academies which attracted the talents of people such as John Dalton did not survive for long and were biased towards studies in divinity (D. Evans, 2007).
The criticism of the technical education system was often mentioned in meetings of the various societies that were formed by groups of scientists who worked in similar disciplines. It is testament to such individuals that England began the industrial revolution despite the lack of technical education institutions.

The 1860/70s saw scientific and technical training centres open in the industrial heartlands of Birmingham, Manchester and London. Local industrialists, manufacturers and merchants supported these, as a national framework did not exist (D. Evans, 2007). The beginnings of this were finally established with the incorporation of the City & Guilds of London Institute to advance technical education. By 1990 there were 390 centres nationally offering 64 courses. In the same period many technical; institutes and polytechnics were established following the recommendations of the Samuelsson report (1881) and the 1889 Technical Instruction Act, which created a national framework for Technical Education. There were also developments in Higher Education as technical and

engineering courses were offered in universities. The 1918 Education Act raised the school leaving age and created a system of part-time education up to the age of eighteen. The part-time developments were finally achieved after the 1944 Education Act. This act required local authorities to provide full and part-time education for people over the school leaving age resulting in a rapid growth in the opening of technical colleges.

The expansion also saw a wide range of technical courses and qualifications. The need to recruit high calibre and for courses to have a broad education as well as subject specific skills continued to create challenges. Numerous committees including the Dainton Committee (1968) identified declining students numbers and pass rates. The Haslegrave Report (1969) proposed greater consistency between grades of staff and qualifications. This lead to the establishment of the Technician Education Council (TEC) and Business Education Council (BEC), later joined to become BTEC The Business and Technician Education Council. To address still poor training rates, and high youth unemployment the late 1970s and 1980s government schemes (YOPs, YTS) offered funding to employers to support training costs. The schemes however were often shorter than traditional training periods with some employers for example in dental technology dismissing trainees after two years to take on new ones for which funding were available.

There have been further government schemes to address training and education in the workplace but the major challenges have been particularly for small and medium enterprises. They have very specific, and often narrow work needs for staff. National curricula require a broad education for which the

workplace is often not able to support in time, expertise or facilities. Part-time education can be expensive to support in time and other costs, and full time graduates require further in house training after graduation when higher salaries are expected to compensate for the debt incurred whilst a student.

1.2.3 Laboratory teaching of dental technology

Dental technology practical laboratory teaching has essentially remained unchanged since the subject was first offered for study in Manchester in the late 1940's. Despite historical changes to reflect new methods, equipment, funding arrangements, materials and calibre of applicant, the actual dissemination of knowledge and practical skills from the tutor to the students has centred around a demonstrate: circulate approach and remains to this day. Essentially, the pedagogic model is one where the students attempt to mimic the skills and procedures demonstrated by a lecturer. It can be summarised as 'Students Observe and Practice', 'Tutors Demonstrate and Give Feedback'. This style however does allow the students to undertake particular tasks without them even understanding why they are doing it.

Teaching any discipline particularly involving the development of professional and practical skills such as dental technology is affected by the financial constraints of the time taken to learn them. Courses can find significant challenges in meeting professional requirements when funding changes affect both the available time and the numbers of students per member of staff (SSR)

Teaching small numbers of students is impractical both financially and on staff

workload. For example, one member of staff currently staffs a laboratory class of four hours for up to 18 (±2) students. Splitting this class size in half would double the timetabled hours for the member of staff and there would be duplication of running costs such as lightning, gas and technical team support. The amount of hours that a student spends in the laboratory are very important as they are studying in a discipline which, on graduation requires a 'safe beginner' and a scientist who meets the requirements of the General Dental Council. Education and training are two completely different theatres. Indeed, without the significant science content, a degree course in dental technology would not exist. Training is the 'how' to do something whereas education is the 'why'. Another definition is that education is 'the building of the mind' whereas training is 'the building of skills'. To build both the mind and skills, the essential laboratory hours must be not just supplemented but entrenched in the underlying scientific theories and principles that support what is being done practically. It is important to make the best possible use of the time that the students spend in the dental laboratories, as this is the most precious resource available to them. The terms 'we do best what we do most often' and 'practice makes perfect' underline how important this time in the laboratories is to enable the students to meet their specific learning outcomes.

Most dental technology courses do not receive additional NHS funding to support professional development and are funded in the same way as other science and engineering courses. With the exception of the recently introduced Scientific Training Programmes (STPs), dental technology students fund their own education through the Student Loans Company (SLC) system. With

university tuition fees in the region of £9000 per year per student, those that do enrol expect to, and are entitled to receive an education worthy of their investment. It is here that there is a juxtaposition of providing bespoke education with a low staff: student ratio (SSR) but in a system that is already quite costly to run and in a competitive sector.

The laboratory teaching facilities at MMU consist of four general-purpose laboratories that seat up to 20 students. They are limited to this number due to the constraints of resources that are allocated by the university and by the amount of actual space that each student requires in which to work. Additionally, there is a further 16 seat laboratory that is used by level 6 students who are undertaking projects that require access to equipment and materials. Three further shared laboratories provide dedicated facilities for material preparation, finishing, burnout, casting and processing of acrylic resins. The main teaching laboratories provide each student with a bench, Bunsen burner, overhead lighting, local exhaust extraction and compressed air. The actual working footprint required by each student is approximately 90 cm by 135 cm.

1.3 Pedagogical and andragogical theories

1.3.1 Comparison

The following table shows the differences between pedagogical and andragogical attributes to learning and is followed by a justification to demonstrate that dental technology overlaps between the two, depending on the study level, personal experiences and desires of the student.

Table 2: Comparison of pedagogical and andragogical attributes

	Pedagogical	Andragogical
The learner	• The student is dependent upon the tutor for all learning. • The tutor assumes full responsibility for what is taught and how it is learned. • The tutor evaluates learning.	• The student is self-directed. • The student is responsible for his/her own learning. • Self-evaluation is a characteristic of this approach.
Role of the student's experience	• The student comes to the activity with little experience that could be tapped as a resource for learning. • The experience of the tutor is most influential.	• The student brings a greater volume and quality of experience. • Adults are a rich resource for each other. • Different experiences assure diversity in groups of adults. • Experience becomes the source of self-identity.
Orientation to learning	• Learning is a process of acquiring prescribed subject matter. • Content units are sequenced according to the logic of the subject matter.	• Students want to perform a task, solve a problem, live in a more satisfying way. • Learning must have a relevance to real-life tasks. • Learning is organised around life/work situations rather than subject matter units.
Motivation for learning	• Primarily motivated by external pressures, competition for grades and the consequences of failure.	• Internal motivators: self-esteem, recognition, better quality of life, self-confidence.

1.3.1.1 The learner

In the Table 2, dental technology laboratory teaching at Level 4 (Year 1 of the degree course) is essentially based on behaviourist theory as the students learning goal is to acquire new skills (behaviour) through conditioning and repetition. Students are dependent on the tutor to demonstrate what they need to do and the tutor also evaluates and marks the work that they produce. Furthermore, the tutor must deliver his or her subject according to set 'intended learning outcomes' that are predefined. The fixed number of laboratory hours for students must be planned in such a way as to meet these outcomes. In contrast, there are also some andragogical elements in their learning that students have to be responsible for. Demonstrations by the tutor are typically

only done once so students need to make notes and then plan their time to meet the objectives demonstrated by the tutor in the time available.

1.3.1.2 Role of the students experience

Dental technology is quite a niche subject and is only offered at further and higher education (FE & HE) level and consequently, applicants do not arrive with any prior knowledge of, or qualification in the subject. Compare this to a subject such as Chemistry, which is taught at school and college prior to beginning at university. A student entering a Chemistry degree course at MMU for example must possess a minimum A' Level Grade C qualification in Chemistry to meet part of the institutional entry requirements. They will have a clearer vision of what to expect on their course than a dental technology student who will be influenced to a greater extent by the experience acquired by their tutors.

Those students entering university after studying a Foundation Degree in dental technology bring with them experience that they then blend with their new learning and fit better into the example of an andragogical learner.

1.3.1.3 Orientation to learning

As students on the dental technology course advance onto Level 5 (Year 2 of the degree course), they retain the behaviourist approach to learning in the earlier months as they are producing devices that have a definite production sequence and are often prescriptive. There is some variation on a theme at this point. Students will have already learned to manipulate the materials such as

wax and plaster in Level 4, and be familiar with the operation of equipment and acquired dexterity with hand tools.

The students will be considering graduation and the reality of entering into a career in dental technology so the content at Level 5 is designed to encourage them to undertake cases that promote application of their learning by involving more thought and consideration of the consequence of factors such as poor design, future-proofing, treatment alternatives and professionalism. This content is elevated in Level 6 to become a more prominent feature of their learning. By relating casework to real-life scenarios, students become more prepared to begin work on graduation.

1.3.1.4 Motivation for learning

Attributes towards motivation for learning can be seen in both pedagogical and andragogical terms but will however, vary according to the individual. The goal of any student entering a degree programme (or indeed any programme leading to an award) is to successfully complete it. However, competition for grades, consequences of failure and internal driving factors will determine to what level that goal is achieved. Motivation can be separated further into intrinsic and extrinsic factors but both result in being “to be moved to do something” (Ryan and Deci, 2000).

Intrinsic motivation is driven by the desire to carry out an activity for the satisfaction that it brings of completing a challenge rather then for external reward such as a qualification (Ryan and Deci, 2000). It is a generic human trait to be inquisitive and curious and to possess a will to learn without any external incentive. Intrinsic motivation may not be applicable to everything that a person

does. The motivation may only exist for one or a few particular types of activity - those that provide psychological satisfaction.

Extrinsic motivation is in stark contrast to intrinsic motivation as it is clearly driven by the need to undertake an activity purely to reach an outcome rather than for the challenge of doing it. A student may not be particularly fond of the subject they are studying, as it may be that they don't plan on continuing it into their working lives. They may have their sights set on a completely different career, the prerequisite of which is that they must possess a degree. This type of student will carry out the activities just to pass rather than because of an inherent passion and desire for it. Extrinsic motivation should not be seen as negative as it can be recognised as a positive by a simple example: -

Consider a dental technology student who completes his coursework merely so that he does not have to take re-sits. Another student may personally believe that what he is doing is of value for his career. Both of these are extrinsically motivated and do the activities for their instrumental value rather than out of interest. The former is done for compliance; the latter for personal endorsement but both are intentional.

1.3.2 Demonstrate: circulate teaching

A particular laboratory manufacturing process involves a number of procedures that when completed, results in the production of a dental device, be it for removable or fixed prosthodontics or orthodontics. Each procedural stage is demonstrated by the tutor at the lecturer's bench and is viewed by students

gathered around it. Following the demonstration, the students return to their benches then the tutor circulates amongst the class to check that they are undertaking the process correctly and to offer advice on improvements in both the work and technique. As mentioned previously, this teaching paradigm offers little opportunity for the student to understand why they are doing what they are doing, concentrating mainly on the 'how'. The previous statement must be tempered with the fact that dental technology students do have theoretical, mostly didactic lectures covering the entire syllabus to underpin their practical activities but in a separate timetabled theory session where all the students meet as one group. This does have an advantage in that the entire group can interact and learn together in an environment that is more conducive to note taking, watching presentations and undertaking worksheet exercises.

Considering the general size of components used to make a dental device, they are typically no larger than a thumbnail and an entire device no larger than the collective size of the middle three fingers on one hand. This in itself is a challenge to demonstrate, even at close-quarters.

When class sizes are small (n~10), this particular style of teaching is effective as all students have a clear view of the demonstration. With a row of six students around the bench as seen in Fig 1, the remaining students have a clear view between the others which can be visualised by picturing a photograph of a sports team or school class where all the subjects are arranged in rows with the ones behind filling in the gaps between the heads of those in front. As the rows extend further backwards, they are elevated so that five or

more rows can be easily viewed.

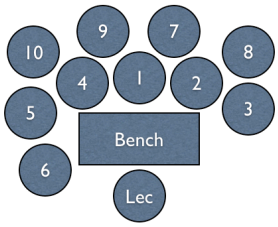


Figure 1: View of bench demonstration with 10 students

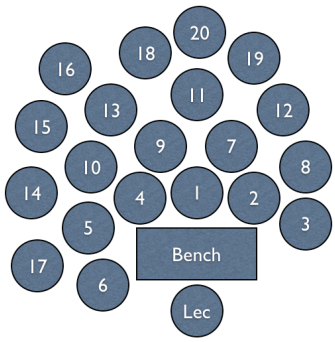


Figure 2: View of bench demonstration with 20 students

In more recent times where the student population has more than doubled, it is not uncommon to have a practical class that contains around 20 students to one member of staff. Unlike the example above, the students cannot be elevated over subsequent rows and consequently, the view beyond row two is very restricted in both size and clarity (Fig 2). Here, the student experience varies greatly and is directly proportional to the distance from the tutors demonstration bench. Commonly, the students who assemble at the back of the group tend to be of a more socially shy disposition and will often not complain about their view or ask questions. This pedagogic style (demonstrate: circulate) also has another major flaw in that in order for it to be effective, it must assume that all students learn and progress their work at the same speed, which is not the case, regardless of the nature of the work. Some students will naturally position themselves towards the back of the laboratory as it offers the greatest opportunity for distraction in order to engage in text messaging, social media and avoiding the direct gaze of the lecturer and therefore the possibility of

having to answer any questions (Anonymous, 2012). Rebeta et al, in their 1993 study suggest that (Based on the Bandura study from 1986), that students' personalities affect their choice of seating position. Those with low anxiety, high self-esteem and motivation believe that they are capable of occupying the front seats as they feel capable of behaving and producing more positive results for themselves through greater interaction with the instructor. The converse is also true. Anxious students with low self-esteem may have arrived at the conclusion that they are not capable of behaving in a nature that they would personally see as that required occupying the foremost seats, opting therefore to sit away from the front (Rebeta et al., 1993).

1.3.3 The Flipped Classroom

The Flipped Classroom is a relatively modern term that relates to an educational model whereby students access (typically digital) learning materials in their own time, at home or away from a learning institution. The access is not limited by the constraints of location or time and learning materials can be accessed as many times as an individual user requires in advance of the timetabled lesson. Another common phrase used to explain the concept is that students do 'their schoolwork at home and their homework at school'. On it's own, this statement gives an indication of the structure but a more precise definition is 'an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom' (Bishop and Verleger, 2013). It combines constructivist ideology with behaviourist principles by blending active and problem-based learning approaches with traditional 'instructional' lectures.

Salman Khan founded the Khan Academy in 2006, which is built around the Flipped Classroom model and contains over 3200 videos and hundreds of exercises. These resources are free to 'anyone, anywhere'. The Khan Academy gained rapid momentum and inspired Stanford University professors Sebastian Thrun and Andrew Ng to develop and launch online courses. Thrun's free course alone attracted over 160,000 students (Bishop and Verleger, 2013). Recently, the Massachusetts Institute of Technology (MIT) agreed an online, open, educational initiative titled 'EdX' at a cost of $60 million to 'offer Harvard and MIT classes online for free'. This has not gone unnoticed by students who attend bricks-and-mortar institutions who have seen tuition fees triple since 2000. Added to this, a 2011 study indicated that undergraduate tuition fees were subsidising research leading to the question of what exactly do students receive for their money? (Gillen et el 2011, cited in (Bishop and Verleger, 2013). If such free, online courses are to exist now and grow in the future then in response, academic institutions need to investigate methods to improve or enhance the experience for those students who physically attend. The use of bespoke digital learning aids; tailored for use in, before and after a lecture or laboratory session, offers one such route.

Many courses are required to meet the requirements for accreditation by their relevant regulating body. Specifically, this regulation drives the actual design of the course as it must align to the learning outcomes of the regulating body, yet satisfy the educational academic quality and standards set by the institution. As the regulating body updates their policies, so must the course to keep abreast of them.

1.3.3.1 Flipped classroom example

Consider a situation where a class is to learn about algebra. Traditionally, this would involve students attending a timetabled lesson where the instruction about solving algebraic problems would be given. The majority of the lesson would be consumed by the actual instruction of how to solve the problem; the actual mechanics that must be carried out in order to find the solution. With this approach there is little opportunity for application of the learning and it assumes that all students progress at the same pace and possess equal ability. This pedagogical method is mostly cognitive in that students learn a series of sequential techniques and procedures that are first demonstrated. The student must then attempt to recall and apply what they have learned. When the lesson has finished, any further work a student requires on this topic must be undertaken in his or her own time without the help of the teacher. The recall and application is only effective if the student has the ability to do so based on what they have learned

People learn in different ways, and the 'one-size-fits-all' clearly presents barriers to the progress of those who find a didactic approach challenging, difficult and/or misaligned with their preferred style. Additionally, this teaching style encounters problems if a student is absent from the class as there is little opportunity to recover the topic if the lesson is part of a set of learning outcomes that are addressed each week.

Using the previous example involving a lesson on algebra, the Flipped Classroom would be structured very differently. Firstly, the actual instruction on how to solve algebraic equations could be delivered as an online digital video, followed by further videos of examples showing the application of the theory.

The student is able to watch these resources in their own time, at their own pace and as many times as they personally require in order to acquire the necessary knowledge to feel comfortable attempting a problem on their own. Students can also review any parts of the video that they may have misunderstood or which they feel needs further reinforcement. A traditional lesson is quite linear in that it has a beginning, middle and end. However, a student may only need part of that lesson in order to be comfortable with the topic to advance their work. Digital video allows users to advance the software-controlled play-head interactively to the point where they need to view (Zhang et al., 2006). This is known as 'scrubbing'. They may then also view the additional videos that show examples being worked through to consolidate the theoretical concepts and their learning.

All of this is done in advance of the actual timetabled lesson and is not limited by the actual location or time of access. Location in this context relates to where the user has the opportunity to view the videos on a viewing device such as a desktop computer or mobile device such as a tablet or smartphone and may access the Internet using WiFi[2] or cellular[3] connections.

Students who may have missed a traditional lesson will still have the opportunity to access the lesson through the use of the online videos.

[2] WiFi is a term used to denote wireless technology used to connect to the internet using radio waves using the 'Institute of Electrical and Electronics Engineers' [IEEE] 802.11x Standard (The Institute of Electrical and Electronics Engineers (IEEE), 2012). This is most commonly found in homes and public places and typically uses a wireless router that is itself physically wired to a telephone socket to access the Internet through an Internet Service Provider (ISP).

[3] Cellular is an collective term used to denote any wireless technology that is used to connect to the internet using radio waves that are distributed over land areas from fixed locations known as cell sites or base stations which, when connected to each other form a cellular network that is operated by a national or international telecommunications company such as BT (British Telecommunication), Orange, EE (Everything Everywhere), Vodafone or O2.

1.3.4 Teaching interaction types

There are three main teaching interaction types: face-to-face, online and blended.

- Face-to-face learning is, as the name suggests, where all classes take place between students and in the physical presence of their tutor(s).
- Online learning is where all instruction and assessment is undertaken online away from the delivering institution and is also known as 'distance learning'.
- Blended learning is a mix of the above two types where the student undertakes part of their course online and part face-to-face.

In 2009, a study was carried out at the University of Illinois at Springfield to investigate the comparison between the above three types of teaching for 168 students studying for 'Management Information Systems' course (Larson and Sung, 2009). These were divided into the three types (63 in face-to-face, 22 purely online and 83 in blended type). The study concluded that when measured for student satisfaction, learning effectiveness and 'faculty satisfaction', there were no significant differences.

This further emphasises that people learn in different ways and that one style, whilst being effective for one type of learner, may not be the most suitable for another. Furthermore, certain topics may lend themselves to one particular teaching style over another. The face-to-face style may be more suited to courses such as law and languages whereas manufacturing and skills-based

courses such as dental technology, art and engineering may be better served using a blended approach.

1.3.5 E-Learning

E-learning provides certain benefits to both institutions and learners. Principally, the learner is not fixed to one particular location and at a certain time meaning that they may access resources at, or away from the institution, at a time that suits them, at a pace that suits them and without limitation on the number of times they can access it. Institutions can also reduce cost and time savings by making better use of their resources (Zhang et al., 2006). Learners see actual objects, in real and scenes, especially if the video material has been recorded in an environment of which they are familiar. Marchionini suggests that well-indexed video in small portions that are incorporated into lessons are “the first step to realizing its potential” (Marchionini, 2003).

The study by Zhang et al (2006) found that the use of video for learning was effective but only when students were able to interact with it. Video is linear by nature but the addition of a button to allow the student to advance the play-head to a particular point (scrubbing) means they don’t need to watch the video in its entirety as they may access the video segment they require then exit at will. Furthermore, the study found that students who used interactive video showed better learning performance and satisfaction than students who used a different approach. Conversely, performance and satisfaction were unaffected if the video that was being used was non-interactive. Non-interactive video is more difficult than using a textbook due to the learner having to wait until a particular portion of the linear video ‘arrives’ (Marchionini, 2003).

1.4 Teaching technologies

1.4.1 Visual displays in dental technology teaching

In an attempt to improve the delivery of practical demonstrations, the Centre for Dental Technology submitted a successful 'Capital Expenditure Bid' in 2011 to provide funding to equip a laboratory with a camera set-up to enable the recording and live relay of demonstrations to students using a 40 inch flat panel display positioned above and behind the lecturers bench. The laboratory is arranged as four rows of five students as seen in Fig 3. The system consisted of a touch screen video camera system (Sony HXR-MCP1; Sony Corporation, Tokyo, Japan) held on a desk-mounted lockable swing-arm (Magic Arm; Manfrotto, Bassano del Grappa, Italy) that was connected to a previously installed distribution board to broadcast captured video onto the flat panel display.

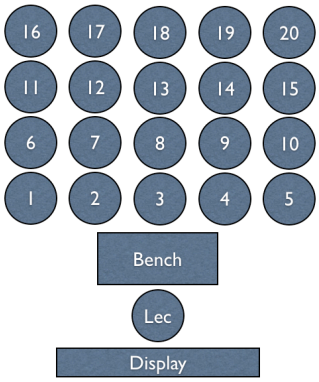


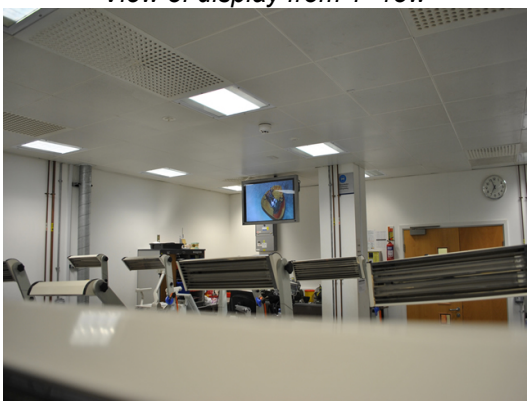
Figure 3: Arrangement when viewing demonstration on a screen

This allowed the demonstration stages to be showed in greater detail without the need for students to assemble around the lecturer's bench. However, it provided only a slight improvement, as essentially the same problem existed:

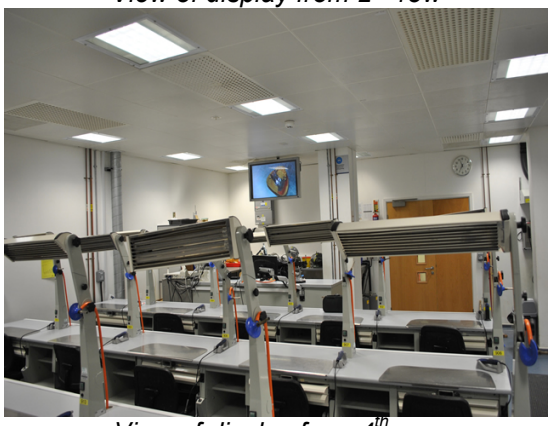
the experience of the demonstration was directly proportional to the distance from the display and this in turn compromised the student-tutor relationship. The students on the most rearward (4th) row of the laboratory sit approximately 8 metres from the display and at that distance; the detail diminishes to the point where it is barely possible to discern the content without image zooming (Fig. 4).

View of display from 1st row

View of display from 2nd row



View of display from 1 3rd row



View of display from 4th row

Figure 4: Views from each row in dental laboratory

Furthermore, the previously installed flat panel display was 'HD Ready' but the video stream from the distribution board transmitted at a much lower resolution[4] meaning that much of the clarity was lost between the camera and the display.

[4] Resolution is a term used to denote the number of pixels used to form an image measured horizontally and vertically on a display.

The video camera recorded in ‘Full HD’ which is a term given to equipment that can record and/or display at 1920 pixels across by 1080 pixels vertical. The term 'HD - High Definition’ is a non-specific term for any video that is greater than 570 vertical lines. The flat panel display in the laboratory was only technically capable of showing 720 lines vertically, representing a reduction in clarity between the possible camera output and actual display output of 33%.

The system also introduced the facility to record demonstrations onto a memory card (8 Gb Sony MemoryStick™ Pro-HG Duo) that could be replayed on demand by the lecturer via the installed system. This was occasionally used for those who wished to view the demonstration again for reinforcement of learning or in cases where they had been absent from part of the session. The memory card could also be removed to allow import of the source media into video editing software on a computer.

Using the demonstrate: circulate teaching style, the session pace is set by the lecturer with the aim to meet the learning outcomes set for that particular session. This can bring frustration from different students for different reasons. Students who are more technically capable or who have had previous dental laboratory experience will find the pace restrictive as they will need to wait for the tutor to advance to the next stage, whereas students who find the technical work more demanding may struggle to keep up, which may introduce greater scope for error. Furthermore, every time the tutor presents a new demonstration, the class need to stop working, which reduces the actual laboratory working time for the students. In a typical three-hour laboratory

session, some one quarter to one third is spent watching the tutor carry out demonstrations.

When students are gathered around the tutor bench during a demonstration, it is a much more intimate environment created by the proximity between the tutor and students. This makes for a more comfortable setting in which to ask questions, as they do not need to be asked at a volume to be heard across the laboratory. This is in contradiction to the case when the demonstration is being relayed by video on the overhead display when the student needs to first attract the attention of the tutor before asking the question at a volume suitable to be heard across the laboratory, knowing that all the class is now listening to them ask their question.

1.4.2 Shared area demonstrations

In the dedicated areas, there are significant challenges to effectively demonstrate the processes to large numbers of students. For example, when demonstrating the use of a polishing lathe, the tutor will often have their back to the students leaving only a small space either side for students to view the technique. Again, these demonstrations reduce the actual amount of time that the students spend working and deduct from their available laboratory hours. The use of a lathe in the above example could be demonstrated more profitably in terms of student time and quality of instruction by means of a video. This is because it is generic procedure that is essentially the same, regardless of a case being worked on. A similar approach could be applied for flasking, packing, wire working, investing and articulation. Prior to a laboratory session, a student could view the relevant videos in preparation for the actual session

thereby saving many hours of waiting for a demonstration by the tutor. Furthermore, they are able to advance at their own pace. To use a cycling analogy, the majority of students (the peloton) mostly advance as a group together with a few more capable or experienced students forming a breakaway group. The use of video in the above examples would accommodate both types without restricting either. This would not be as possible with a scheduled laboratory programme that required all students to be at a particular stage at a certain date and/ or time.

1.5 The Internet

1.5.1 Internet access in Great Britain

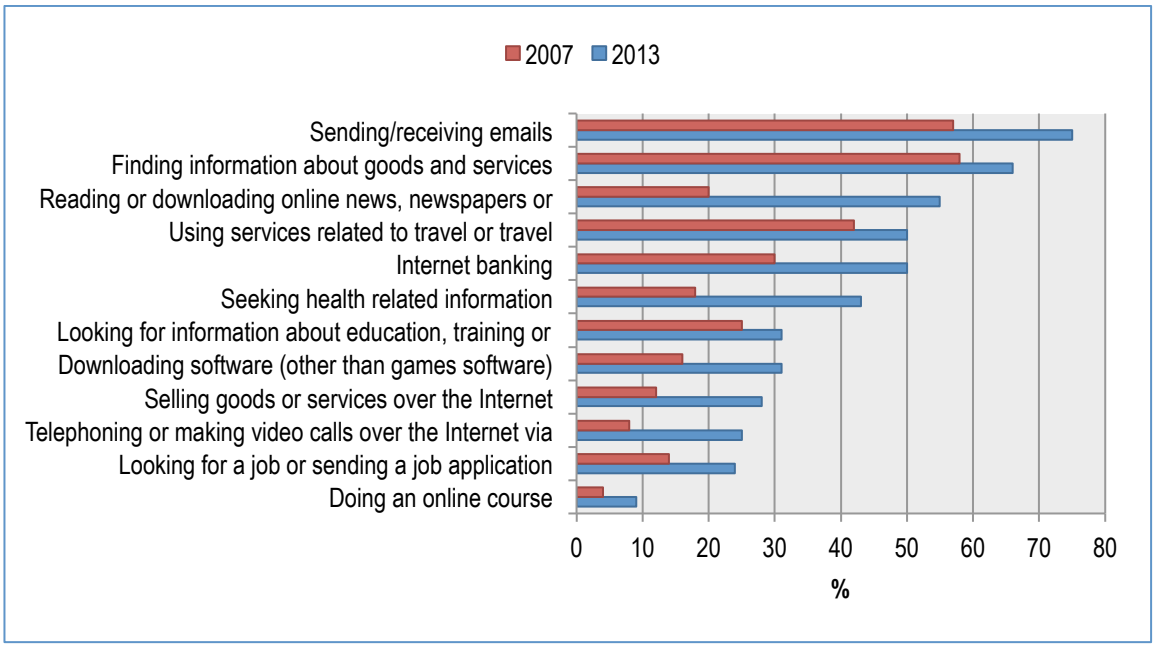


Figure 5: Internet activities, 2007 and 2013 (Source: Office for National Statistics, 2013)

In 2013, nearly three quarters of the 36 million adults in Great Britain accessed the Internet every day compared with 16 million when records began in 2006. Of these users, 53% accessed the Internet using a mobile phone, which is an increase of over 50% in just three years. 83% of UK households now have

Internet access (Office for National Statistics, 2013). Internet use is not constant across age groups but adults up to the age of 34 represent the largest number of users. The lower age range between 16 and 24 engage in online activities that are focussed on leisure and recreational such as Facebook and Twitter. 4 out of 10 people in this range also make Skype (Luxembourg City, Luxembourg) calls using the Internet. Every category of use has seen a marked increase when compared with 2007 as seen above in Figure 5.

1.5.2 Internet trends and shifts

In 1996, 66% of worldwide Internet traffic passed through devices in the US compared to just 13% today (14% when including Canada).

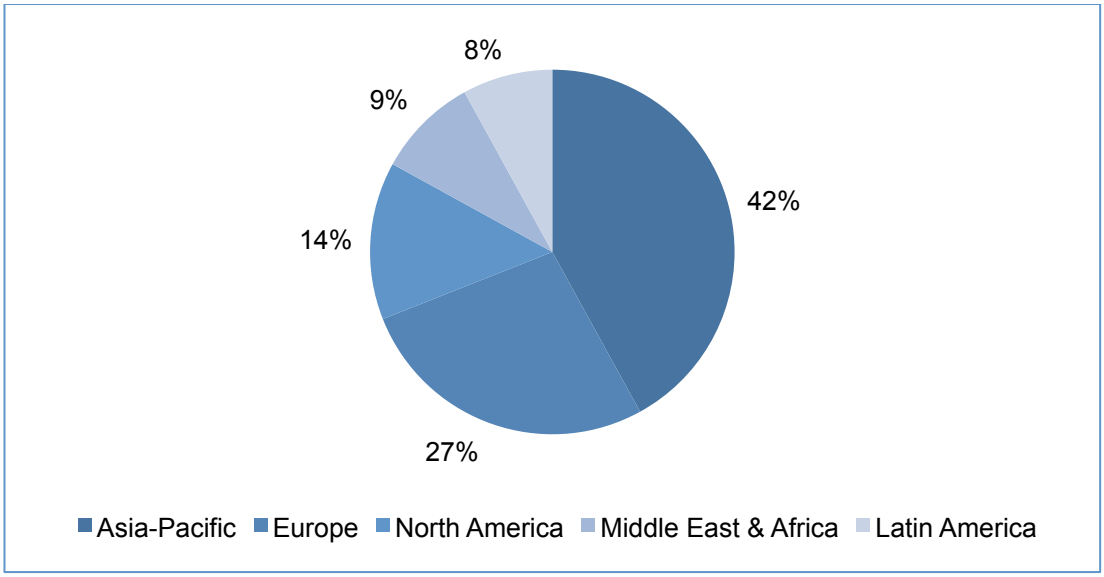


Figure 6: Global share of Internet Audience (Source: European Travel Commission Digital Portal, 2013b)

Figure 6 shows the share of the global internet audience from a 2012 report on the use of the Internet (European Travel Commission Digital Portal, 2013b). Of this global traffic, 13% is through mobile devices, driven by the increasing number of broadband service providers, Wi-Fi access points in public places and cafés and competition between service providers and cellular carriers.

Broadband services are improving in both speed and number and are slowly transitioning from copper wire to fibre-optic cable to transmit data at the speed of light. Globally, broadband prices dropped by 75% between 2008 and 2011 making them more affordable to those who may have previously been unable to pay for them. There are more mobile broadband subscribers worldwide than fixed (wired) subscribers. Many households have copper telephone lines that may have been installed a long time ago and do not work to their full potential, resulting in slower data download speeds and 'drop-outs'. When customers pay for 'line rental' as part of their telephony or broadband contract, this means the actual cable that joins the property or business to the telegraph pole and should be of optimal quality to transmit and receive data at the greatest speeds.

Fast broadband is no longer considered a luxury but an essential part of modern life and seen as important as a reliable electricity supply for consumers. The UK government is striving to provide fast broadband to 99% of the population by 2018 through a combination of wired and wireless 4G services but regulatory body OFCOM show that only 65% of the population currently have this capability (British Broadcasting Corporation, 2013).

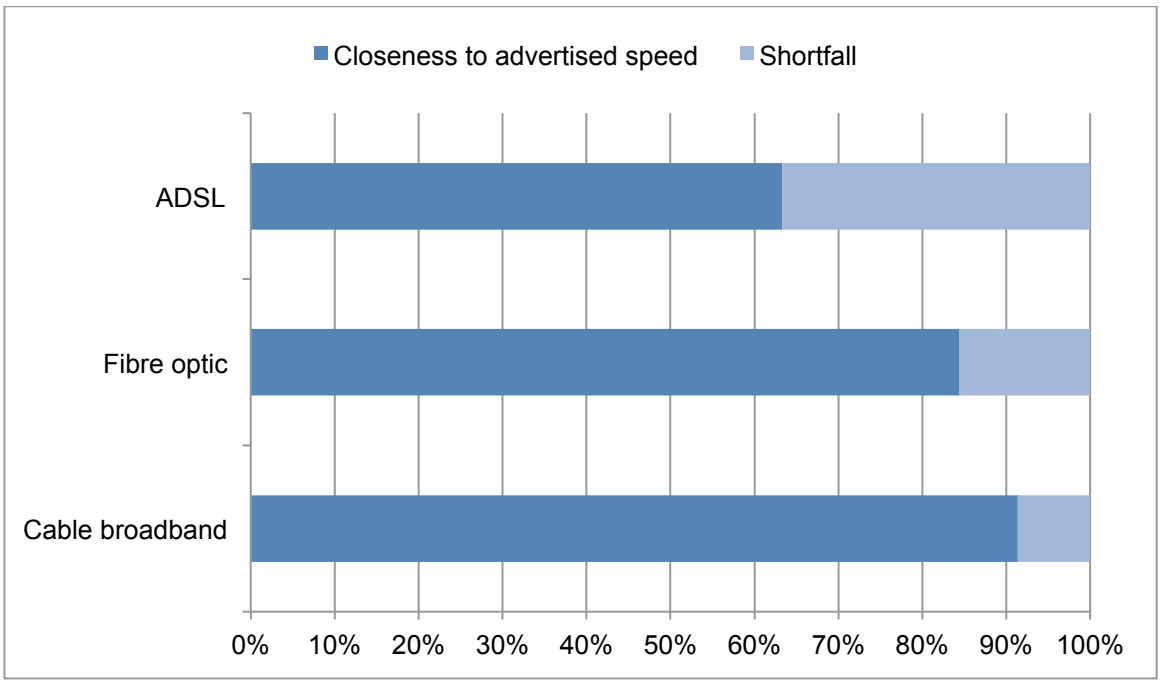


Figure 7: Comparison of actual speeds against advertised connection speeds (Source: (British Broadcasting Corporation, 2013) [ADSL = Asynchronous Digital Subscriber Line]

Another complication is that of advertised speeds against actual speeds. Providers typically use the phrase 'download speeds up to' rather than the actual speed that is served and a study reported on the BBC website states that when compared to the advertised speeds, the actual download speed varies greatly as seen in Figure 7. The EU targets a download speed by the end of 2013 of 30 Mbps (Megabits per second) for all households yet the above study suggests this has some way to go, with the European average being only 19.7 Mbps (British Broadcasting Corporation, 2013).

In 2012, the International Telecommunication Union published their annual report on Information Communication Technologies (ICTs) (International Telecommunication Union, 2012). It showed that there was a definite correlation between high-income countries and their progress with ICT and that this was twice as high as that of developing countries. Eight of the top ten countries

listed were European. It would also appear that updating existing infrastructure (such as replacing copper wire with fibre-optic) could be a barrier to the overall speed of progress. Shifting out the old to make way for the new takes time and money. In African countries, up to £46bn a year is being spent by a combination of governments and private sources on new infrastructure, 28% of which is telecoms-related. Because there are no legacy infrastructures to first replace, the current best technology can be installed 'as new' in Africa, opening up opportunities for commerce, entertainment, telephony and educational services. In remote rural areas, the reach of the broadband services can also be extended by using wireless services (Sassoulas, 2012). Despite this, Africa is still regarded as a 'Third World Country' according to the Encyclopaedia of World Geography which is one where there is high infant mortality, high levels of poverty and the absence of a middle-class; instead there is a large lower economic class and a very small elite upper class which is in control of the resources and wealth of the country. Other such countries include large parts of South America, India and some countries in the Middle and Far East (McColl, 2005) and are indicated in dark green in Figure 8.

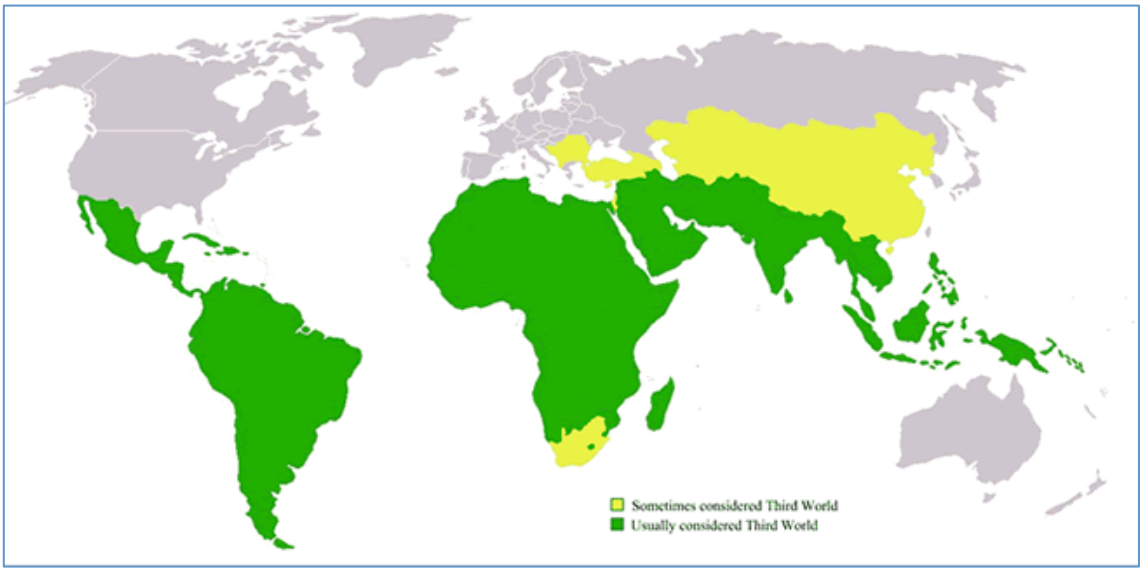


Figure 8: Third Word Countries - Source: Gavilan College (Online), CA, USA

1.5.3 Widening participation and social media

University students today are made up from a very diverse group of people due to demands by government for institutions to widen participation to social groups who may not have previously been considered. 'Widening Participation' is the term used to describe the initiative of educational institutions to open up fair access to higher education to social backgrounds that may have previously been denied it (HEFCE, no date). This may be due to each institutional policy on entry qualifications, fees or a combination of both. However, elitism still exists in some institutions due to the recruitment process generally as universities choose students rather then the other way around. This is opposed to previous cohorts where places were only offered to selected students (C. Evans, 2013).

The modern student population has grown up with social media. Douglas Adams, author of 'Hitchhikers Guide to the Galaxy' once quoted 'Whatever's in the world when you're born is just normal'. To these modern cohorts, social

media is not a recent technological phenomenon, merely something that has always been there. The term social media denotes user-generated content that is created and shared in virtual online communities. Popular social media services such as Facebook and Twitter are available on all platforms from desktop computers to mobile phones and are incredibly popular. Their overall statistics are staggering. An Associated Press article on the Yahoo website reported that as of May 2013, Facebook had 1.11 billion active users (Associated Press, 2013). The key word here is 'active' which means that they regularly accessed the service as opposed to dormant user accounts that have been registered but not used. 23% of Facebook users check their accounts more then five times every day and users collectively upload 350 million images every day. Facebook took only 5½ years to grow from 1 million users to half a billion, then only a further three years to double this to one billion. Of these, 751 million access the service using a mobile device and consequently this is a large driver in the use of mobile devices generally. Twitter alone handles 400 millions 'tweets' every day and 60% of these originate from a mobile device.

Social media is not limited to Facebook and Twitter. There are others, most notably Google+, Linked In, Instagram, Pinterest, WhatsApp and Vine and users may shift their allegiance between these due to age or 'crowd mentality'[6]. A report in 'The Guardian' in late December 2013 (Kiss, 2013) found that 16-18 year olds had opted to leave Facebook in favour of other social media services. In the report, anthropologist Daniel Miller of University College London states that 'mostly they (teenagers) feel embarrassed to even be associated with it, …

[6] Crowd (or mob) mentality is the term used to describe how people may be influenced by others in their social groups to follow a particular trend, adopt views and behaviours. In this particular context, crowd mentality refers to the adoption of a social media brand based on what a users peers are using; usually at the expense of an existing brand.

children say it is their family that insist they stay (on Facebook) to post about their lives'. Young people are interested in their perceived style and status in relation to their friends and social group and it is simply a case that they do not consider Facebook as 'cool' any more (Kiss, 2013).

1.6 Mobile devices

Mobile phones are now ubiquitous with 94% of 16-24 year olds accessing the Internet with a portable device. Age is a distinct driver in the adoption of new technology. In contrast to the above figure, only 17% of those over 65 have accessed the Internet on a portable device (Office for National Statistics, 2013). In the Middle East, 44% of the regional population are under 20 years old resulting in 125 million users online via mobile with 53 million of these active in the use of social media networks (European Travel Commission Digital Portal, 2013a). A Dubai School of Government Report in 2013 found that the rate of growth in mobile Internet use in the region 'continues to increase by over 30% on average each year'.

Mobile phones can be considered to reside in one of two main categories, 'feature phone' and 'smartphone'. Both of these terms are non-standard and have evolved to basically distinguish the capabilities and often the perceived pricing of each type of device. Handset makers typically manufacture a broad range of devices that cellular network providers can offer to customers with differing incomes. A suitable analogy is that of the iPod (Apple Inc., Cupertino, US) which is offered in different models of reducing capability ranging from the 'iPod Classic®' at £200 down to the 'iPod Shuffle®' at £40 (prices as of Autumn

2013). Regardless of the income of a customer, there is at least one of the devices that is within their financial reach.

1.6.1 Feature phones

A feature phone is a device that has additional features beyond basic calls and short messaging system (SMS) such as a camera, calendar and games. They are usually bought outright as opposed to a purchase by monthly contract and do not integrate fully with the mobile Internet but may contain some on-board applications that download data such as weather and email.

1.6.2 Smartphones

Although there is no standard definition of the term, a smartphone is a handset device that has all the capabilities of a feature phone but has better Internet connectivity and the capability to install and run software applications 'Apps'. Another distinct feature is the inclusion and availability of application programming interfaces (API's) that allow third-party software developers to integrate their Apps closely with the hardware and software of the device.

The first major smartphone to really make an impact was the Apple iPhone™, which was launched by then Chief Executive Officer (CEO) Steve Jobs at the Moscone Centre in San Francisco on January 9th 2007. It was the first device to utilise a full touchscreen as the sole method of communicating and interacting with the device (Apple Inc., 2007). In his presentation of that morning, he showed examples of other competitor smartphones but the iPhone was a radical breakthrough that coalesced three devices; a phone, Internet communicator and music player (iPod® – Apple Inc.). No other handset maker offered a device that was purely controlled by touch. Furthermore, Apple

controlled the supporting ‘ecosystem’ as they manufactured both their own software (iOS, Apple, Cupertino, US) and hardware unlike any other handset maker.

In the November of 2007, Google announced that it was to offer its free operating system named ‘Android™’ to anyone who wished to use it. Android was the name of the company who developed the software and acquired by Google in 2005. Advertising mainly drives Google’s revenue. Its services such as email, video and search (Gmail™, YouTube™ and Google Search respectively) help to harvest lifestyle data to serve up tailored and targeted commercial advertisements that may be of interest to the user. Companies and organisations buy advertising space from Google who in turn show these as links in their web services and charge only if the link is clicked (Pay-Per-Click). It is important to consider here that Google is a software company and does not manufacturer its own handsets like Apple. As of September 2013, their Android operating system is installed on nearly three quarters of mobile phones worldwide. Handset makers are attracted to the features of the software and the fact that they do not have to pay a licence fee to Google for its use, thereby maximising their profit on the handset. Manufacturers such as HTC and Samsung use Android as their main operating system. In recent months, the Android operating system has been modified for use on smart-watches and the Google Glass™ project; a new range of devices grouped under the title of ‘wearable computing’ as seen in Figure 9. Since the 2007 iPhone launch, it took a further three years before an Android powered device utilised a full touchscreen interface. Despite this and within two years of its launch, Android had a 43% market share of the smartphone market (Arthur, 2012).

Figure 9: Wearable computing; left Google Glass™ and right, the Sony Smartwatch™

Other companies such as 'BlackBerry'™ (formerly known as Research in Motion 'RiM'), began strongly in the early 2000s but were offered $4.7 billion from an investor in late September 2013 following poor sales and amid large staff number reductions. The offer was only accepted provisionally whilst Blackberry sought other offers. Microsoft's CEO Steve Ballmer dismissed the iPhone at launch and failed to see its potential. The 'Windows Mobile'™ operating system did not prove popular initially. In recent years there has been a slight resurgence due to their improved operating system. Nevertheless, Windows owns less than 5% of global market share in mobile operating systems.

There is some overlap of these definitions of feature phone and smartphone due to constant improvements made in software and hardware. Some modern feature phones running on faster processors and consequently more capable software exceed the capabilities of older phones that were once considered 'smart'. The term 'feature phone' has also recently been dubbed 'dumb phone' to clearly signify that it is not a 'smart' device. A report in 2013 showed that by December 2012, the number of smartphones in all European countries crossed the 50% boundary meaning there were more smartphones than feature phones (comScore, 2013).

The global smartphone market has seen a significant shift in recent years as seen in Figure 10 below.

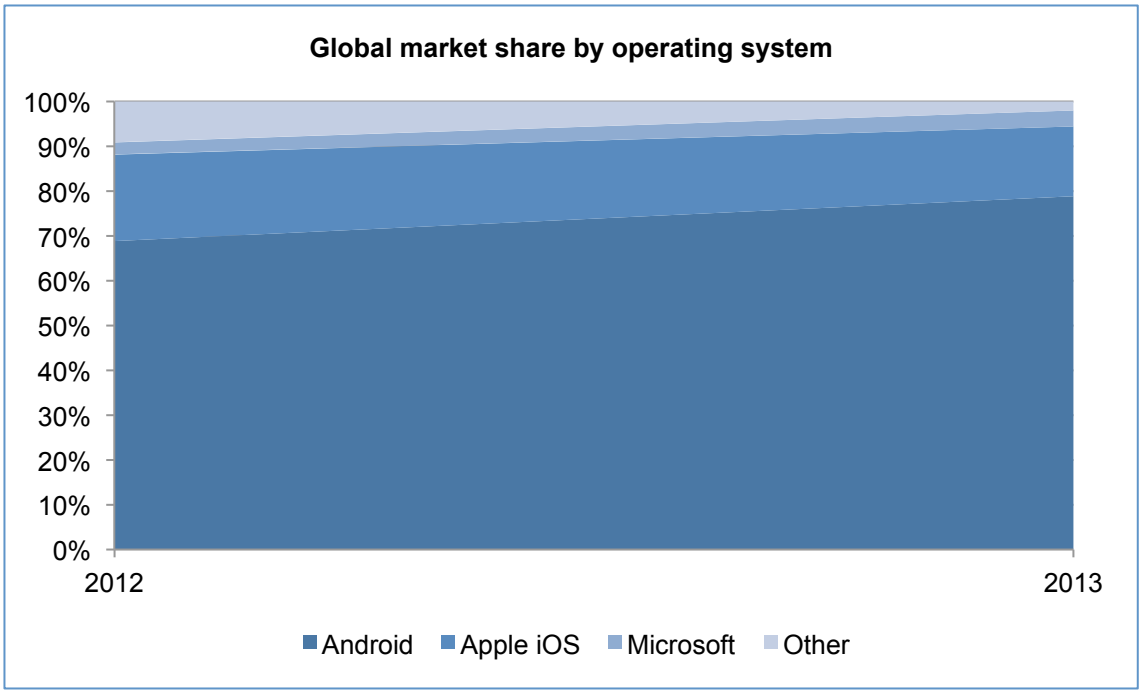


Figure 10: Global market share of smartphones by operating system (Source: Engadget - 29-01-2014)

1.7 Mobile applications ('Apps')

An 'App' is a program developed for use on smartphones. Whilst containing custom code to run the unique content of the program, Apps also engage and interact with native Application Programming Interfaces (API's) on the device to access applications such as the camera, contacts list or maps. Apps should do one thing well, rather than attempt to perform a multitude of tasks. For example, a photo-editing App should not also be a list of contacts and should focus only on editing photographs. The App is installed directly onto the device over the internet for free or for a fee from an online store which is itself built into the device as an App which allows users to search and browse by title, category or rating. After downloading and installing, the App then appears as a tile on the

device screen menu, represented by an icon depicting its title and logo and can be launched (opened) by the user by tapping it.

1.7.1 iPhone and the App Store

When the iPhone first launched, Apple never intended to allow third-party developers to write their own Apps for it. CEO Steve Jobs insisted that these developers could achieve their goals by using so called 'Web-Apps' which were designed to run through their integrated Internet communicator software, 'Safari'. Steve Jobs' autobiography revealed a person who was driven by quality and perfection and he rejected the notion of third-party Apps outright as he could not deduce how to police them to guarantee that they would meet the stringent quality control that Apple put their own applications through (Isaacson, 2011). In October 2007, following repeated lobbying by Apple Board member Art Levinson and the poor reception of Web Apps, Jobs relented and announced that the first iPhone software development kit (SDK) for developers would follow the year after (Bell, 2011). The App Store was opened in July 2008, accepting submissions from third-party developers that met their strict content and design policies. Developers upload their Apps to Apple who then take up to two weeks to profile and test it before deploying it on their App Store for download by iPhone users. As Apple own and control the distribution system (without the need for developers to master and duplicate physical media), they take 30% from every download and consequently, the decision to allow third party Apps on their device has become an enormous source of revenue for the company. A 2013 Forbes article hinted that at current growth, App Store revenue in 2016 could generate $22 billion (C. Jones, 2013).

1.7.2 Development of Apps

Apps are made using a Software Development Kit (SDK) supplied by Apple and is provided free to all users who are registered as developers. Whilst there is no fee to use the software, those wishing to publish their Apps need to pay an annual fee of $99 to submit their software to the Apple App Store. The SDK contains a suite of programs that unite the various graphical and programming interfaces together to develop Apps for Apple Macintosh computers and all iOS touch devices.

The main program in the suite is XCode, which is where the programmer writes the custom program ('code') to enable the App to run scripts that are unique to the application and to integrate with the native Application Programming Interfaces (API's) on the device (Fig. 11).

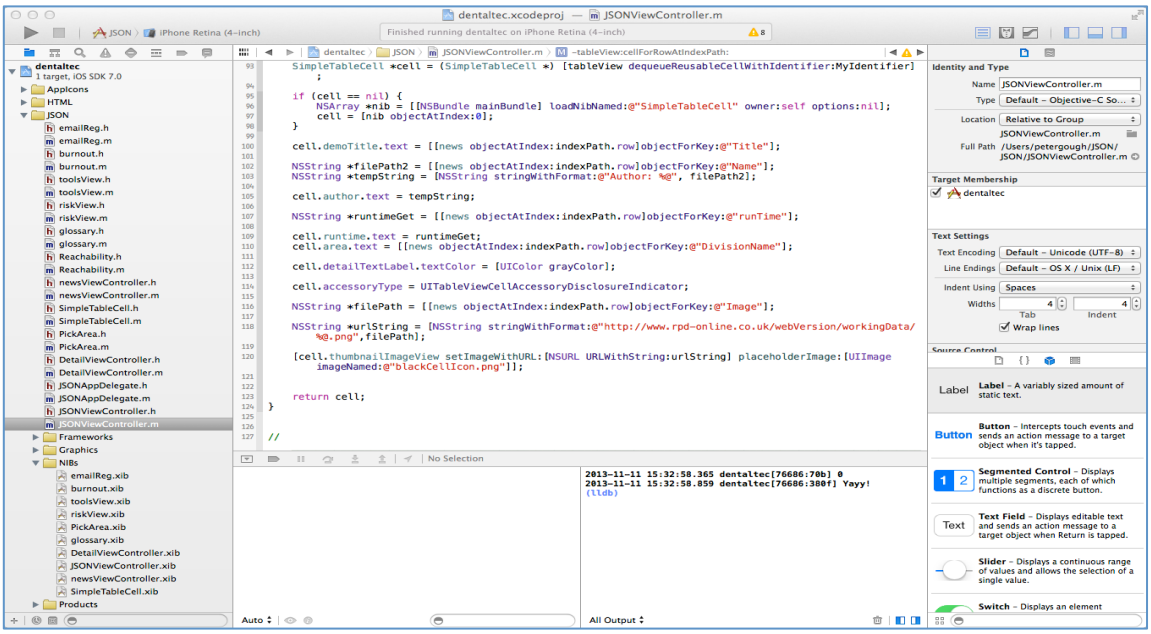


Figure 11: XCode Application Development Environment

One such example is touch, where a user interacts with the screen through a collection of API's that read the input from the screen and convert these

touches into actions that trigger other parts of code to run. This is called a Model-View-Controller architecture and is visualised in Figure 12.

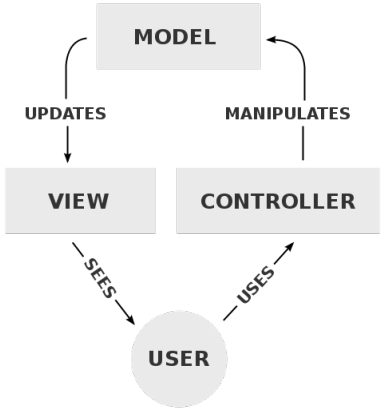


Figure 12: Model-View-Controller Architecture

An example to explain the operation of the above architecture is a calculator App. It would have a number of buttons to represent the numbers (controllers), which then manipulates these inputs to prepare the data for the model. The 'model' is the part of the program that runs the logic and functions such as add, subtract and equal using the data passed to it through the controller. The view is the output representation of the data such as a text label, diagram or chart and in this example, the calculated number that would appear in the main calculator display. By separating the components of the whole program in this way, the data can be used in more than one view one way. A standard progress bar indicator when downloading is an example where the same data is represented in two different ways, as a bar chart and numerically in text (Fig. 13). In the calculator example, the resulting data may be presented to the user and also stored using a memory function in the model (through a controller button) for recall at a later time to use in another calculation or to use in a chart.

Figure 13: Install progress bar showing two representations of same data in 'MVC' architecture.

1.7.3 Process

App development begins by drafting a plan for the MVC to include all the controllers that the user interacts with that are also part of the view. At this stage, drafting is best-organised using paper and pencil to help quickly visualise, amend and review suggested strategies rather than spending time in a digital interface. The functions that are called from the various controller inputs are then written to either run independently (custom code) or to interact with the operating system API's. Common API examples are interpretation of touch inputs, playing audio and video and displaying web pages through accessing a Universal Resource Locator (URL) in the UIWebKit framework.

1.7.4 Layout

XCode supplies 'standard controls' that allow the developer to layout their various views on the screen to connect them to the model. On the iPhone, these exist as buttons that may be presented skeumorphically[7] or not. Skeumorphic designs were common in the early days of smartphones with touchscreens as users needed to be able to recognise a button as a button. In recent years and due to the adoption of smartphones on a large scale, skeumorphism has been superseded in favour of cleaner, subtle designs, as

[7] Skeumorphism is a term used to explain the design of a software element so that it represents its real-world counterpart. An example would be an on-screen calculator button that is designed to look like a button found on a real calculator.

people generally understand how touch interfaces operate and do not require controls to look like their real-world elements.

The layout must adhere to the strict design principles as stated in the Apple Developer Guideline for Submission (Kahney, 2010) and must adhere to the 'Human Interface Guidelines (HIG)' (Apple Inc, 2013). There are many reasons why an App may be rejected by Apple as part of their review process but generally, controls and interface elements should be legible and defer to the content rather than overpowering the user with illegible fonts and graphical elements, favouring clarity and ease of use. When placing a control such as a button onto the view (screen), it should be a size that is suitable to be touched without accidentally triggering a different function than that intended. It should also be placed at a suitable distance from the borders of the screen and from other controls around it. All these elements fall under the HIG requirements and are a common reason why Apps are rejected (Lechat, 2013).

1.7.5 Program coding

The main part of App development is the writing of the code, which will perform the various functions (model) on the data that is handed to them by the user's interaction with the controller. This is really where an App gains its bespoke qualities, setting it apart from other Apps.

Each view or screen that the user may interact with contains three files, the XIB file (XCode Interface Builder), a header file (.h) and a implementation file (.m). The main set-up of the controllers is done in the header file and linked to the design elements in the XIB file. The implementation file contains the majority of the coding and is made up of the various methods that make up the App's

model. The header file is then imported into the implementation file at runtime (build) so that only the implementation files are compiled. Compiling (or software build) is a term used to describe the process whereby source code is transformed into a programming language that may be ran as an executable program.

For example, a text label placed on the screen is called an 'IBOutlet – UILabel'. The 'outlet' means that it may receive the result from the model to display data back to the user thus: -

Header file (.h)	Implementation file (.m)
`{`	`{`
`IBOutlet UILabel *appLabel;`	`appLabel.text = @"Thank you for registering";`
`{`	`}`

1.7.6 Art

Another submission guideline is that the App must contain some custom artwork rather than using standard controls alone. Due to this, professional developers may defer the general design and livery to an external design agency that produce the customised buttons and interface elements that the App developer uses to replace the standard controls (Fig. 14) and to personalise the App. It is not essential that an external design agency is used as App developers may have had training or experience in design work and are competent at both. However, an external agency may be useful if time constraints do not permit the App developers to do this themselves. Large App design companies can also choose to keep the work in-house by employing their own graphical interface designers.

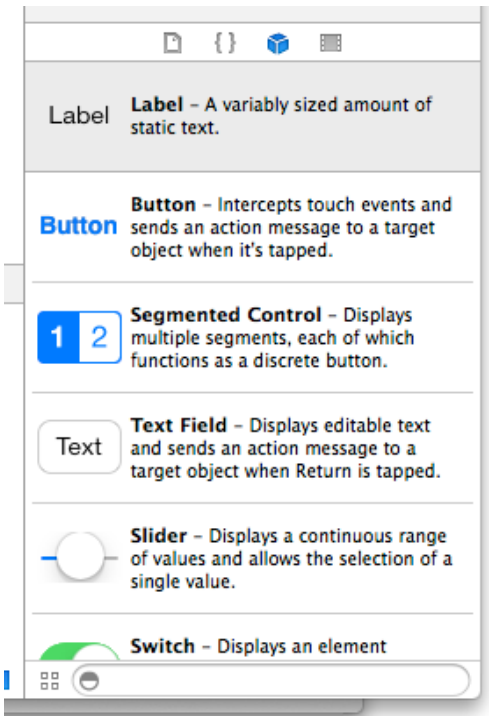


Figure 14: Standard Controls in XCode © Apple Inc 2013

1.7.7 iPhone simulator

Throughout the App development, it may be tested at any point on the 'iPhone / iPad Simulator' which is another component of the SDK.

The simulator is an on-screen software only version of the actual device that is being developed for and allows for testing and evaluation without the need for a physical device being connected, though this is also an option (Fig. 15 overleaf).

There are some restrictions, as users cannot interact using touch as it is running on a desktop or notebook computer rather than a touchscreen phone or tablet. At various stages through App development, the developer runs a 'Build' command, which compiles the implementation files into the final program that will be deployed on a device.

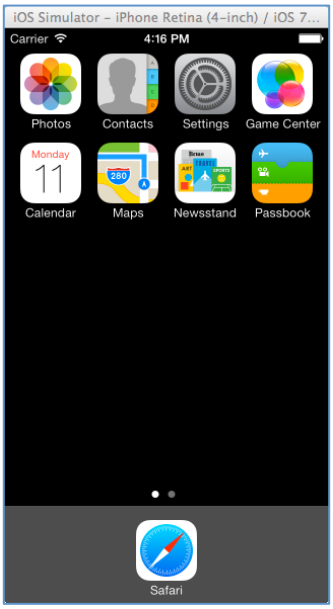


Figure 15: iPhone Simulator

Whilst running on the simulator or connected device, the SDK analyses the performance of the program; for example the amount of processor load that is required to run it and how much memory is being accessed at any particular point during its use. These then may be used to refine or enhance the program code to run more efficiently. The simulator also permits testing of the program on different versions of the iOS software and on different screen sizes. If a program is written only for the latest version of the operating system (iOS), this may limit its potential distribution, as some users may not have a device that is capable of upgrading. The way in which Apple allows users to upgrade their operating system over the Internet with such simplicity encourages a high rate of adoption compared with other operating system manufacturers. Version 7 of the iOS operating system was launched on 18th September 2013 and within 2 days; the number of users with it installed tipped the balance in its favour to 50.92%. On the first day of 2014, nearly 82% of iOS devices have version 7 of the software installed (Mixpanel Trends, 2014).

The simulator is an effective tool for development, however final testing should be carried out on a physical device/s to make sure that it correctly interprets touch commands as intended. Furthermore, there should be a team of people that test the App as the developer alone may only ever do one particular activity in one way whereas others may use it differently and expose a problem that may not have been evident to the developer. As of 2013, there are many different versions of the iPhone (3G 4, 4S, 5, 5C, 5S) and the screen size varies as seen in Table 3 and the App should be written to work on all.

Table 3: Screen sizes of iPhone's

Device	Screen size	Pixels across	Pixels down
iPhone 3G	3.5”	320	480
iPhone 4,4S	3.5”	640	960
iPhone 5, 5C, 5S	4”	640	1136

1.7.8 Deployment

Once the App has been thoroughly tested and profiled, it is submitted over the Internet to Apple who undertakes further quality and performance tests and to make sure that it meets all their design and acceptability requirements. If the App passes this stage, it is uploaded to the App Store and the developer is informed. Only at this point may end users access the App and install in onto their devices from anywhere in the world where the App is available.

1.7.9 Analytics

‘Flurry’ is a company that measures the use of Apps and devices worldwide and provides a barometer of engagement and the behaviour of mobile users. Some 400,000 Apps contain specific code that reports the use of the App to Flurry.

Despite being called 'mobile phones', very little of the time spent using one is taken by making or receiving calls. In a US study, the overwhelming majority is spent in Apps as seen in Fig. 16 below (Flurry, 2013). This generates an economy that was recently estimated by the Wall Street Journal to be worth $25 billion per year and one that did not exist until 2008.

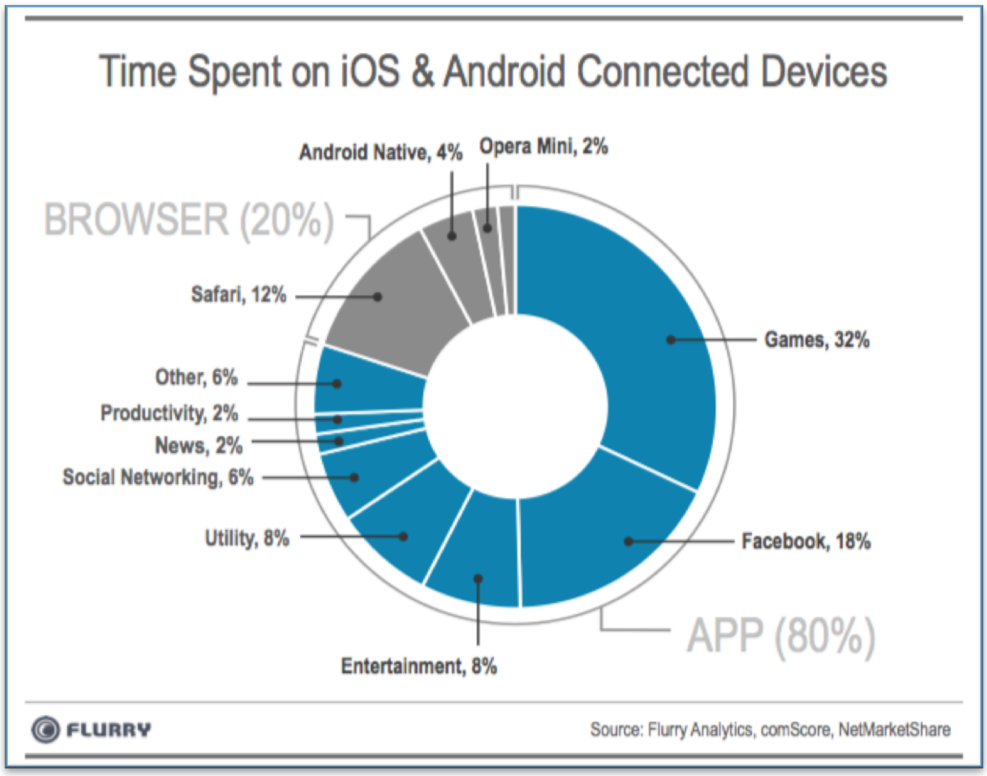


Figure 16: Time spent on iOS and Android Connected Devices © Flurry Analytics

This clearly shows that Apps are being used by the majority of users for the majority of their time; some 80% of the total time spent using the device. The average user will spend 2 hours and 38 minutes each day using their mobile devices, of which 2 hours and 7 minutes will be using Apps. The average user will use only 8 Apps per day but the Apps they use will vary depending on their lifestyle (Flurry, 2013). Some Apps are very short-lived and will be deleted very soon after installation but some will be used for much longer.

1.8 Project rationale and aims

The Universities and Colleges Admissions Service (UCAS) published the results of a survey of 'Freshers' in 2013 as part of an exercise to maximise their marketing (Universities and Colleges Admissions Service (UCAS) Media, 2013). The report, which surveyed students shortly before Christmas in 2012 summarised the following: -

- 82% of new students beginning university or college owned a smartphone and at least 20% owned a tablet.
- Of the 11,000 students surveyed, over 9000 distinctly identified ownership of a smartphone as opposed to a feature phone *(as defined in 1.61 & 1.62)*.
- The number of UCAS applicants that were able to receive content at any time rose by 122% in just 2 years (2010-2012). This suggests an always-on data connection such as 3G, Edge or GSM.
- 92% of applicants were Facebook users and 73% used Twitter.

The above report shows continuing growth in student ownership of Internet devices capable of displaying video allowed an opportunity to try to deliver an existing unit differently using a mobile device. Similar findings have also been reported (Chen and Denoyelles, 2013; The University of Sheffield, 2011; Ofcom, 2012).

MMU already has an App for students titled ‘MyMMU’ that is popular with students and is available on iOS, Android and Blackberry mobile platforms. Averages taken from a dataset of access between early September 2012 and early January 2014 showed that 78% used iOS devices, followed by 21% Android and 1% Blackberry (Appendix 1). Surprisingly, the number of users accessing ‘MyMMU’ via a mobile web browser averaged at 0%, which clearly shows that users prefer using a dedicated App and through an Apple device.

Apple Inc. provide developers with excellent programming and design tools, documentation and quality control systems that encourage and promote clear layout and implementation for users. It was for these reasons that iOS was decided on as the platform to develop for.

1.8.1 Project overview

In consideration of the previous factors, a piece of pedagogic action-research was designed to address the challenge of making best use of the laboratory and tutor while enabling multiple students to observe the fine detail of dental procedures. An intervention was therefore designed based on making videos of dental procedures available to students in advance of laboratory sessions in a format that would enable them to watch the videos on their mobile devices in the laboratory if required. The project was given a working title of ‘dentaltec – rpd-online’ which remained through production and publishing. (Abbreviated to ‘RPD Online’).

1.8.2 Project aim and objectives

The project aim was to measure the effectiveness of a bespoke mobile learning application in a laboratory-based, practical skills undergraduate unit.

The objectives to meet this aim were: -

- To record video and write material in order to develop short ‘lessons’ to mimic the construct of a typical laboratory session which is broken up into separate stages.
- Learn to code in Objective-C in order to develop a bespoke App on the iPhone (and web) to deliver the recorded on-demand lessons and supporting documentation.
- Deploy the App onto the Apple App Store for approval followed by implementation into a single laboratory practical unit for delivery in the autumn term to a cohort of level 5 undergraduate students (2nd year of BSc Hons in Dental Technology).
- Observe use and compare cohort data from previous years.
- Analyse download data from both the App Store and video requests made from within the developed App to gauge usage patterns.

2 METHOD

2.1 Hardware and software

A Macintosh desktop computer with a 27” display (Fig. 17) was used to install a copy of the Software Development Kit (SDK) provided by Apple (Apple Inc., Cupertino, US). This kit contains the main program XCode as seen in Fig.11 (p. 47) that was used to write the program code which was compiled to create the program (or executable) that could be ran on an iOS device. In order to deploy Apps on a physical device rather than using the iPhone Simulator, a developer account was set up through the MMU in-house ‘DigitalLabs’ that allowed devices to be added so that they would be permitted to install the Apps for testing and to drive an iterative process of refinement. Once the development environment was prepared, the objectives for the App were set which were to:

I. Allow the user to select a video resource (‘lesson’) on demand from a series of pre-populated lessons to accompany or prepare for their laboratory session.
II. In each lesson, present advice about Control of Substances Hazardous to Health (COSHH), recommended tools and risk assessments.
III. On demand, stream[8] a video media file from a remote media server in full-screen mode with on-screen scrubbing[9] controls.

[8] To ‘stream’ a video file means to receive and present it whilst being delivered by a provider (rather than first downloading it)
[9] Scrubbing is the process of moving a video (or audio) file to a particular section through the use of buttons or slider controls that may be either physical (hardware) or virtual (software).

The author already owned an iPhone 4 that was used to test the App during development. This was connected to the computer via a universal serial bus port (USB) through the use of a standard 30-pin charging and transfer cable (Apple Inc., Cupertino, US).

Figure 17: iMac 27" desktop computer

Figure 18: Sony HXR-MCP1 HD compact movie camera

Figure 19: Manfroto 'Magic Arm' swing-arm desk camera mount

Figure 20: Memory card used to capture video footage

For the recording of the lesson videos, a Sony HXR-MC1P High Definition video camera (Fig. 18), mounted on a swing-arm desk mount (Fig. 19) (‘Magic Arm’, Manfroto Ltd, Ashby–de-la-Zouch, UK) was used in a dental laboratory to record video footage onto an 8 Gb Sony MemoryStick® Pro-HG Duo memory card (Fig. 20). This footage was then imported into the computer and edited using iMovie ‘11 (Apple Inc., Cupertino, US) before being exported and uploaded to a video streaming service for access on-demand. For video

sequences that could not be recorded at the demonstration bench, a portable movie camera was used (‘Flip Ultra HD’, Flipvideo, UK).

The arrangement of equipment used for recording of the laboratory bench-based demonstrations is shown below in Figure 21.

Figure 21: Recording set-up

2.2 Video streaming service

In the early stages of development, a video hosting and streaming service was sought. A design decision was made to stream the video to minimise the installation footprint on the device and to save storage space. This meant that the device would require a constant connection to the Internet over cellular or Wi-Fi to request and transfer the video file to the device. To satisfy the Apple App Submission Guidelines (Kahney, 2010), additional program coding was added to inform the user if an open connection to the internet was not available which would then programmatically limit the functionality of the App until a connection had been detected or restored.

At the time of development, MMU was running an Apple Podcast Server that was nearing the end of its usable capability and was not configured to handle modern streaming video standards. Even though a connection was established in early trials, the server could only allow the file to be first downloaded in full, which detracted from the user experience due to waiting time. YouTube™ was also trialled without success, as a direct path[10] to the video file could not be provided. At the time the App was scheduled for launch, the university (MMU) was investigating potential providers for an integrated streaming video service but this was still approximately a year away, necessitating the need to seek a third-party external provider. A video streaming service was found that satisfied the requirements of the App and a monthly hosting package was purchased (vzaar.com, London, UK) that permitted up to 100 Gb of data transfer each

[10] A file 'path' is the absolute reference to a specific location in a file system on a computer. (eg: C://Windows/System32/mouse.exe)

month and an unlimited number of video uploads. This was considered sufficient to meet the anticipated demands of the App during the autumn term.

2.3 App layout and design

The design philosophy was to present a simple to navigate series of lessons that were arranged in a logical sequence that was presented immediately after the App had been launched on the device. Before this view is shown and whilst the program is being loaded into memory, a loading or 'splash' screen is presented to confirm to the user that the App tile icon had been tapped and the program had been requested (Fig.22). The entire program code is listed in Appendix 5.

Figure 22: Launch 'splash' screen

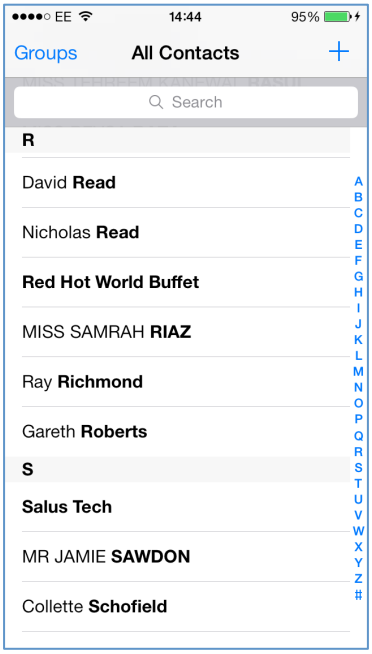


Figure 23: iPhone default contacts UITableView controller

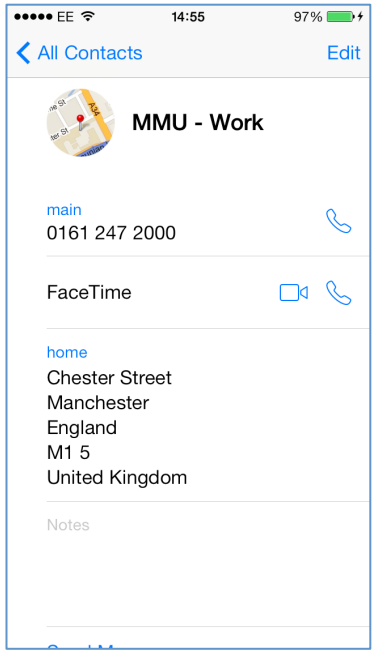


Figure 24: iPhone default contacts DetailView controller

Once launched, the App presents a list of lessons using a design element known as a 'UITableView Controller' which is already familiar to iPhone users as it is the default way of presenting a long series of records and is also used in

the embedded ‘Contacts’ App where each record in the table is selectable and when selected, opens up a detail view controller (Figs. 23 & 24).

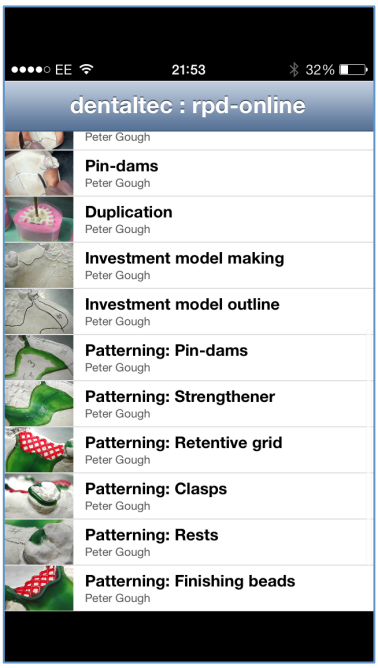


Figure 25: RPD Online TableView controller

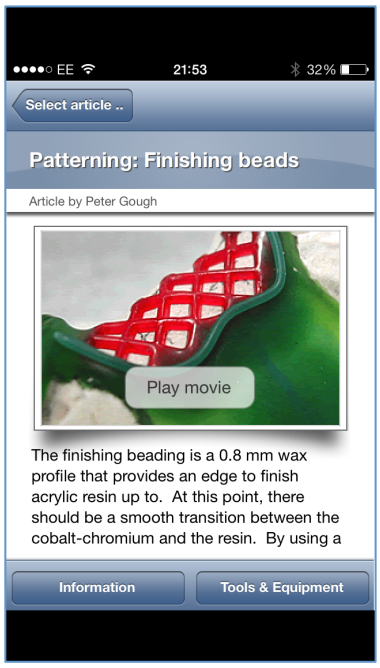


Figure 26: RPD Online DetailView controller

Similarly, the RPD Online App used a list of lessons that the user could swipe through until they had located it in the list (Fig. 25). When a particular row or table cell is tapped, the table view slides across to reveal a detail view based on the selection (Fig. 26).

2.3.1 Detail view controller

The detail view was designed to brief the user on the lesson they had selected as a confirmation they had made the correct choice from the table view. It contained a photograph representing the lesson content that also offered a ‘Play movie’ button. When this button was tapped, the App sent a request to the

remote media server, which then initiated a data transfer back to the device over Wi-Fi or cellular to deliver the requested movie file.

Figure 27: Movie player with software controls

This streaming movie file allowed the user to begin viewing immediately whilst it continued to load into memory in the background. The movie player view (Fig. 27) allows the user to scrub through the video using the top slider control, volume adjustment slider on the lower left and forward, backward, play/pause controls. If the user rotated the device into landscape mode then the built-in accelerometer would detect the movement and inform the App program to flip the video so that it played in full screen view.

Further view controllers were added as links from the detail view controller, which provided an 'Information' view which was a text file that the user could swipe through (scroll) using touch gestures. This view also linked to views

containing specific information relating to COSHH, suggested tools to use and risk assessments per activity.

2.3.2 User registration

In order to poll users about the App, a link was offered to allow them to enter their email address which was then written to an external database table. It was initially planned to only allow users access to the core functionality of the App after email registration but the Apple App Store Submission Guidelines state: -

> *17. Privacy*
> *17.2 Apps that require users to share personal information, such as an email address and date of birth, in order to function will be rejected.*

Consequently, the registration view was modified to give the option for users to opt-out whilst still retaining full functionality of the App. The following flowchart shows the final App hierarchy to show which views linked to each other. For example, if viewing the COSHH screen, three taps of the 'Back' button would return the user to the list view (Fig. 28).

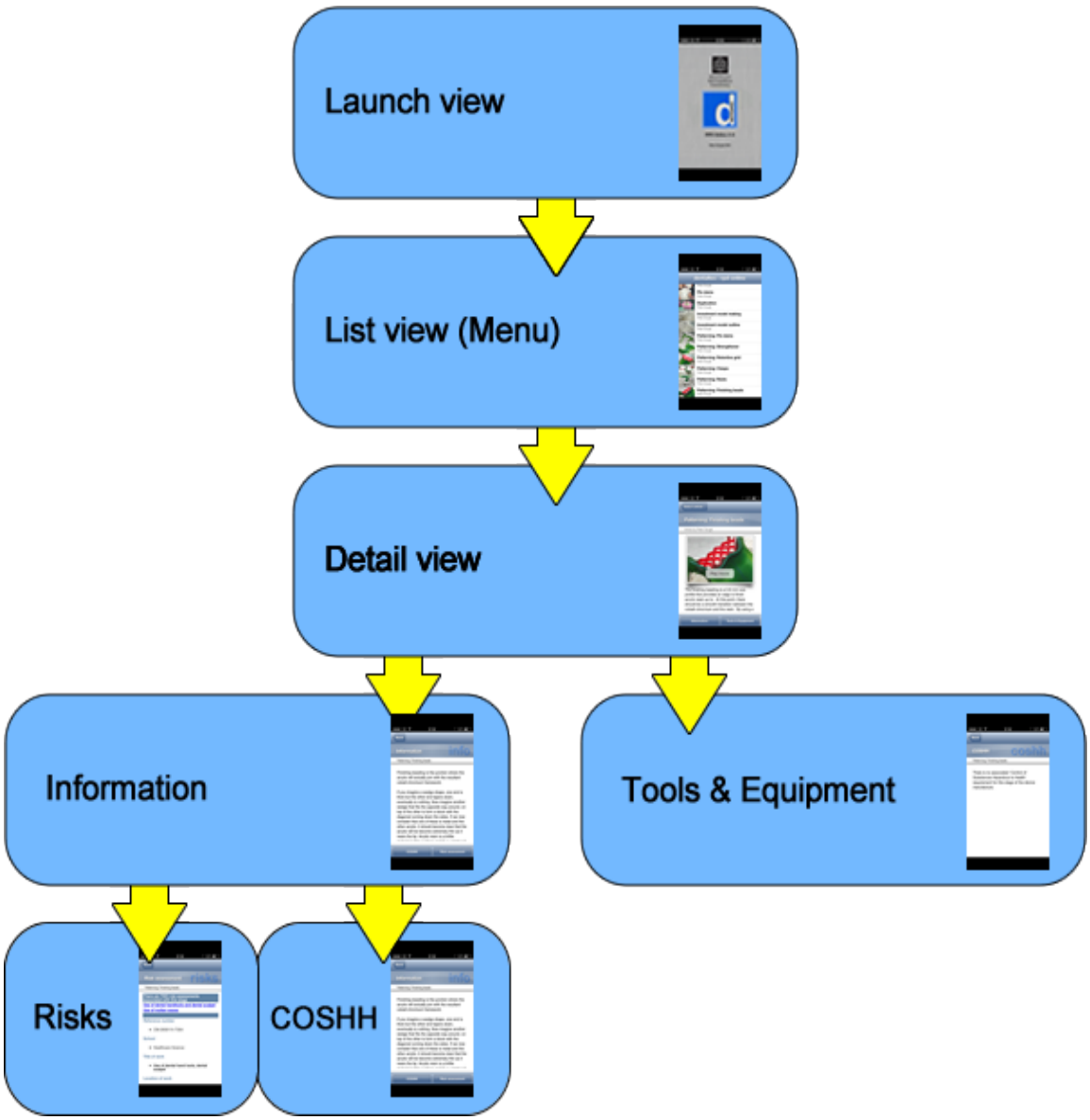


Figure 28: RPD Online view hierarchy

2.4 Lessons

20 lessons were written, recorded and edited and the data was written to a database hosted on a remote server for access by the App. The lessons were divided into five distinct sections representing different activities by theme. The numbers of videos in each section are shown in parentheses.

- Introductory (2)
- Surveying (4)
- Model preparation (4)
- Duplication (3)
- Patterning (7)

2.5 SQLite database integration

Rather than have a series of separate static pages that would be loaded into the App on request, it was designed so that all the information pertaining to each lesson was stored within an SQLite embedded database (Fig. 29) (Hwaci, Charlotte NC, US) that resided on the device within the program code. This is different to a MySQL server-side database, which is operated remotely from the application and queried from a client-side piece of program code on a webpage, application or mobile App.

SQLite Database Browser – /Users/petergough/Desktop/workingData/4GB PEN DRIVE/newDental.sqlite

Database Structure | Browse Data | Execute SQL

Table: Article

New Record | Delete Record

	ID	Title	Aul	Introduction	Di	Image	furtherInfo	videoURL	Coshh	Tools	Safety
1	1	Introduction	1	This video will	1	introPic	This case is for	http://view.vza	There is no	No tools a	noRisks
2	2	Design outline	1	This stage tran:	1	designOutline	Every compone	http://view.vza	There is no	A propellir	noRisks
3	3	Cast surveyor a	1	The cast survey	1	castSurveyor	Dental cast sur	http://view.vza	There is no	Surveyor :-	noRisks
4	4	Selecting a path	1	The term 'path	1	surveyPic	The path of ins	http://view.vza	There is no	Surveyor	noRisks
5	5	Survey lines & u	1	This stage reco	1	claspProfile	Once the path c	http://view.vza	There is no	Surveyor	noRisks
6	6	Measuring clasp	1	Only the final tl	1	measure	Testing 4.5.6	http://view.vza	There is no		noRisks
7	7	Blocking out un	1	In order for the	1	blockingOut		http://view.vza	There is no		moltenSoften
8	8	Waxing clasp le	1	Pencil lines anc	1	waxLedge		http://view.vza	There is no		moltenSoften
9	9	Spacing wax	1	In large edentul	1	spacerWax		http://view.vza	There is no		moltenSoften
10	10	Pin-dams	1	Pin-dams are s	1	pinDams	Pin-dams are s	http://view.vza	There is no	Le-Cron	eyeProtection
11	11	Duplication	1	The prepared m	1	duplicate			There is no		
12	12	Investment moc	1	Investment mat	1	investmentMod			Investment		
13	13	Investment moc	1	The original de:	1	pencilOutline	The original de:		There is no	A sharp pr	noRisks
14	14	Waxing: Pin dan	1	Wax patterning	1	waxingPinDams			There is no		moltenSoften
15	15	Waxing: Strengt	1	A shallow 'D' sh	1	waxingStrength			There is no		moltenSoften
16	16	Waxing: Retenti	1	Where edentulo	1	waxingRetentiv			There is no		moltenSoften
17	17	Waxing: Clasps	1	Clasps (direct r	1	waxingClasps			There is no		moltenSoften
18	18	Waxing: Rests	1	Occlusal rests l	1	waxingRests			There is no		moltenSoften
19	19	Waxing: Beading	1	The beading is	1	waxingBeading			There is no		moltenSoften
20	20	Waxing: Stipple	1	The final stage	1	waxingStippled		http://www.you	There is no		moltenSoften

< 1 - 20 of 20 >

Go to: 0

Figure 29: Early development version of the SQLite database table used in RPD Online

In the App, each cell in the table view controller contained a unique hidden identifier that was sent as a request to the database to retrieve the data for a specific record within in. The database server queried its contents and returned a string of data back to the App which then was then parsed[11] to separate it into it's native fields for use in the different placeholders and views that would be populated by them.

[11] Parsing is a procedure carried out by a computer program that is provided with a string or series of data, which is then broken down into sections (tokens) based on supplied delimiters.

2.6 Video duration

Modern mobile devices are powerful and fast connection speeds are cheap and widely available. The duration of a video depends on the target audience according to a blog article in 2012 (S. Jones, 2012). The article suggests that the viewer experience should be the first consideration when providing video content and that “longer videos are ideal for infotainment products, instructional video or product launches”.

When planning the structure of the lessons for the App, it was decided to break the source (video) material into small sections, following recommendation from BBC Active which suggested ten ways to use educational video effectively (BBC Active, 2010). The article summarises that conducted research showed that the average attention span (of a learner) lasts between 7 and 15 minutes and recommends that the video is delivered in ‘short-bursts’ rather than showing a single long video (Marchionini, 2003). The BBC Active article further advises to “make students work while they watch”. This was, from conception to be the aim for the App; to be used before and after the laboratory sessions but principally for use during the session to complement the practical exercises that students were to carry out. The average duration of the 20 videos in the App was 6 minutes and 5 seconds. The shortest duration was 3 minutes 12 seconds and the longest duration was 13 minutes and 50 seconds.

2.7 Refinement

2.7.1 Text size refinement

As the App approached completion, it was deployed on the device of a project supervisor so that it could be tested for stability in real world settings such as on the move and in areas where Wi-Fi was not readily available. Here, the App relied on a cellular connection and no problems were reported with the connection to the media server or the streaming data that was served from it. However, one particular feature of the App did become very noticeable when using on the mobile device and that was text size. When developing the App, the iPhone simulator was used on the computer screen and was roughly twice the size of the actual device. This made the App appear very clear and legible. Although this was only a matter of changing a few lines of code, it was a very important stage and underlined the importance of testing and profiling on a physical mobile device prior to publishing.

2.7.2 Video dimension refinement

All the videos recorded using the system shown in Figure 21 were recorded in full frame high definition at 1920 * 1080 pixels resolution. Early playback testing at these resolutions resulted in poor performance and on the web version in particular (see 2.10) the amount of pre-fetch time taken to load the video was considered excessive. Having the screen so close to a user (as in the case when holding a mobile device), meant that a lower resolution file could be afforded which, with little loss of clarity performed much better and streamed more reliably. A final resolution of 640 * 360 pixels was finalised and all videos were encoded at this resolution and uploaded to the video host.

2.8 Branding and icon

One very important element of an App is the icon tile that identifies it on the device screen and is the first experience users will have with it and can be a factor in a users overall perception (Gatsou et al., 2012). The study by Gatsou et al surveyed 60 participants of various backgrounds to find out how easily recognisable App icons were and found that only 54% of those could recognise two thirds of presented icons. This is because there are no international standards on icon design for use in mobile interfaces, unlike, for example, the symbol of the Red Cross, which is universally recognised around the world. An App icon does not have to suggest what the App does, but should be designed to be easily recognisable and non-complicated. The RPD Online App opted for a simple letter 'd' for 'dentaltec' as seen in Fig. 30 so that it could be easily noticed in a screen of other icons. As the App would also run on the iPad, different sizes of the icon needed to be made. This was also necessary for use on devices with different screen resolutions. The icon for a standard resolution such as the iPhone 3G is 57 x 57 pixels whereas the same icon for a 'retina'[12] screen for all devices from iPhone 4 onwards requires a 114 x 114 pixel icon. Also, another larger icon was required for the App Store listing.

[12] 'Retina' in this context relates to an Apple naming specification of screen resolution based on a pixel density of 326 pixels per inch. The human retina cannot determine the edges of pixels above 300, making for a clearer display.

Figure 30: The RPD Online App icon

2.9 Submission

After extensive testing and profiling of the App (where memory load, memory leaks, processor demand and bandwidth are measured), the App was packaged for upload to the App Store. The submission was made through the Apple Developer website (iTunes Connect), together with other information that is required: -

- Screenshots to show potential users what the app looks like
- Key words (for searching on the App Store)
- A description of what the app does
- Developer and publishing information
- A link to developer website*
- Different sizes of the Application icon

Following submission, the App was profiled and tested by Apple before being successfully accepted and uploaded to the App Store.

*The domain name 'rpd-online.co.uk' was purchased and a website was created to host a page that was linked to from the App Store.

2.10 Web version

Not all students had an iPhone and it was considered a disadvantage to only allow access to those who did. As a website domain (rpd-online.co.uk) had already been purchased to host the App Store link page, a copy of the App database was created using MySQL and was added to the domain host to enable it to be hosted remotely. A series of web pages were produced that contained pre-hypertext (PHP) scripts that queried the database in the same way as the App. The returned data was parsed and used to populate the web pages to present the same data to all users who did not have an iPhone / iPod Touch / iPad.

As the web pages used modern web standards (HTML5), the web version of the App worked perfectly with any known web browser on mobile phones, tablets, laptops and desktops. Even though the web version contained the same functionality and data, the interface was not as streamlined as the iOS App and it was not as easy to navigate. For example, the web version required the user to scroll-up and down to reach different parts (e.g. tools, COSHH) whereas these areas could be reached from one screen through the use of on-screen buttons in the App version.

2.11 Collected data and software metrics

For each tap of a video icon in the App, a request was sent to the video hosting company (Vzaar.com) to serve the video in M4V[13] format to the device. As M4V is a modern web standard, it is recognised and is therefore playable on the vast majority of modern digital media players on fixed or mobile devices. Each video on the server contained the following parameters:

1. Video ID (7 digit code)
2. Video title (e.g. 'claspsDirectRetainers')
3. Video dimensions in pixels (X & Y, e.g. 640 x 360)
4. Video duration in seconds (e.g. 197 s = 3 m 17 s)
5. Number of plays
6. Bandwidth (the total amount of data in bytes transferred)

The first four items in the above list are fixed. Each video request was logged and recorded by Vzaar.com and items 5 and 6 were updated and recorded on the database. It follows that the number of plays was directly proportional to the bandwidth.

2.12 Implementation

All level 5 students were informed of the App at the beginning of the Autumn Term and were encouraged to install and familiarise themselves with its interface. Students without an iOS device such as a Blackberry, Android or

[13] The M4V file format is a video container developed by Apple Inc. based on the MP4 format but with optional digital rights management (DRM) copy protection.

Windows device were provided with a URL to enter into their mobile web browser that allowed them to use the web version. Students who had a netbook or laptop as opposed to a mobile phone were also directed to the web version. The App was advertised on the unit area within the institutional VLE, Moodle (Moodle Pty Ltd, Perth, Australia) and was promoted before the start of the laboratory sessions for the first month.

The level 5 unit that used the App featured 64 students in four laboratory groups that were operated in blocks of six weeks, week beginning 24th September 2012. The teaching plan is shown in Tables 4 and 5 below. The numbers in each shaded cell correlate with the aims of the sessions shown in Table 6. The full teaching plan is shown in Appendix 4.

Table 4: Structure of unit in Autumn Term

Lab group	**24/09/12**	**01/10/12**	**08/10/12**	**15/10/12**	**22/10/12**	**29/10/12**	**05/11/12**	**12/11/12**	**19/11/12**	**26/11/12**	**03/12/12**	**10/12/12**
1/3	1	2	3	4	5	6						
2/4							1	2	3	4	5	6

Table 5: Structure of unit in Spring Term

Lab group	**07/01/13**	**14/01/13**	**21/01/13**	**28/01/13**	**04/02/13**	**11/02/13**	**18/02/13**	**25/02/13**	**04/03/13**	**11/03/13**	**18/03/13**
1/3	7	8	9	10	11	12					
2/4							7	8	9	10	11

Table 6: Structure of teaching aims by week

Week	Teaching aims	Section
1	Introduction Cast surveying Design sketching	Introductory Surveying
2	Cast surveying Model preparation	Surveying Model preparation
3	Surveying completion Duplication of cast into investment	Surveying Model preparation Duplication
4	Wax patterning (Pattern 1 – Stage 1)	Patterning
5	Wax patterning (Pattern 1 – Stage 2)	Patterning
6	Wax patterning (Pattern 2 – Stage 1)	Patterning
7	Wax patterning (Pattern 2 – Stage 2)	Patterning
8	Spruing and investing	*The App was not designed to cover these activities*
9	Devesting and de-spruing / coarse trimming	
10	Trimming / Electrobrightening	
11	Smoothing / Polishing	
12	Smoothing / Polishing / presentation	

In the 2011-12 and 2012-13 academic years, the level 5 practical laboratory unit structure was as seen in Table 7. The items relating to the use of the App are shown in bold

Table 7: Unit structure 2011-12 & 2012-13

Unit code and assessment breakdown	Credits	Topics	Assessment contribution (CW=Coursework EX = Exam)
6ADT5305 (100% Coursework)	20	Fixed prosthodontics **Removable prosthodontics** Orthodontics Complete removable prosthodontics	25% CW **25% CW** 25% CW 25% CW
6ADT5306 (40% Coursework, 60% examination)	20	Fixed prosthodontics Removable prosthodontics Orthodontics Complete removable prosthodontics	10% CW 15% EX 10% CW 15% EX 10% CW 15% EX 10% CW 15% EX
6H5Z1022 (40% Coursework, 60% examination)	30	Fixed prosthodontics **Removable prosthodontics** * Orthodontics Complete removable prosthodontics ** (The wax pattern contributed up to 4% of the 10% coursework mark)*	10% CW 15% EX **10% CW** 15% EX 10% CW 15% EX 10% CW 15% EX

3. RESULTS

3.1 Number of video plays

When a video stream was requested, the video hosting company logged this request and the amount of data that was transferred to the client-side device while the video was being used, based on the duration of the video. The App consisted of 20 lessons in 5 distinct sections that were accessed between September 2012 and August 2013. The total time that data was transmitted over 12 months was 38 days (910 hours, 49 minutes and 47 seconds) and is shown broken down by section in Figure 31. The primary vertical axis shows the number of video plays and the secondary vertical axis shows the total time in hours that the videos in that section totalled over 12 months.

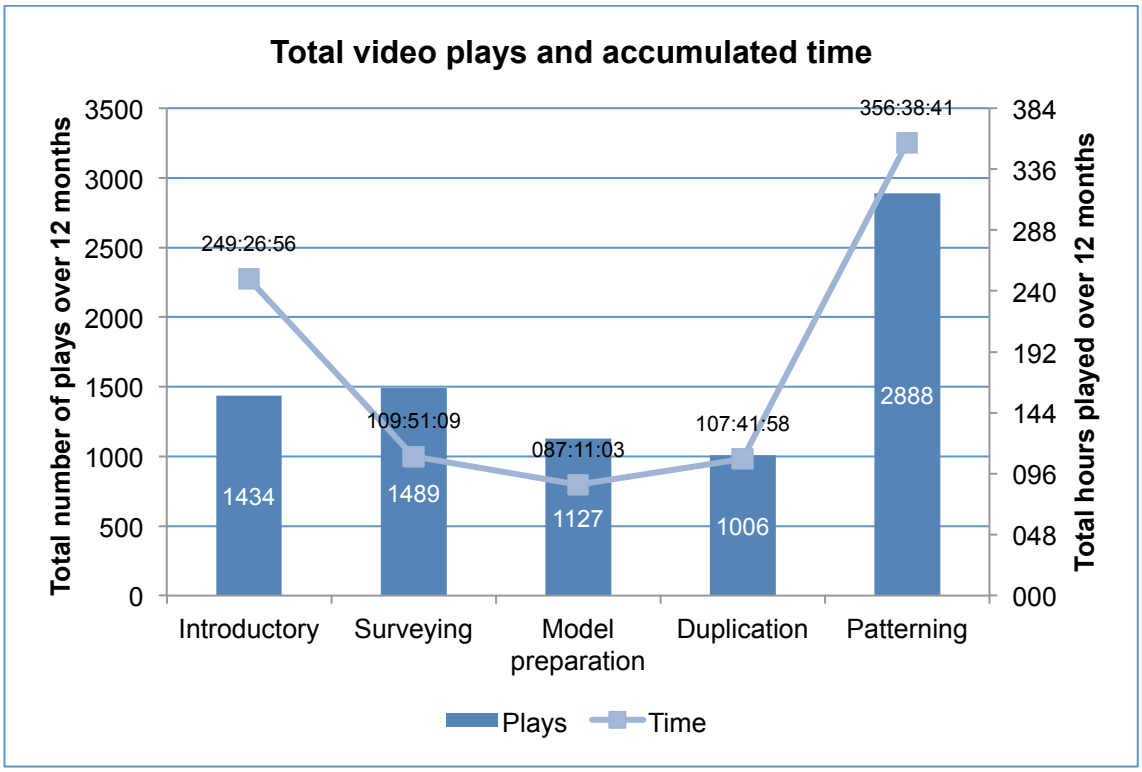


Figure 31: Total number of plays and accumulated time over 12 months

When the number of video plays is divided by the number of videos in each section, the average results are seen in Figure 32 where the primary vertical axis shows the total number of plays and the secondary vertical axis shows the number of videos in each section.

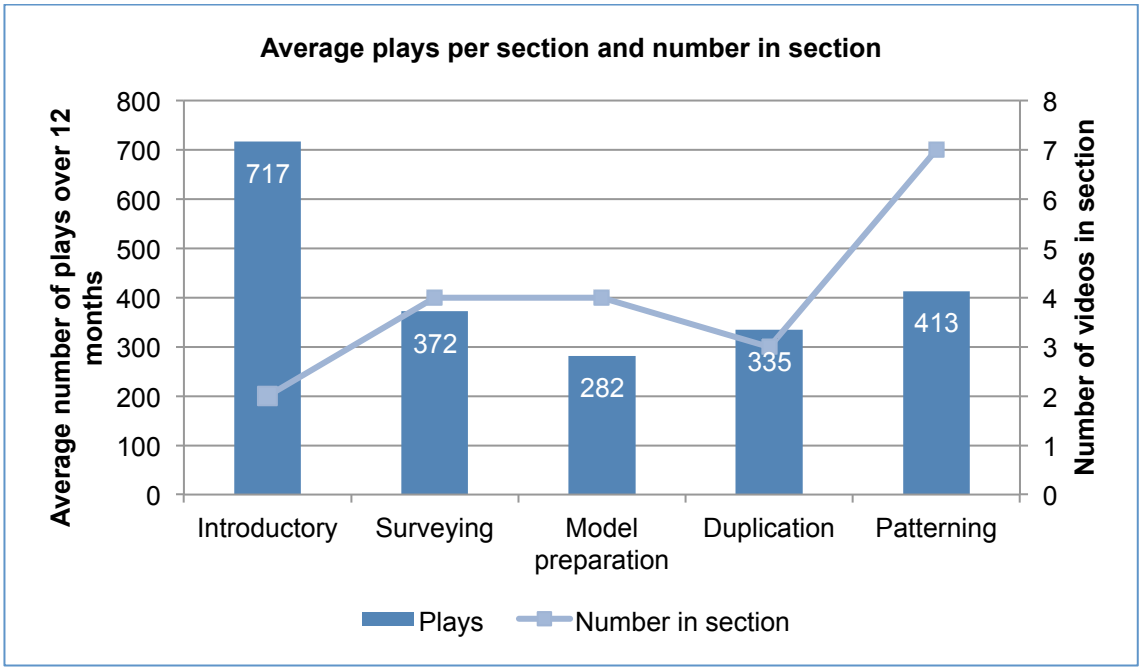


Figure 32: Number of videos requested divided by number in section

When the distribution of video requests over the 12-month period is proportioned, the breakdown by section is shown in Figure 33.

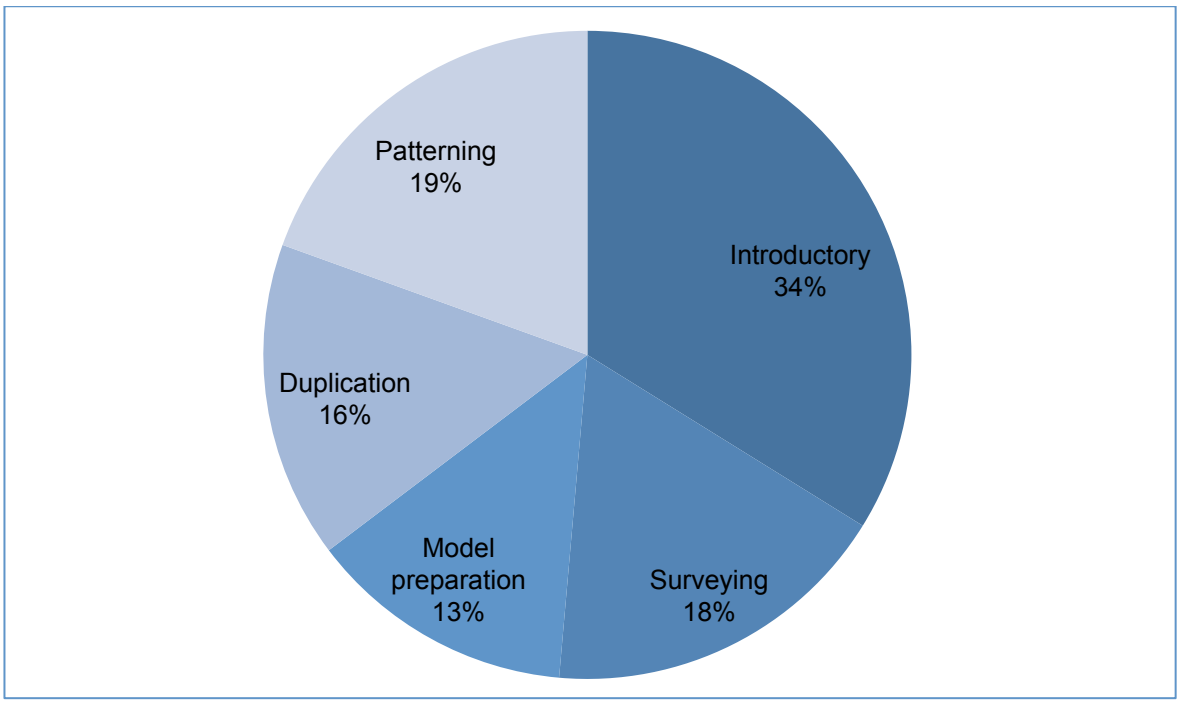


Figure 33: Distribution of video plays over 12 months

Figure 34 shows the number of plays for each video on the primary vertical axis and the duration in seconds on the secondary vertical axis, arranged by ascending number of plays to ascertain whether video duration was a factor in popularity.

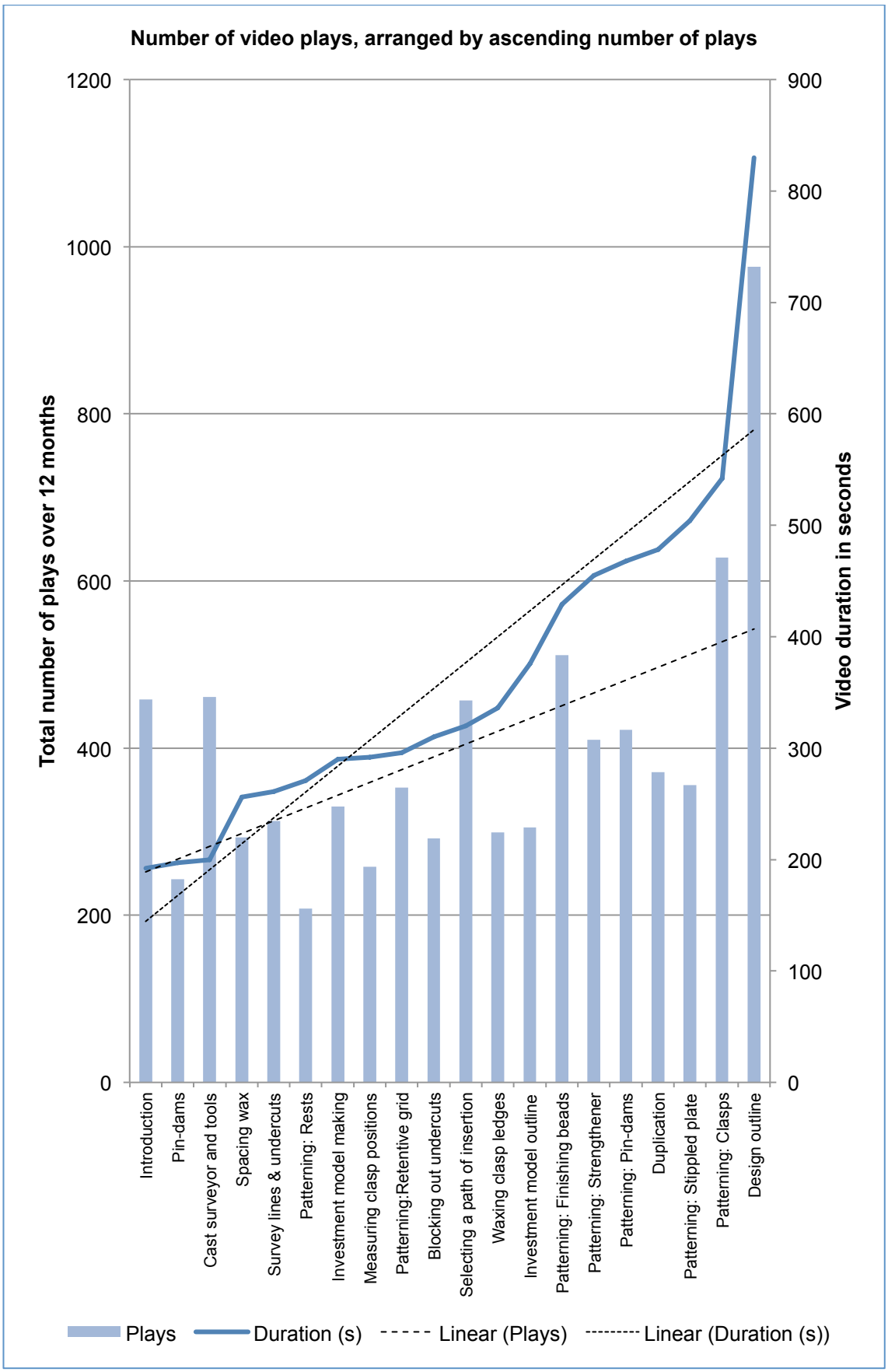


Figure 34: Number of video plays, arranged by ascending number of plays

3.2 *Internal student survey data*

Data from five previous internal student surveys (ISS) were collated and the results are shown in Figure 35. The bar chart shows the unit rating out of 5, measured against the secondary vertical axis. The upper plot shows the unit satisfaction rating as a percentage as indicated against the primary vertical axis. Student satisfaction, shown on the upper plot, is measured by the number of students who responded with a unit rating of either 4 ('Agree') or 5 ('`Definitely agree') divided by the total number of respondents. The unit rating is the mean of student responses who rated each unit on a 5 point scale where 5 is the highest.

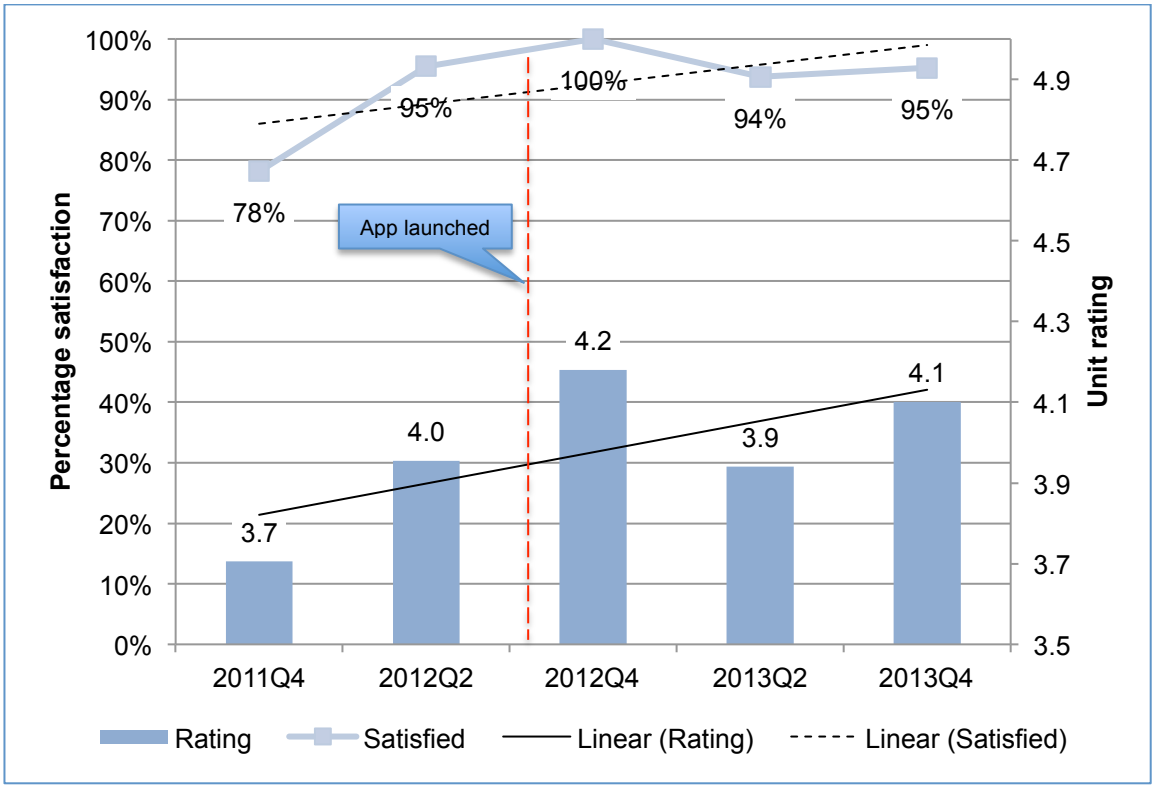


Figure 35: Comparison of unit satisfaction and rating before and after App implementation

3.3 *Internal student survey comments*

ISS also polls opinion on certain aspects of a unit and its delivery. One such question is 'Best things about this unit'. Students on the 6H5Z1022 unit

submitted the following comments relating to the App as seen in Table 8. Only the comments pertaining to the technology used and the App have been listed.

Table 8: ISS Student comments

Date	Student comments (Question: Best things about this unit ?)
ISS Q4 2012	The mobile application created by Peter Gough, which is extremely helpful and gives a step by step guide on what we need to do in visual form, whenever we want. This enables us to work at our own pace and not waste time waiting in line to ask questions.
	Pete's RPD app with the video is really helpful in his practical session.
	I would like to include that the cam set ups in each laboratory have been very useful source of learning. (thanks Pete)
ISS Q4 2013	Peter provided us with a very helpful app which related to the work we were producing which allowed us to refer back to it in our own time.
	pete goughs app

3.4 Unit results comparison

The removable partial prosthodontics coursework component amounted to 10% of practical unit 6H5Z1022, which consisted of two pieces of summative coursework; a wax pattern that accounted for 40% and a completed cobalt-chromium framework that accounted for the remaining 60%. The students completed the wax pattern independently without any direct staff intervention in year 2011-12 and without the RPD Online App. In 2012-13, the same piece was again completed independently without any direct staff intervention but with the support of the RPD Online App and web version for non-iOS users. The comparison of the two cohorts for the independently produced wax pattern is shown in the form of a bar chart in Figure 36.

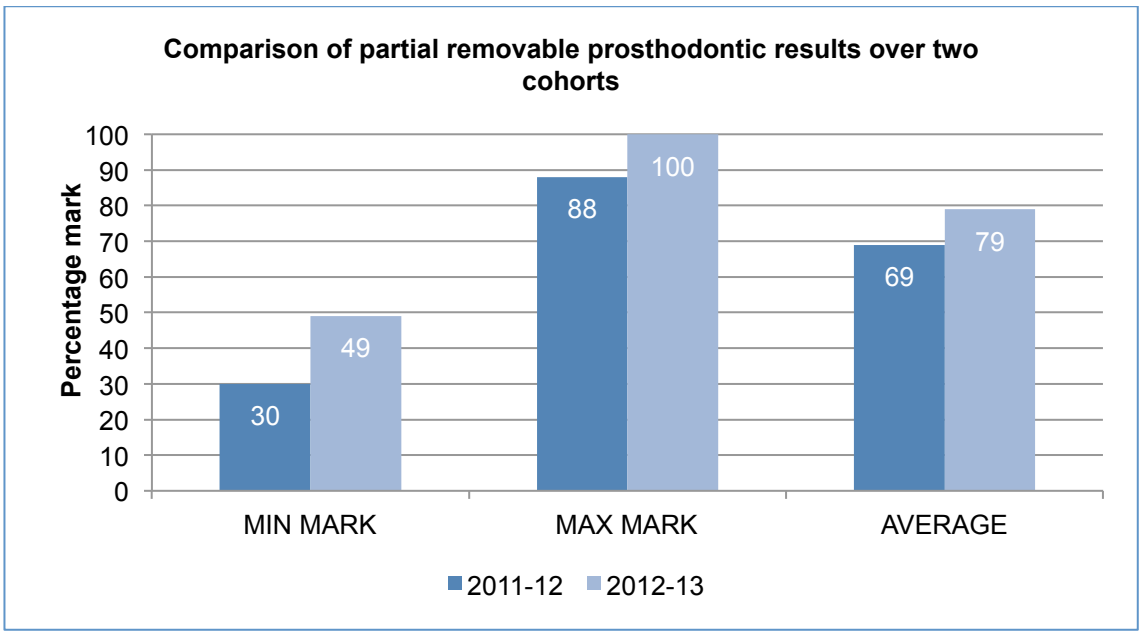


Figure 36: Comparison of 40% wax pattern coursework in 2011-12 and 2012-13

In addition to removable partial dentures (RPD), the unit examined in this study also featured work in fixed prosthodontics, orthodontics and complete prosthodontics [‘Other’]. The average marks for each of these data are compared over two years and the results are shown in Figure 37.

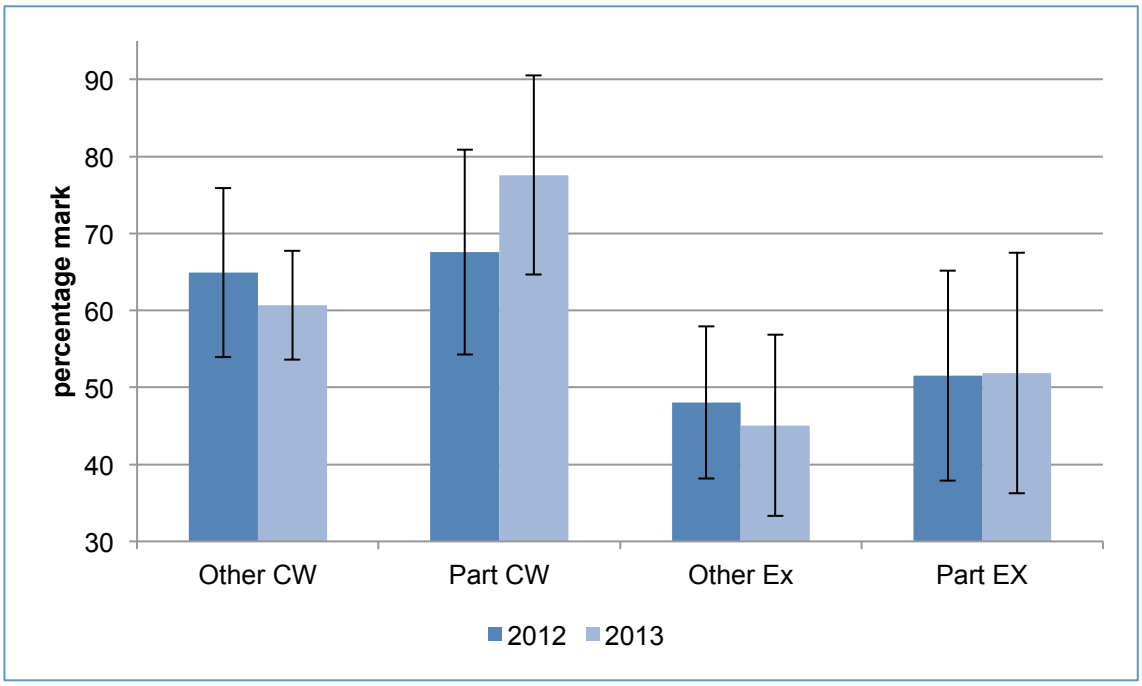


Figure 37: Comparison or coursework and exam performance over two years including standard deviation

Table 9, the analysis of cohort performance shows a highly significant statistical difference (P = 0.0001) in performance of students in partial denture coursework, although there was an overall weaker performance of the cohort in 2012-13. However, for partial dentures, there was only a negligible performance difference from 2011-12 in the practical examination. In the other unit topics, the 2012-13 cohort performance was slightly lower in both examinations and coursework. However, there was no significant statistical difference between the cohorts. The raw data is shown in Appendix 6.

Table 9: Statistical analysis of 2011-12 and 2012-13 cohort data

	Par Pr CW		**Pr Ex Part**		**Partial CW**		**Pr Ex Other**	
	2012	*2013*	2012	2013	2012	2013	2012	2013
Mean	67.58	77.59	51.51	51.86	67.58	70.72	48.07	45.06
Observations	57	59	57	59	57	59	57	59
df	113		113		113		112	
P(T<=t) two-tail	**0.0001**		**0.90**		**0.20**		**0.13**	

3.5 App installations (downloads)

Apple provides developers with access to App metrics to gauge sales (even if they are 'sold' as free). Figure 37 shows the number of downloads by territory (total n = 613) of the RPD Online App onto an iOS device between launch on 10th September 2012 and 31st August 2013. Figure 38 shows an approximate indication of downloads by country where darker colours represent a greater number of downloads for that country. Light grey represents zero downloads for that country.

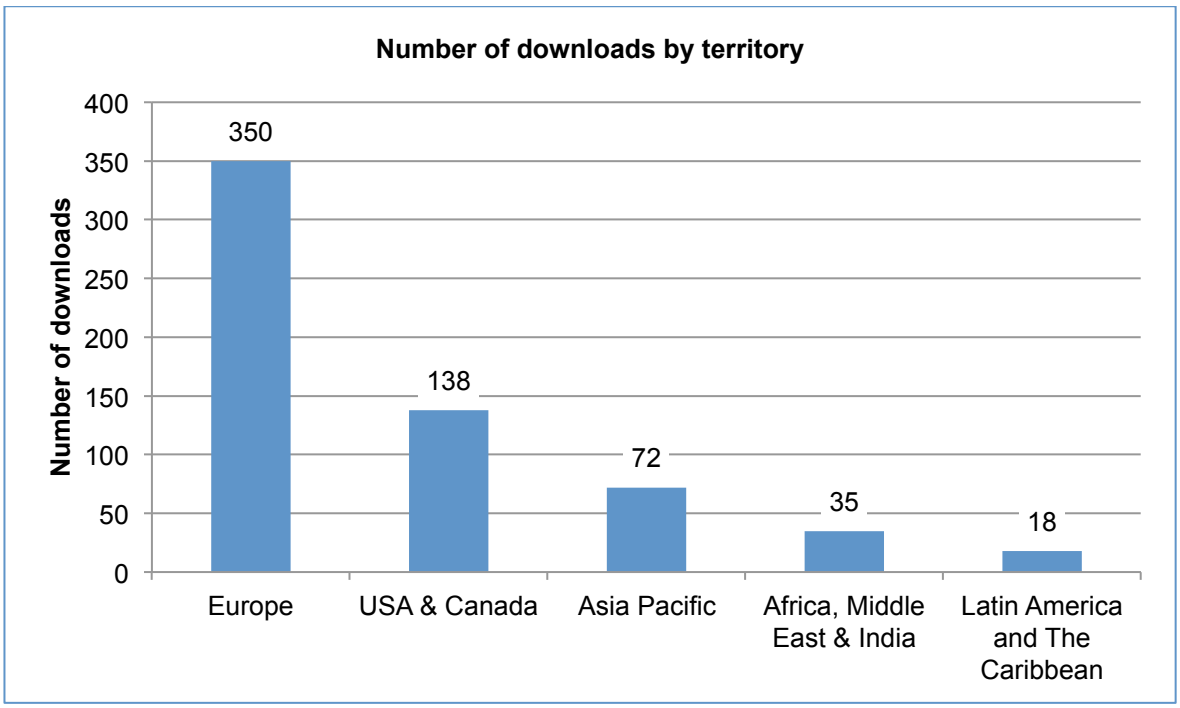


Figure 38: Total number of App downloads by territory (n = 613)

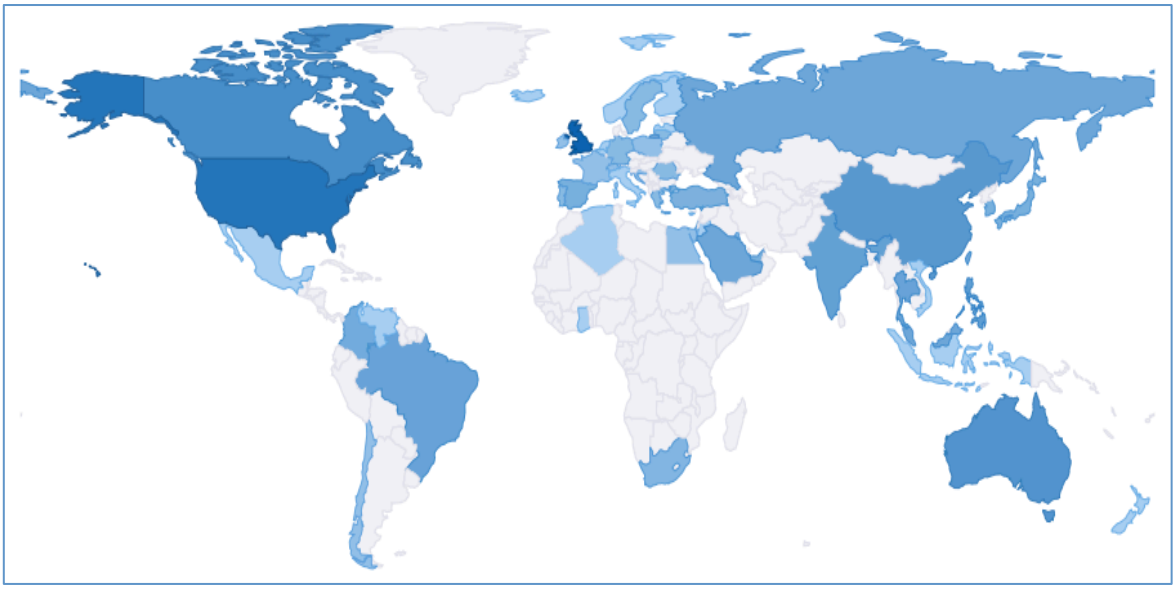


Figure 39: RPD Online App downloads by country

When the number of installations by device is broken down, the share is seen in Figure 39. Desktop installations are those where the user has installed the application via the iTunes software on their computer rather than 'over-the-air' using Wi-Fi.

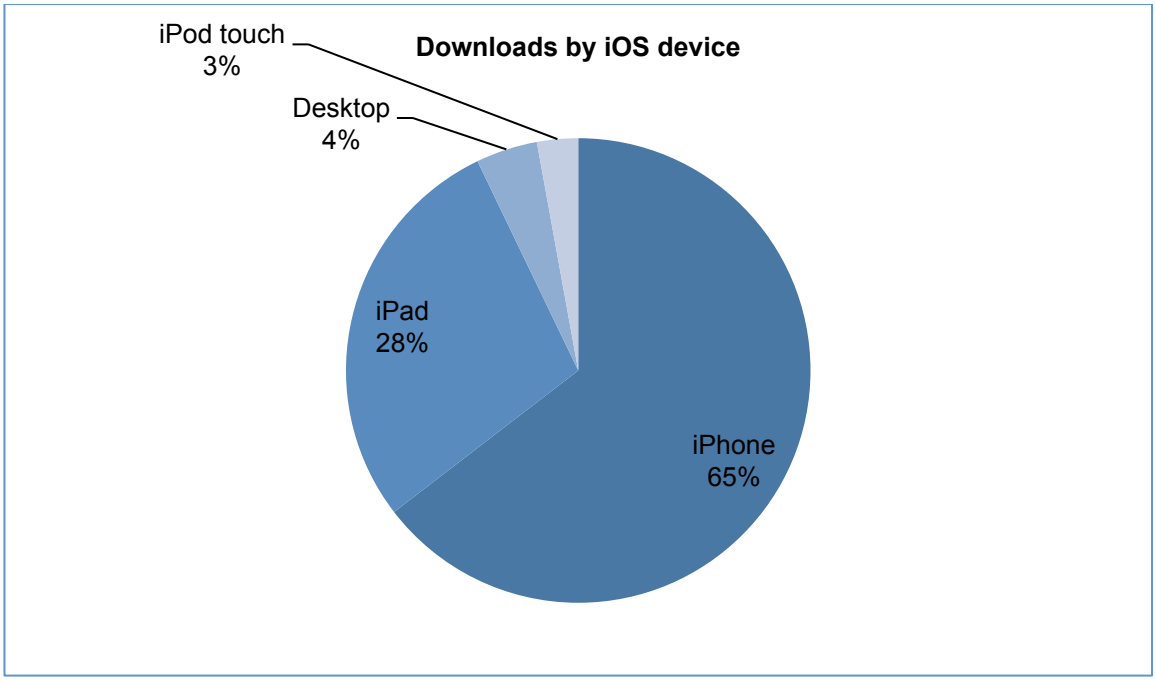


Figure 40: Downloads by device

4. DISCUSSION

The method for this research involved the publication of a bespoke App to apply a blended approach to the delivery of a level 5 undergraduate unit. Whilst considered fit for purpose, evaluation of its effectiveness lies in the results and comments from institutional internal student surveys, video play data from the video hosting company and number of device installations (downloads). However, downloads should be viewed whilst appreciating that they represent global data, not only the use of MMU students, or indeed the RPD Online App as it was also available on a website on the world wide web. When an App is available on the App Store, it is in the public domain and may be installed by anyone who has access to it.

The lessons used in the App were placed into five different categories that signified stages in the process that could be grouped along a similar theme or procedure. Figure 31 shows the number of times that videos in each of the categories were accessed and the total download time in hours, minutes and seconds. Videos in the introductory and surveying categories can be seen as the 'whys' rather than the 'hows' as they discuss removable partial denture design and planning and can be considered to be at a slightly higher level than those in model preparation, duplication and patterning categories. The lesson that had the longest video duration, 'Design outline' was slightly under 14 minutes, yet this did not reduce its number of plays. This may be due to it being the first in the series of lessons, which may have prevented users skipping this stage as they may consider the top of a list to be the most important.

By experience, surveying is an often-difficult subject to teach and it was unexpected that the four videos in this section received so few plays.

Students studying the 6H5Z1022 unit were demonstrated each stage of the laboratory procedures including the first formative attempt at wax patterning in weeks 4 and 5. In weeks 6 and 7 (last week of Autumn Term, first week of Spring Term) students repeated the work but this time summatively and independently but with the use of the App or web version. In these weeks, they only carried out patterning procedures and consequently this led to a greater number of plays in the patterning category as they had to rely on the App or web version as the tutor did not offer any guidance or assistance. This method serves as a true gauge of a students ability as the tutor does not touch the students work and therefore, all work that is submitted is that of the student alone.

As each section contained a differing number of lessons, the number of plays was divided by the number of lessons within that section to show which sections showed the greater average number of plays (Fig. 32). It is here that the introductory category dominated despite containing only two lessons whilst Figure 33 shows that these lessons represented over a third of total plays in the year with the other four categories accounting roughly equal share of the remaining 66%.

Figure 34 shows the relationship between the total number of plays over the observed period and the length of each video in seconds. There is no direct correlation between the duration of the video and the number of times it was

played. As there is no discernable link between the two, it can be concluded that for the RPD Online App, video duration was not a factor that determined whether it was played. Surprisingly, the longest video, ‘Design outline’ at 13 minutes and 50 seconds was played the most of all videos; a total of 976 times. As the videos were interactive and users could scrub along the timeline to find the segment they need, this may be a reason why selecting longer videos was not considered a problem as it was not necessary to watch them (the videos) in their entirety.

On the fifth week of the unit operation, all video feeds ceased one morning due to excessive bandwidth usage with the hosting service. Students were unable to receive any videos on either the App or through the web version. During planning of the project, a maximum bandwidth requirement had been estimated which proved to be short of the actual requirement. A further payment was made to the hosting service later the same day and following a further bandwidth excess later in the term, the university agreed to fund an annual hosting account which effectively doubled the amount of available bandwidth and no further outages were encountered.

The first outage did highlight one important observation in that some students had become entirely dependent on the App to show them what to do. Rather than use the App in support of their learning and to reinforce what they had learned, some students used the App only when they were in the laboratory to guide them through the different practical stages. If the students had watched the videos previous to the session then the bandwidth outage may have had less of an impact.

One of the comments from the ISS, “not waiting in line to ask questions” highlighted another advantage of using video e-learning resources. In a typical laboratory session that is unsupported by an App or e-learning, students often have to queue to seek guidance from the tutor. In large groups, this can amount to a large loss of time spent actually undertaking course work and can be a barrier to progress. Some students also seek the tutor’s advice more regularly than others whilst others can learn independently, providing there is source material they can access, as in the case of the App. This was clearly evidenced during the Autumn Term of the unit where one female student had not attended a single laboratory session in the first five weeks. On week 6, she arrived and was at the stage where the other students had been at week 1. Providing one-to-one tuition in this case was not an option as it would have compromised the progress of all the other students in the group. Instead, the student was directed to install the App and by the end of the term she completed and submitted her work along with the other students in the group. Using video alone shows how to do something and the use of audio can state ‘why’. Without the accompanying commentary, it is difficult for the learner to establish why a particular technique is being carried out or why a particular component is being placed in a specific location. Audio adds authenticity, interest, and if the audio is that of the tutor, familiarisation.

By students using the App and not queuing for answers to questions, this allowed the tutor to circulate more often to offer advice on how to improve the their work or to prevent a mistake being made. Using wax in this particular setting means that it cannot be boiled-off if mistakes are made. This is possible

within other areas of dental technology such as making acrylic partial dentures. By offering advice before timely mistakes could be made, students more often avoided imprecisions that would have resulted in a loss of marks once submitted for grading and which would have been most probably irreversible.

Zhang el at (2006) reported that the use of video alone is not adequate to improve learning and that interactive video, that the user is allowed to control randomly, leads to better learning outcomes and satisfaction. Another study into student satisfaction in a blended e-learning system (BLES) also concluded that interaction has a “significant effect on learning climate” (Wu et al., 2010). The study by Larson and Sung (2009) concluded that there was no significant difference when face-to-face, online and blended teaching styles were measured for student satisfaction, learning effectiveness and ‘faculty satisfaction’ but it is not clear if this study investigated interactivity.

The RPD Online App allowed such random access and interactivity as the user was able to select a video on-demand from a series and to manipulate the play-head to seek a particular portion of the video as necessary. In addition, short blocks of text supported the videos to explain what each was demonstrating and included relevant theory. However, in personal conversations with students, this was seldom used which questions the importance of text when video is available and could be a factor to explore in further study in this area.

Each year, an internal student survey process is carried out which invites students on all years of a course to rate and make comments on all the units that form their study profile. Figure 35 shows the results of the previous five

surveys and indicates the point at which the RPD Online App was introduced. This chart should be viewed with the consideration that as it does not only represent the removable partial dentures component, but all that make up the unit structure : complete removable prosthodontics, fixed prosthodontics and orthodontics. The trend for both unit rating and satisfaction shows a steady rise suggesting that the unit is well received and meets the expectations of students. It is not possible to directly associate any improvement or otherwise with the introduction of the RPD Online App as there are too many variables to consider such as change in unit structure from two 20 credit units to a single 30 credit unit, inter-cohort variability relating to entry qualifications and previous experience and the operation of the unit from a single 12 week block to two blocks of six weeks each.

In addition to the numerical ratings that are shown in section 3.3, students on all years of the course are invited to make individual comments for each unit they study. These comments are anonymous and are not restricted so students may add any comments they wish. The summary of comments from two successive final quarters (2012, 2013) is seen in Table 8. The comments collectively capture the essence of what the App was intended to achieve such as allowing students to work at their own pace in the practical session, save time waiting for advice and for use as a reference tool after the actual laboratory session.

In May 2013, Manchester Metropolitan University Student Union, MMUnion presented their annual teaching awards to reward excellence in 8 categories that recognised individuals, courses and departments. Nominations by students were short-listed by an expert panel and the author collected the award for his

work on the RPD Online App in the category 'Outstanding Innovation in Teaching'. The fact that the nominations were made by the users of the App, the students themselves, further supported that the App was of value to them.

When the results of two successive cohorts are compared, there is a clear difference between the two sets of data as seen in Figure 36. A piece of summative coursework that accounted for 40% of the removable partial dentures assessment was used to gauge the performance of students over two years; one without the App or web version (2011-12) and the other with use of it (2012-13). Both years of the coursework were marked using the same marking scheme, which used 13 different criteria. Firstly, the minimum mark for the assessed piece is shown but this must be set in context of other factors that contribute towards it. The minimum mark relates to a single individual and may be due to their poor unit performance in general, attendance and punctuality. Similarly, the maximum mark for the assessed piece relates to an individual rather than an average and the mark of 100% cannot be singly attributed to the use of the App but may be due to a particularly talented student or one who may have had previous experience in dental technology.

When the average mark from both cohorts are compared, the cohort who had access the App or the web version scored 10% higher than the previous year's cohort. This may be due to natural inter-cohort variation and may have a bias in that the author of the App was also the tutor and also marked the work. Whilst honesty and integrity with the marking process was fully intended, there remains the possibility that some bias may have occurred. To further consider

effectiveness of the App, it is useful to examine results from the other components of the unit such as examination performance.

The difference between cohorts in partial dentures course work was highly significant (P= 0.0001). The data presented in Figure 37 and Table 9 indicates a 10% improvement in student marks after use of the RPD Online App in the coursework. In the other topics that constitute the unit (fixed prosthodontics, complete removable prosthodontics and orthodontics), the performance was marginally poorer although not significantly different from the previous year.

In the examination, however, there was no significant inter-cohort difference. In the partial denture element, the performance was almost identical. However, the cohort difference in the other topics was marginally poorer. The students were not able to access the RPD Online App during the examination. This could be interpreted that the students required the App, either for reference for manufacturing techniques, final quality standards required or both. The App was used independently by the students during the year so they achieved their performance with significantly less direct tutor involvement yet maintained the standards required even without the App independently in the examination. The App will have allowed a more consistent student experience. The nature of teaching dental technology practical requires maximum class sizes; currently of 20 students thus classes are repeated 3 or 4 times a week to different groups of students at MMU, which can lead to inter-group variation and learning experience which has not been an aim of this study.

When a comparison is made of minimum, maximum and average results over successive cohorts, the data shown in Figure 36 shows an average rise of 13.7%. When these results are compared with the ‘Other CW’ in Figure 37, there is a clear difference in performance between the results for partial dentures and the other coursework components.

On reflection, the App encouraged an approach to learning that aligns with behaviourist learning theory in that students were heavily reliant on the tutor to the point where, following observation of use and student interaction, there was a growing degree of dependency. The fact that the tutor was ‘virtual’ does not reduce or remove the implication of this. The learning was based on repetition of a task and was passive. The comparison of results in the coursework and practical examination showed that the App was most effective when students ‘had it to hand'. In this scenario, there was little need for the student to actually understand why they were doing a particular activity. The students were passive learners and the learning style was very much behaviourist. Having the App available at all times meant that students could watch a section of a video and then mimic the same activity in their own work. If they were unsure or needed further clarification or reinforcement, they only had to replay the video section again. Without assessment, it would be difficult to gauge if actual learning had taken place.

However, in the practical examination the App was not permitted into the laboratory and therefore students who wanted to achieve good grades had to prepare beforehand and watch the videos to commit them to memory. The pedagogical motivation for learning would be driven by pressure to compete for

grades and the consequences of failure. Andragogical motivation would be for self-esteem or recognition. This situation left all students at the point where they needed to apply or synthesize their learning to a new situation that required a constructivist approach. In this context, they constructed new knowledge by adding the required new learning to their existing knowledge of dental technology, which very much aligns to existing theories of constructivist learning. Furthermore, when this new knowledge is applied in the practical examination, students are able to contextualise what they have learned. This involves the attributes of discovery learning (active learning - 'learning by doing'). Generally, examinations place the responsibility for learning onto the learner. In dental technology practical examinations, students work independently and cannot consult a member of staff (or another student) for advice, clarification or reinforcement. Passive learning cannot take place in this scenario, as they have to engage with a learning process for which they are responsible in advance of the actual examination. The wax pattern that the students undertook in the practical examination was different to that in the coursework. To aid preparation in the exam, video resources were made available (via the institutional VLE) but not the App. Here, the task of completing the examination could not be purely behaviourist, as they had not previously attempted it.

Learners learn in a variety of different methods. Neil Flemings VARK (Visual, Auditory, Reading, Kinaesthetic) model launched in 1987 can be quite strongly associated with the App as every strand of it is contained either within the App itself (Visual, Auditory and Reading) or whilst undertaking the practical application or activity that those media resources detail (Kinaesthetic - 'hands-

on'). Whilst the video component of the App has been the main focus and shows a student ‘how’ to do the practical procedures, the audio component on each lesson contains the rationale for ‘why’ a particular item or technique is used. In Flemings VARK model, some students may make benefit of this audio track as their main conduit for learning, particularly because it fits their personal learning style. This model was of particular use for the aforementioned student who only began to attend from week 6 of a 12-week schedule yet still managed to complete the work with minimal assistance from the tutor.

The number of educational apps on the App Store as of February 2014 equated to nearly 115,000 titles, representing approximately 11% of the total number of Apps available (148Apps.biz, 2014). Only four results were returned when a search was performed using the phrase ‘partial denture’. Of these, only one, ‘DentALL’ (Minimentes, Minimentes.com) featured content that is slightly comparable in nature to the RPD Online App suggesting that the market for teaching and learning applications in the dental technology subject area is very niche and specialist.

The App became available on the App Store on September 10th 2012 and by the end of the year (112 days) it had been downloaded 340 times. This represents an average of 3.04 installs per day. In 2013, the number of downloads increased by a further 29% to 437 downloads but these were spread over 365 days showing an average of 1.20 apps per day. Up until August 31st 2012, the App was downloaded 613 times. The RPD Online App proved popular in the early weeks of release and received 5-star reviews from 9 users on the iTunes (Apple Inc., Cupertino, US) page listing. Reviews are shown in

Appendix 2. Between 16th and 29th September 2012, the App was featured on the iTunes App Store desktop in the category 'Reference'.

The number of downloads of an App cannot be seen as a true barometer of it's effectiveness, popularity or quality as users may simply uninstall it immediately after installing it. The download count is purely an indicator of the number of times that it was installed on an iOS device. The RPD Online App was made available for free and users were therefore more likely to trial it if they did not have to pay for it. Figure 38 shows the number of downloads by territory and the majority of downloads (57%, 350 ÷ 613) were by users in Europe which can most likely be attributed to use predominantly by MMU students and nearly double that of the next largest territory, USA and Canada at 23% (138 ÷ 613).

The App was downloaded across all 5 continents, which demonstrates the reach of an online store where geographical location to access is not a barrier. The global map shown in Figure 39 is representative of the number of downloads per country. Although it does not show actual download numbers, the darkness of the colour of each country may be used as an indicator and tallies with the bar chart shown in Figure 38. When Figure 39 is compared with Figure 8 (Third World Countries (McColl, 2005)), there is significant similarity in the global locations where the App was not installed.

Figure 40 shows the percentage of downloads by device between September 2012 and the end of August 2013. The App was installed a total of 613 times. 65% of the user base installed the App on an iPhone with a further 28% installing on an iPad, followed by desktop (4%) and iPod touch (3%). The

desktop number can be misleading as the App is for use on a mobile device but this figure reflects the number of users who installed the App through the iTunes software rather than 'over-the-air' using Wi-Fi. These ratios align with data from Apple's 2013 first quarter revenue as reported by 'Bare Figures – (www.barefigur.es/apple/), iPhone 56.25%, iPad 19.58% and iPod 3.93%. The number of users using an iPhone to install the App is high only because there are a greater percentage of iPhones in use generally. An iPhone contains all the functionality of an iPod and iPad but with the capability to make telephone calls and is most likely the most popular device as users need carry only one device. Consequently, the greater number of iPhone's used to install the RPD Online App is indicative only of device ownership in general.

The study identified usage between September 2012 and August 2013, during which, the App remained unchanged. On September 18th 2013, Apple released a major revision to the iOS operating system that had the immediate effect of making existing Apps look dated as they used old style graphics and standard controls that still adopted the skeuomorphic style favoured by outgoing head of iOS, Scott Forstall. iOS 7.0 presented a cleaner, flatter interface and the RPD Online App was updated to adopt these principles in build version 2.0.

As Apps can be immediately uninstalled after installing, the number of downloads alone cannot reflect popularity or effective use. The RPD Online App update (version 2.0) was released on 22nd November 2013, and was updated by users a total of 325 times (to Feb 17th 2014). Updates could only be installed by users who had the first version of the App. New users were only offered version 2 from November 22nd. By choosing to install the updates, this shows a

clear indication that the App is still installed on their devices and that they consider it useful enough to merit the update.

At the time of the update, MMU had launched the new 'mmutube' service running on Kaltura Open Source Video technology (Kaltura, New York, US). The App database was updated so that the video feeds were requested from the Kaltura service rather than through Vzaar.com, which made a financial saving.

Version 1 of the App included an embedded SQLite database which limited the App to only as many videos as where included at install. This restricted the potential to add further videos at a later date. As the App had it's own registered domain name (www.rpd-online.co.uk), this was used to create a server-side database running on a MySQL server, which was linked to the App through PHP (Pre-Hypertext Processor[14]) scripts on web pages. When the App was launched on the device, a connection was made through PHP scripts that gathered the content from all available lessons from a number of different tables. This data was then parsed using JSON (JavaScript Object Notation) to provide the App with a formatted text string that was then stripped into its embedded tokens for use in view controllers as required. All the database content was moved to a MySQL database that resided on a remote server. By moving the database external to the device, this created a much more flexible infrastructure to integrate more lessons as they were added to the database. Furthermore, as the database was external, any errors could be corrected

[14] A PHP script is code that requests the server to carry out functions such as database integration when a web page containing the code is requested. The web page is then built 'on-the-fly' to present a user with a formatted web page containing the data requested from the server request.

immediately without the need to ask users to update their App.

The RPD Online App was written exclusively for iOS based devices such as the iPhone, iPad and iPod touch. However, the number of smartphones being used around the world using the Android operating system is rising as seen in Figure 10. iOS is slightly reducing in popularity but the remaining providers such as Blackberry and Symbian are in rapid decline from 9% in 2012 to just 2% in 2013. This limits a vast amount of potential users to the web-based RPD Online service that does not allow the easy navigation and video integration that the App version provides. For example, requesting a video on an Android device invokes the native video playing application and takes the user away from the web page. These figures strongly support the need for the development of an Android App for RPD Online and should also be a consideration in any future e-learning ventures at the early planning stage.

The data collected by the video hosting company only recorded the number of times a video had been requested and the amount of bandwidth (measure of served data). The records however did not record at what point the video playback ended. The data collected assumes that the user played the video for it's entirety but the App provided a 'Done' button that allowed users to return to the detail view at any time. For assessment of effectiveness, it would have been useful to know if a particular video, or numbers of videos were exited at a certain point. This has since been addressed in version 2 of the App that uses the 'mmutube' service, which generates 'play-through ratio' data to show how much of a video was viewed as a percentage of it's total duration. In order to consider the actual results and as a point of reference for the results, a single

video resource in the later stages (patterning) of the series was queried in February 2014. It showed a play-through ratio of 52.11% meaning that 37 of the 71 plays were viewed from start to finish.

By definition, to undertake any creative endeavour means to do something new. With anything new, there is the very real possibility that not everything will work out as planned as not everything can be foreseen. These unplanned events and outcomes can serve to inform future development and should be welcomed and accepted. American life-coach Anthony Robbins quote “if you do what you’ve always done, you’ll get what you’ve always gotten” encourages new learning and teaching developments of which this App may be considered to contribute.

5. CONCLUSIONS

The objective of this thesis was to gauge the effectiveness of a bespoke mobile learning application in a laboratory-based, practical skills undergraduate unit and the following conclusions were made.

In 2011-12, students completed a piece of course work independently without the use of an App or web version. In the 2012-13 cohort, students were provided with an App and statistical analysis of these two successive cohorts proves that there is a highly significant improvement in student performance using the App.

An App provides a cost-effective and useful vehicle for delivering re-usable, flexible and adaptable learning resources and can be employed at higher education level to supplement face-to-face teaching and encourage self-directed learning.

The use of the App had a positive effect on student satisfaction and learning experience as supported by the comments and ratings made in the institutional student surveys and the MMUnion Award in the category 'Outstanding Innovation in Teaching' in 2013.

Video is useful in e-learning only if the user is able to interact with it. This supports findings by other research and opinion (Wu et al., 2010; Zhang et al., 2006; BBC Active, 2010).

Having video resources on-demand reduced the amount of times a student would otherwise have queued for advice, favouring the viewing of videos to find their answer and maximising the time that they spent undertaking their coursework.

An App that uses a remote server to host a database offers much greater scalability for updating and providing new content. This was discovered following the study period when the App was updated in November 2013.

The number of times a video is viewed is not related to its duration. A video of nearly 14 minutes was the most-viewed in the study. However, improved metrics and the availability of play-through ratio data in the future will measure whether videos are watched for their duration or exited at some point before the end.

In part-answer to the objective, the outcome is that the learning intervention (the App) did prove to be effective in its intended purpose. However, there is improved performance in measurable outcomes in completed practical coursework but in the examination, independence (without the App) indicates that there is a slight marginal difference between examination results for those students who had the use of the App and those who did not. The app allows for greater independence in the laboratory and improved quality, which could indicate that beyond university, working in practice, the use of a similar application could mimic the role of an experienced mentor to clarify and reassure the learner of the standards required for device manufacture.

The broader implications of the study relate to general use of smartphones. They are ubiquitous, powerful and capable devices that have a place in the learning environment whilst their global range offers great opportunities for the delivery of dental technology (and other subjects) in the future.

6. RECOMMENDATIONS

The RPD Online App has demonstrated the potential benefits to learning in the use of video ‘on-demand’ in an undergraduate, skills-based dental technology practical unit. However, the App was limited purely to iOS devices, which represents about a quarter of the global smartphone market. Future projects, or indeed further development of the RPD Online App needs to consider a strategy that offers it to the maximum potential number of users, necessitating the need for an Android version and to be aware of growing trends in the smartphone market.

Remotely hosted database driven content (introduced in version 2.0) is a much more effective method with which to deliver new and updated content to an App and should be seen as the model with which to build future applications. Using an embedded SQLite database proved effective for a small amount of lessons but it is not scalable without requiring users to update their software each time a new lesson is made available.

To truly understand usage of an App or service, further work and research is required to deliver detailed analytics of user engagement (such as play-through ratios) and to allow users to comment, question or rate content through greater interactivity with the App. By adopting a rating or comments system, videos could be sorted by popularity or by comment keywords. Furthermore, as the list of lessons grew, it would be necessary to provide search functionality within the App so that users could target content immediately without the need to scroll through the list until they had found the resource that they require.

Further research could be carried out to gauge the effectiveness of the RPD Online App by providing short assessments for each lesson in the form of multiple-choice questions (MCQ's). These can then be marked automatically by the App and possibly form the basis of an extension to the App to provide a service for dental technicians to carry out continuing professional development (CPD) in their own time which could be delivered via an 'in-app purchase' scheme for a small fee, thereby generating revenue for the content provider(s).

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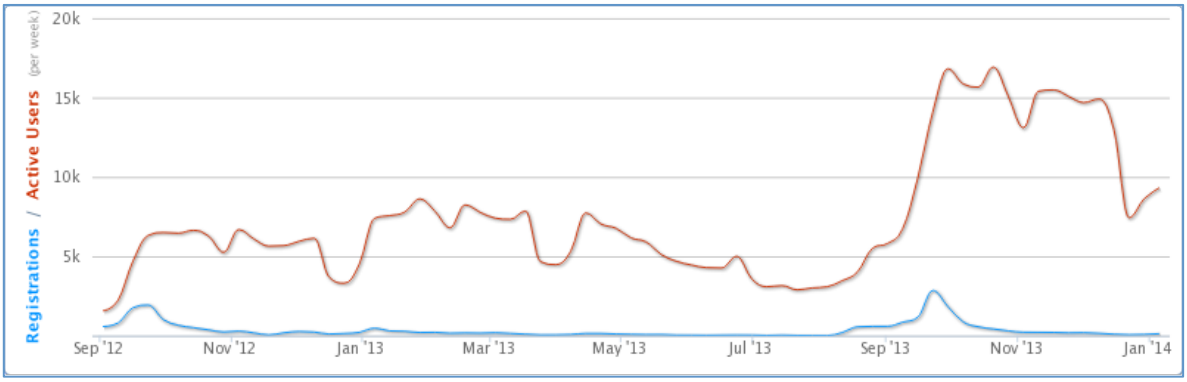
APPENDICIES

Appendix 1 – MyMMU App Access Data

MyMMU App usage between September 2012 and January 2014



MyMMU App hits by device between September 2012 and January 2014

Device	Hits
iPhone4,1	5536617
iPhone5,2	4533795
iPhone3,1	3374136
GT-I9300	698865
iPad2,5	691800
iPad3,4	445265
GT-I9100	385675
iPad3,1	382999
Other	4733017

MyMMU App Device Hits by device with percentage share

WEEK	iOS	Android	Web	RIM	Total	%iOS	%Android	%Web	%RIM
03/09/2012	1258	260	13	40	1571	80%	17%	1%	3%
10/09/2012	1736	394	21	66	2217	78%	18%	1%	3%
17/09/2012	3673	823	42	177	4715	78%	17%	1%	4%
24/09/2012	4709	1295	34	279	6317	75%	21%	1%	4%
01/10/2012	4740	1429	28	302	6499	73%	22%	0%	5%
08/10/2012	4660	1481	24	295	6460	72%	23%	0%	5%
15/10/2012	4822	1491	31	292	6636	73%	22%	0%	4%
22/10/2012	4600	1417	15	250	6282	73%	23%	0%	4%
28/10/2012	4022	1218	14	0	5254	77%	23%	0%	0%
04/11/2012	5226	1445	14	0	6685	78%	22%	0%	0%
11/11/2012	4764	1318	15	0	6097	78%	22%	0%	0%
18/11/2012	4432	1198	12	0	5642	79%	21%	0%	0%
25/11/2012	4483	1169	22	0	5674	79%	21%	0%	0%
02/12/2012	4647	1286	12	1	5946	78%	22%	0%	0%
09/12/2012	4840	1291	6	2	6139	79%	21%	0%	0%
16/12/2012	2866	801	4	2	3673	78%	22%	0%	0%
23/12/2012	2584	717	4	2	3307	78%	22%	0%	0%
30/12/2012	3611	904	9	1	4525	80%	20%	0%	0%
06/01/2013	5834	1544	15	0	7393	79%	21%	0%	0%
13/01/2013	5930	1618	13	1	7562	78%	21%	0%	0%
20/01/2013	6156	1621	6	1	7784	79%	21%	0%	0%
27/01/2013	7045	1560	12	1	8618	82%	18%	0%	0%

10/02/2013	5411	1380	10	1	6802	80%	20%	0%	0%
17/02/2013	6718	1509	11	1	8239	82%	18%	0%	0%
24/02/2013	6251	1502	15	1	7769	80%	19%	0%	0%
03/03/2013	5883	1512	9	0	7404	79%	20%	0%	0%
10/03/2013	5831	1487	11	0	7329	80%	20%	0%	0%
17/03/2013	6381	1460	9	0	7850	81%	19%	0%	0%
24/03/2013	3717	932	4	2	4655	80%	20%	0%	0%
01/04/2013	3515	909	4	47	4475	79%	20%	0%	1%
08/04/2013	4286	970	4	51	5311	81%	18%	0%	1%
15/04/2013	6143	1499	9	83	7734	79%	19%	0%	1%
22/04/2013	5596	1359	12	70	7037	80%	19%	0%	1%
29/04/2013	5385	1303	5	73	6766	80%	19%	0%	1%
06/05/2013	4847	1264	8	42	6161	79%	21%	0%	1%
13/05/2013	4666	1179	3	53	5901	79%	20%	0%	1%
20/05/2013	4041	1017	10	41	5109	79%	20%	0%	1%
27/05/2013	3726	915	7	40	4688	79%	20%	0%	1%
03/06/2013	3506	898	16	32	4452	79%	20%	0%	1%
10/06/2013	3434	826	4	22	4286	80%	19%	0%	1%
17/06/2013	3444	788	8	24	4264	81%	18%	0%	1%
24/06/2013	4032	937	8	21	4998	81%	19%	0%	0%
01/07/2013	2876	665	4	26	3571	81%	19%	0%	1%
08/07/2013	2501	568	1	16	3086	81%	18%	0%	1%
15/07/2013	2506	618	7	20	3151	80%	20%	0%	1%
22/07/2013	2322	545	2	23	2892	80%	19%	0%	1%
29/07/2013	2418	556	18	14	3006	80%	18%	1%	0%

05/08/2013	2509	552	12	11	3084	81%	18%	0%	0%
12/08/2013	2785	648	11	23	3467	80%	19%	0%	1%
19/08/2013	3202	759	19	30	4010	80%	19%	0%	1%
26/08/2013	4392	1051	22	38	5503	80%	19%	0%	1%
02/09/2013	4536	1202	24	49	5811	78%	21%	0%	1%
09/09/2013	5362	1314	23	41	6740	80%	19%	0%	1%
16/09/2013	8213	1633	35	50	9931	83%	16%	0%	1%
23/09/2013	11056	2887	63	99	14105	78%	20%	0%	1%
30/09/2013	12936	3665	83	127	16811	77%	22%	0%	1%
07/10/2013	11931	3723	62	144	15860	75%	23%	0%	1%
14/10/2013	11731	3738	57	133	15659	75%	24%	0%	1%
21/10/2013	13085	3668	52	113	16918	77%	22%	0%	1%
27/10/2013	11500	3529	40	2	15071	76%	23%	0%	0%
03/11/2013	9917	3142	40	2	13101	76%	24%	0%	0%
10/11/2013	11791	3565	43	0	15399	77%	23%	0%	0%
17/11/2013	11876	3572	37	0	15485	77%	23%	0%	0%
24/11/2013	11493	3541	38	0	15072	76%	23%	0%	0%
01/12/2013	11077	3566	41	1	14685	75%	24%	0%	0%
08/12/2013	11243	3631	33	1	14908	75%	24%	0%	0%
15/12/2013	9739	3192	24	2	12957	75%	25%	0%	0%
22/12/2013	5576	1845	10	2	7433	75%	25%	0%	0%
29/12/2013	6586	2031	10	0	8627	76%	24%	0%	0%
05/01/2014	7212	2084	12	0	9308	77%	22%	0%	0%

MyMMU App hits by week beginning

Week	Sessions	Hits
03/09/2012	7004	65879
10/09/2012	9396	84667
17/09/2012	25379	192371
24/09/2012	62301	327785
01/10/2012	60977	300346
08/10/2012	53480	282032
15/10/2012	50290	277597
22/10/2012	44006	249577
28/10/2012	28294	177060
04/11/2012	44215	243916
11/11/2012	41040	226796
18/11/2012	36813	211974
25/11/2012	36298	206166
02/12/2012	36929	223238
09/12/2012	36034	223860
16/12/2012	13359	89361
23/12/2012	7951	54939
30/12/2012	14994	103808
06/01/2013	58007	320784
13/01/2013	57512	325523
20/01/2013	56476	325631
27/01/2013	51735	298937
03/02/2013	51496	296676
10/02/2013	40724	231309
17/02/2013	51334	283466
24/02/2013	52810	305916
03/03/2013	50309	291088
10/03/2013	57124	339189
17/03/2013	85780	519772
24/03/2013	20286	124628
01/04/2013	17933	108976
08/04/2013	25642	158609
15/04/2013	52829	306359
22/04/2013	49119	284703
29/04/2013	44514	255997
06/05/2013	38083	212701
13/05/2013	37123	219741
20/05/2013	29287	180837
27/05/2013	23892	149313
03/06/2013	21224	137623
10/06/2013	18955	122569
17/06/2013	19568	128978
24/06/2013	24364	162093
01/07/2013	14948	95702
08/07/2013	11262	71308
15/07/2013	11650	76953
22/07/2013	9877	64474
29/07/2013	10805	55953
05/08/2013	10863	70147
12/08/2013	12604	86843
19/08/2013	14588	111840
26/08/2013	23616	175267
02/09/2013	23865	178010
09/09/2013	29890	235488
16/09/2013	49155	340016
23/09/2013	105390	649133
30/09/2013	201834	1005481
07/10/2013	163335	831157
14/10/2013	144756	792520
21/10/2013	127377	695719
27/10/2013	108075	614637
03/11/2013	89075	535919
10/11/2013	117826	660517
17/11/2013	109333	620766
24/11/2013	95926	646099
01/12/2013	70164	639328
08/12/2013	70337	674732
15/12/2013	48341	585322
22/12/2013	10329	150372
29/12/2013	14087	200733
05/01/2014	20548	284943

Appendix 2 – iTunes App Reviews

United States Reviews

Superb !!
by Ash5 & leCron on Wednesday, September 26 2012

"This is a fantastic app. Very thorough, easy to follow walk-through of fairly complex processes. By far, the best there is in this field. Hats off to ya !!"

United Kingdom Reviews

BEST APP for dental tech students
by MyTa9 on Sunday, November 24 2013

This app is very helpfull and interesting for dental tech students. Explains everything so well.
BRILLIANT APP! A+
*by Appleane** on Friday, November 22 2013*

Such an easy app to use and navigate around extremely useful for students.
Spot On!!!
by HamadT on Tuesday, October 01 2013

Perfect, finally we have an app dental technicians!!!!
RPD ONLINE
by Kirsty P 28 on Tuesday, February 19 2013

Brilliant app, very helpful...
Superb
by Sara Jalloul on Wednesday, January 02 2013

great app for students or even for REALLY inquisitive patients wanting to know what it takes to make it!
navigation and content is brilliant.
revelation!!
Superb App
by Oscar Puente on Thursday, September 20 2012

Helpful App to enhance manual dexterity. Brilliant!!!
Brilliant
by Dave in Sheffield on Wednesday, September 12 2012

This is what dental technology has been waiting for! Easy to use and navigate through, every one should have it.

Appendix 3 – RPD Online App - Downloads by country

September 10th 2011 > August 31st 2012

Country	Downloads
United Kingdom	306
United States	102
Canada	36
Australia	14
Philippines	14
China	13
Brazil	8
India	8
Saudi Arabia	8
Taiwan	8
Colombia	7
Thailand	7
Russia	6
Spain	6
Malaysia	5
Republic of Korea	5
United Arab Emirates	5
South Africa	4
Japan	3
Kuwait	3
Lithuania	3
Portugal	3
Turkey	3
Chile	2
France	2
Germany	2
Greece	2
Israel	2
Mauritius	2
Poland	2
Romania	2
Sweden	2
Switzerland	2
Algeria	1
Croatia	1
Cyprus	1
Egypt	1
Finland	1
Ghana	1
Hong Kong	1
Iceland	1
Indonesia	1
Ireland	1
Italy	1
Latvia	1
Netherlands	1
New Zealand	1
Norway	1
Venezuela	1

n = 613

Appendix 4 – Lesson plans

6H5Z1022 – Applied dental laboratory techniques
Week by week agenda – partial dentures

#	Topic	Objectives	Resources
1	Introduction to partial dentures topic Cast surveying and design sketching	• Setting up and component overview • Surveyor tools and their uses • Applying a design using SCRIBS acronym • Determining major connector size	Dental cast surveyors Spare graphite markers Coloured pencils Dividers Propelling pencil Surveying kits
2	Cast surveying and preparation	• Survey lines and undercuts • Measuring undercuts • Blocking out undercuts • Spacer wax for mesh grid retention • Pin-dam cutting • Adding wax clasp shoulders / ledges	Dental cast surveyors Spare graphite markers Undercut wax (MMU own) Spacer wax (0.6 mm BEGO) 1 mm rose-head burs Coloured pencils Dividers Propelling pencil Surveying kits
3	Surveying completion and duplication of cast into investment	• (Remaining items from # 1 & 2) + • Muffle forming • Stabilisation insert / silicone saver • Debubbliser • Mixing and pouring investment (The doughnut challenge)	Dental cast surveyors Spare graphite markers Undercut wax (MMU own) Spacer wax (0.6 mm BEGO) 1 mm rose-head burs Surveying kits Clear duplication tape (Siladent) Aptisil Rose Silicone (~100ml per student) Granisit investment material (1 * 180g bag per student) 75 % dilution expansion liquid (Siladent) Neutrasil debubbliser (Siladent) Duplication frames (Siladent) Mestra vacuum mixing units (x3)
4	Wax patterning (Pattern 1 – Stage 1)	• Pattern outlining • Infilling / free-hand waxing • Mesh grid retention for mechanical retention • 0.8 mm beading palatal strenghtener	Propelling pencil Casting wax pots (MMU Green) Mesh grid wax (Yeti) 0.8 mm round profile (BEGO / Yeti / Winters)
5	Wax patterning (Pattern 1 – Stage 2) FORMATIVE	• Retentive clasps and bracing components • Finishing beading • Stippled plate application	Casting wax pots (MMU Green) Clasp profiles (Yeti) 0.8 mm round profile

	ASSESSMENT AND FEEDBACK	• Pattern review (check for errors) • Formative assessment and feedback of wax pattern 1 • Pour second investment model	(BEGO / Yeti / Winters) 0.4 mm stippled plate wax (Yeti / BEGO) Clear duplication tape (Siladent) Granisit investment material (1 * 180g bag per student) 75 % dilution expansion liquid (Siladent) Neutrasil debubbliser (Siladent) Mestra vacuum mixing units (x3)
6	Wax patterning (Pattern 2 – Stage 1) *(THIS IS THE PATTERN THAT IS CAST)*	• Pattern outlining • Infilling / free-hand waxing • Mesh grid retention for mechanical retention • 0.8 mm beading palatal strenghtener	Propelling pencil Casting wax pots (MMU Green) Mesh grid wax (Yeti) 0.8 mm round profile (BEGO / Yeti / Winters)
7	Wax patterning (Pattern 2 – Stage 2)	• Retentive clasps and bracing components • Finishing beading • Stippled plate application • Pattern review (check for errors) • Summative assessment (<< *see opposite*)	Casting wax pots (MMU Green) Clasp profiles (Yeti) 0.8 mm round profile (BEGO / Yeti / Winters) 0.4 mm stippled plate wax (Yeti / BEGO)
8	Spruing and investing	• Two sessions (FRONT ROWS 1st TWO HOURS and BACK ROWS 2nd TWO HOURS) • Principles of spruing • Attach sprues and casting cone • Making casting muffles	6.5 x 2 mm sprue ribbon (BEGO) Blue casting funnels (BEGO) Yellow muffle tape (Siladent) Granisit investment material (2 * 180g bag per student) Neutrasil debubbliser (Siladent) Duplication frames (Siladent) Cobalt-chromium alloy (~25 g per student) Mestra vacuum mixing units (x3) Dividers
9	Devesting and de-spruing / coarse trimming	• Two sessions (FRONT ROWS 1st TWO HOURS and BACK ROWS 2nd TWO HOURS) • De-vesting and sandblasting • Removing sprues • Trimming attachment points • Restoring the shape	Sandblast units x 2 22 mm cut-off discs 22 mm coarse grinding wheels Screw-top mandrels Brown / pink stones Foster alloy grinding machines x 3 Plaster nippers
10	Trimming / Electrobrigthening	• Restoring the framework shape • Rounding-off sharp corners and edges	Brown / pink stones Electrolytic polishing units x 3

		• Sandblasting • Electrolytic polishing	
11	Smoothing / Polishing	• Smoothing the framework using rubber wheels and barrels / removing scratches • Final polish using lathes	18 mm green and black rubber wheels (Dedeco) Green and black rubber barrels (Dedeco) Blue polishing compound Black, metal centred stiff polishing brushes Abbott Robinson brushes
12	Smoothing / Polishing / presentation	• Smoothing the framework using rubber wheels and barrels / removing scratches • Final polish using lathes • Presentation of work – quality control	18 mm green and black rubber wheels (Dedeco) Green and black rubber barrels (Dedeco) Blue polishing compound Black, metal centred stiff polishing brushes Abbott Robinson brushes

SUMMATIVE ASSESSMENT
Partials element of unit mark is made up from 40% - wax pattern assessed at end of Week 7 and 60% from completed cobalt-chromium casting on Week 12
FORMATIVE ASSESSMENT
Assessment and feedback of wax pattern on Week 5
10 question, Moodle MCQ formative assessments on weeks 4, 7, 10 and 13.

Appendix 5 – Program code

Table view controller – Header file (.h)

```
//
//  RootViewController.h
//  SQL
//  Copyright 2012 Peter Gough. All rights reserved.
//
//

#import <UIKit/UIKit.h>
#import "Product.h"
#import "DBAccess.h"
#import "ProductDetailViewController.h"
#import "infoView.h"
#import "SQLAppDelegate.h"

@interface RootViewController : UITableViewController {

    NSMutableArray *products;
}

@property(nonatomic, retain) NSMutableArray *products;

@end
```

Table view controller – Implementation file (.m)

```
//
//  RootViewController.m
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import "RootViewController.h"
#import "Product.h"
#import "ProductDetailViewController.h"


@implementation RootViewController

@synthesize products;


- (void)viewDidLoad
{
    [super viewDidLoad];
    DBAccess *dbAccess = [[DBAccess alloc] init];
    self.products = [dbAccess getAllProducts];
    [dbAccess closeDatabase];
    [dbAccess release];

}

- (void)viewWillAppear:(BOOL)animated
{
    [super viewWillAppear:animated];
}

- (void)viewDidAppear:(BOOL)animated
{
```

```
    [super viewDidAppear:animated];
}

- (void)viewWillDisappear:(BOOL)animated
{
     [super viewWillDisappear:animated];
}

- (void)viewDidDisappear:(BOOL)animated
{
     [super viewDidDisappear:animated];
}

//_____________________________________________________________________
_________________________________
// Customize the number of sections in the table view.

- (NSInteger)numberOfSectionsInTableView:(UITableView *)tableView
{
    return 1; // Only 1 section that scrolls up and down
}

-             (NSInteger)tableView:(UITableView             *)tableView
numberOfRowsInSection:(NSInteger)section
{
    return [self.products count];
}

//_____________________________________________________________________
_________________________________
// Customize the appearance of table view cells.

-      (UITableViewCell      *)tableView:(UITableView      *)tableView
cellForRowAtIndexPath:(NSIndexPath *)indexPath
{
    static NSString *CellIdentifier = @"Cell";

    UITableViewCell            *cell            =            [tableView
dequeueReusableCellWithIdentifier:CellIdentifier];
    if (cell == nil) {
        cell           =           [[[UITableViewCell           alloc]
initWithStyle:UITableViewCellStyleSubtitle
reuseIdentifier:CellIdentifier] autorelease];
    }

    // Configure the cell.
    Product* product = [self.products objectAtIndex:[indexPath row]];

    cell.textLabel.text = product.title;
    cell.textLabel.font = [UIFont boldSystemFontOfSize:14.0f];
    cell.textLabel.textColor = [UIColor blackColor];

    cell.detailTextLabel.text = product.author;
    cell.detailTextLabel.font = [UIFont systemFontOfSize:10.0f];
    cell.detailTextLabel.textColor = [UIColor darkGrayColor];

    //                        cell.accessoryType                        =
UITableViewCellAccessoryDisclosureIndicator;

    NSString       *filePath       =       [[NSBundle       mainBundle]
pathForResource:product.image ofType:@"png"];
```

```
    UIImage *image = [UIImage imageWithContentsOfFile:filePath];

    cell.imageView.image = image;

    return cell;
}
//_____________________________________________________________________
___________________________________


-                (void)tableView:(UITableView                *)tableView
didSelectRowAtIndexPath:(NSIndexPath *)indexPath
{
    // Get the product that coresponds with the touched cell
    Product *product = [self.products objectAtIndex:[indexPath row]];

    // Initialize the detail view controller from the XIB
    ProductDetailViewController     *productDetailViewController     =
[[ProductDetailViewController                                    alloc]
initWithNibName:@"ProductDetailViewController" bundle:nil];


    // Push the detail controller on to the stack
    [self.navigationController
pushViewController:productDetailViewController animated:YES];

    // Populate the details
    [productDetailViewController setLabelsForProduct:product];

    //  Release  the  view  controller  because  it  is  retained  by  the
Navigation Controller
    [productDetailViewController release];



}
//_____________________________________________________________________
___________________________________

- (void)didReceiveMemoryWarning
{
    // Releases the view if it doesn't have a superview.
    [super didReceiveMemoryWarning];

    // Relinquish ownership any cached data, images, etc that aren't
in use.
}

- (void)viewDidUnload
{
    [super viewDidUnload];

  }

- (void)dealloc
{
    [super dealloc];
}
//_____________________________________________________________________
___________________________________
-
(BOOL)shouldAutorotateToInterfaceOrientation:(UIInterfaceOrientation)i
```

```
nterfaceOrientation
{
    // Return YES for supported orientations
    //return          YES;          //(interfaceOrientation          ==
UIInterfaceOrientationPortrait);
      return (interfaceOrientation == UIInterfaceOrientationPortrait);
}
@end
```

Detail view controller – Header file (.h)

```
//
//  ProductDetailViewController.h
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import <UIKit/UIKit.h>
#import "Product.h"
#import "DBAccess.h"
#import <MediaPlayer/MediaPlayer.h>


@interface ProductDetailViewController : UIViewController {

    MPMoviePlayerViewController *player;
    IBOutlet UILabel *titleLabel;
    IBOutlet UILabel *authorLabel;
    IBOutlet UITextView *introductionText;

    IBOutlet UIImageView *imageHolder;

    IBOutlet UIButton *movieShow;


}

-(void) setLabelsForProduct: (Product *) theProduct;

@property(nonatomic, retain) IBOutlet UIImageView *imageHolder;


-(IBAction)switchview:(id)sender;
-(IBAction)switchview2:(id)sender;
-(IBAction)switchtools:(id)sender;

@end
```

Detail view controller – Implementation file (.m)

```
//
//  ProductDetailViewController.m
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import "ProductDetailViewController.h"
#import "infoView.h"
#import "SQLAppDelegate.h"
#import "MediaPlayer/MediaPlayer.h"
#import "tools.h"
```

```
#import "Product.h"
#include <netinet/in.h>
#import <SystemConfiguration/SCNetworkReachability.h>
#import "emailReg.h"

@implementation ProductDetailViewController

@synthesize imageHolder;


//_____________________________________________________________________
_____________________________________
// Open the further info view when 'Info' button is clicked.

-(IBAction)switchview:(id)sender {

    infoView    *productDetailViewController    =    [[infoView    alloc]
initWithNibName:@"infoView" bundle:nil];

    [self.navigationController
pushViewController:productDetailViewController animated:YES];
    [infoView release];

}
//_____________________________________________________________________
_____________________________________
// Open the tools view when 'Info' button is clicked.

-(IBAction)switchtools:(id)sender {

    tools     *productDetailViewController     =     [[tools     alloc]
initWithNibName:@"tools" bundle:nil];

    [self.navigationController
pushViewController:productDetailViewController animated:YES];
    [tools release];

}
//_____________________________________________________________________
____________________
// Open the movie URL when the 'Play movie' button is clicked.

-(IBAction)switchview2:(id)sender {

        SQLAppDelegate       *dataCenter2       =       (SQLAppDelegate
*)[[UIApplication sharedApplication] delegate];

        /*/dataCenter2.urlData;/*/

        NSURL *path = [NSURL URLWithString:dataCenter2.urlData];

        player = [[MPMoviePlayerViewController alloc]
                  initWithContentURL:path];

        [self presentMoviePlayerViewControllerAnimated:player];

    }


//_____________________________________________________________________
_______________________
```

```
-(void) setLabelsForProduct: (Product *) theProduct
{
    [titleLabel setText:theProduct.title];

    [authorLabel setText:theProduct.author];

    [introductionText setText:theProduct.introduction];


    // Get a filename from the database 'Product.Image' call of type
PNG.  Convert to a string to path then load into imageHolder

    NSString       *filePath       =       [[NSBundle       mainBundle]
pathForResource:theProduct.image ofType:@"png"];
    UIImage *img = [UIImage imageWithContentsOfFile:filePath];
    [imageHolder setImage:img];

//===== ===== ===== ===== ===== ===== ===== ===== ===== ===== =====
===== ===== ===== ===== ===== =====

    // Put the further details into a variable and hold until next
view

    // Get the 'further details' text from database
    NSString *infoPath = theProduct.furtherInformation;
    SQLAppDelegate  *datacenter  =  (SQLAppDelegate  *)[[UIApplication
sharedApplication] delegate];
    datacenter.data = infoPath;

    // Get the 'video URL' text from database
    NSString *videoPath = theProduct.videoURL;
    SQLAppDelegate  *datacenter2  =  (SQLAppDelegate  *)[[UIApplication
sharedApplication] delegate];
    datacenter2.urlData = videoPath;

    // Get the 'tools' text from database
    NSString *toolInfo = theProduct.tools;
    SQLAppDelegate  *datacenter3  =  (SQLAppDelegate  *)[[UIApplication
sharedApplication] delegate];
    datacenter3.toolsData = toolInfo;

    // Get the 'coshh' text from database
    NSString *coshhText = theProduct.coshh;
    SQLAppDelegate  *datacenter4  =  (SQLAppDelegate  *)[[UIApplication
sharedApplication] delegate];
    datacenter4.coshhData = coshhText;

    // Get the 'safety' text from database
    NSString *safeT = theProduct.safety;
    SQLAppDelegate  *datacenter5  =  (SQLAppDelegate  *)[[UIApplication
sharedApplication] delegate];
    datacenter5.safetyData = safeT;

    NSString *titleStorage = theProduct.title;
    SQLAppDelegate  *datacenter6  =  (SQLAppDelegate  *)[[UIApplication
sharedApplication] delegate];
    datacenter6.titleData = titleStorage;

}


- (BOOL)connectedToNetwork  {
```

```
    // Create zero addy
    struct sockaddr_in zeroAddress;
    bzero(&zeroAddress, sizeof(zeroAddress));
    zeroAddress.sin_len = sizeof(zeroAddress);
    zeroAddress.sin_family = AF_INET;
    // Recover reachability flags
    SCNetworkReachabilityRef        defaultRouteReachability        =
SCNetworkReachabilityCreateWithAddress(NULL,                    (struct
sockaddr*)&zeroAddress);
    SCNetworkReachabilityFlags flags;
    BOOL                        didRetrieveFlags                    =
SCNetworkReachabilityGetFlags(defaultRouteReachability, &flags);
    CFRelease(defaultRouteReachability);
    if (!didRetrieveFlags)
    {
        NSLog(@"Error. Could not recover network reachability flags");
        return 0;
    }
    BOOL isReachable = flags & kSCNetworkFlagsReachable;
    BOOL needsConnection = flags & kSCNetworkFlagsConnectionRequired;
    return (isReachable && !needsConnection) ? YES : NO;
}


//_____________________________________________________________________
___________________________________

-    (id)initWithNibName:(NSString    *)nibNameOrNil    bundle:(NSBundle
*)nibBundleOrNil
{
    self = [super initWithNibName:nibNameOrNil bundle:nibBundleOrNil];
    if (self) {
        // Custom initialization
    }
    return self;
}
//_____________________________________________________________________
___________________________________
- (void)dealloc
{
    [super dealloc];
}
//_____________________________________________________________________
___________________________________
- (void)didReceiveMemoryWarning
{
    // Releases the view if it doesn't have a superview.
    [super didReceiveMemoryWarning];

    // Release any cached data, images, etc that aren't in use.
}
//_____________________________________________________________________
___________________________________
#pragma mark - View lifecycle

- (void)viewDidLoad
{

    NSUserDefaults *defaults = [NSUserDefaults standardUserDefaults];


        NSString *manchy = [defaults objectForKey:@"firstRun"];
```

```
        NSLog(@"%@", manchy);

    if (manchy == @"RAN") {

        emailReg       *merecat       =       [[emailReg       alloc]
initWithNibName:@"emailReg" bundle:nil];
        [self presentModalViewController:merecat animated:NO];
        }



    if ([self connectedToNetwork]) {
        NSLog(@"Connected OK");
        [movieShow setEnabled:YES];
        [movieShow                setTitle:@"Play                movie"
forState:UIControlStateNormal];
    }
    else {
        NSString *alerta = [[NSString alloc] initWithFormat:@"There is
no connection to the internet. Cannot play movie."];
        UIAlertView      *alert      =      [[UIAlertView      alloc]
initWithTitle:@"Connection problem"
                                                          message:alerta
                                                         delegate:self
                                                cancelButtonTitle:@"OK"
                                                otherButtonTitles:nil];
        [movieShow setEnabled:NO];
        [movieShow              setTitle:@"No              connection"
forState:UIControlStateNormal];
        [alert show];
    }



    [super viewDidLoad];
    // Do any additional setup after loading the view from its nib.
}
//_____________________________________________________________________
_____________________________________
- (void)viewDidUnload
{
    [super viewDidUnload];
    // Release any retained subviews of the main view.
    // e.g. self.myOutlet = nil;
}
//_____________________________________________________________________
_____________________________________
-
(BOOL)shouldAutorotateToInterfaceOrientation:(UIInterfaceOrientation)i
nterfaceOrientation
{
    // Return YES for supported orientations
    return (interfaceOrientation == UIInterfaceOrientationPortrait);
}

@end
```

Information view – Header file (.h)

```
//
//  infoView.h
//  SQL
```

```
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import <UIKit/UIKit.h>
#import "Product.h"
#import "SQLAppDelegate.h"

@interface infoView : UIViewController {

    IBOutlet UITextView *infoLabel;
    IBOutlet UITextView *titleReminder;

}

@property(nonatomic, retain) UITextView *infoLabel;
@property(nonatomic, retain) UITextView *titleReminder;


-(IBAction)switchback:(id)sender;
-(IBAction)showCOSHH:(id)sender;
-(IBAction)showSafety:(id)sender;


@end
```

Information view – Implementation file (.m)

```
//
//  infoView.m
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import "infoView.h"
#import "ProductDetailViewController.h"
#import "Product.h"
#import "SQLAppDelegate.h"
#import "coshh2.h"
#import "safety.h"


@implementation infoView

@synthesize infoLabel;
@synthesize titleReminder;

//_____________________________________________________________________
___________________

-(IBAction)switchback:(id)sender {

ProductDetailViewController       *productDetailViewController       =
[[ProductDetailViewController                                    alloc]
initWithNibName:@"ProductDetailViewController" bundle:nil];

    [self.navigationController
pushViewController:productDetailViewController animated:YES];

}
//_____________________________________________________________________
```

```
____________________
// Open the COSHH page when [COSHH] is tapped

-(IBAction)showCOSHH:(id)sender {

    coshh2    *productDetailViewController    =    [[coshh2    alloc]
initWithNibName:@"coshh2" bundle:nil];
    [self.navigationController
pushViewController:productDetailViewController animated:YES];
    [coshh2 release];

}
//____________________________________________________________________
____________________
// Open the safety page when [safety] is tapped

-(IBAction)showSafety:(id)sender {

    safety    *productDetailViewController    =    [[safety    alloc]
initWithNibName:@"safety" bundle:nil];
    [self.navigationController
pushViewController:productDetailViewController animated:YES];
    [safety release];

}
//____________________________________________________________________
____________________
-    (id)initWithNibName:(NSString    *)nibNameOrNil    bundle:(NSBundle
*)nibBundleOrNil
{
    self = [super initWithNibName:nibNameOrNil bundle:nibBundleOrNil];
    if (self) {

    // Custom initialization
    }
    return self;
}

//____________________________________________________________________
____________________

- (void)dealloc
{
    [super dealloc];
}

//____________________________________________________________________
____________________

- (void)didReceiveMemoryWarning
{
    // Releases the view if it doesn't have a superview.
    [super didReceiveMemoryWarning];

    // Release any cached data, images, etc that aren't in use.
}

#pragma mark - View lifecycle

//____________________________________________________________________
____________________
- (void)viewDidLoad {
```

```
    SQLAppDelegate  *dataCenter  =  (SQLAppDelegate  *)[[UIApplication
sharedApplication] delegate];
    [infoLabel setText:dataCenter.data];

    SQLAppDelegate  *dataCenter2  =  (SQLAppDelegate  *)[[UIApplication
sharedApplication] delegate];
    [titleReminder setText:dataCenter2.titleData];


    [super viewDidLoad];

}

//_____________________________________________________________________
____________________
- (void)viewDidUnload {

    [super viewDidUnload];

    // Release any retained subviews of the main view.
    // e.g. self.myOutlet = nil;
}

//_____________________________________________________________________
____________________

-
(BOOL)shouldAutorotateToInterfaceOrientation:(UIInterfaceOrientation)i
nterfaceOrientation
{
    // Return YES for supported orientations
    //return          YES;          //(interfaceOrientation          ==
UIInterfaceOrientationPortrait);
      return (interfaceOrientation == UIInterfaceOrientationPortrait);
}

@end
```

Safety view – Header file (.h)

```
//
//  safety.h
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import <UIKit/UIKit.h>

@interface safety : UIViewController {

    IBOutlet UITextView *safetyInfo;
    IBOutlet UITextView *titleReminder;
    IBOutlet UIWebView *risks;
}

@property(nonatomic, retain) UITextView *titleReminder;

@end
```

Safety view – Implementation file (.m)

```
//
//  safety.m
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import "safety.h"
#import "SQLAppDelegate.h"

@implementation safety

@synthesize titleReminder;

-   (id)initWithNibName:(NSString   *)nibNameOrNil   bundle:(NSBundle
*)nibBundleOrNil
{
    self = [super initWithNibName:nibNameOrNil bundle:nibBundleOrNil];
    if (self) {
        // Custom initialization
    }
    return self;
}

- (void)didReceiveMemoryWarning
{
    // Releases the view if it doesn't have a superview.
    [super didReceiveMemoryWarning];

    // Release any cached data, images, etc that aren't in use.
}

#pragma mark - View lifecycle

- (void)viewDidLoad
{

    SQLAppDelegate   *becker   =   (SQLAppDelegate   *)[[UIApplication
sharedApplication] delegate];
    [safetyInfo setText:becker.safetyData];

    SQLAppDelegate  *dataCenter2  =  (SQLAppDelegate  *)[[UIApplication
sharedApplication] delegate];
    [titleReminder setText:dataCenter2.titleData];

    SQLAppDelegate   *riskLink   =   (SQLAppDelegate   *)[[UIApplication
sharedApplication] delegate];

    NSString *aviva = riskLink.safetyData;

    NSString *filePath = [[NSBundle mainBundle] pathForResource:aviva
ofType:@"html"];
    NSData *htmlData = [NSData dataWithContentsOfFile:filePath];
    [risks           loadData:htmlData           MIMEType:@"text/html"
textEncodingName:@"UTF-8"                           baseURL:[NSURL
URLWithString:@"http://iphoneincubator.com"]];

    //NSLog(@"%@", filePath);

    [super viewDidLoad];
    // Do any additional setup after loading the view from its nib.
}
```

```
- (void)viewDidUnload
{
    [super viewDidUnload];
    // Release any retained subviews of the main view.
    // e.g. self.myOutlet = nil;
}

-
(BOOL)shouldAutorotateToInterfaceOrientation:(UIInterfaceOrientation)i
nterfaceOrientation
{
    // Return YES for supported orientations
    return (interfaceOrientation == UIInterfaceOrientationPortrait);
}

@end
```

Tools view – Header file (.h)

```
//
//  tools.h
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import <UIKit/UIKit.h>

@interface tools : UIViewController {

    IBOutlet UITextView *toolsLabel;
    IBOutlet UITextView *titleReminder;

}

@property(nonatomic, retain) UITextView *titleReminder;

@end
```

Tools view – Implementation file (.m)

```
//
//  tools.m
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import "tools.h"
#import "SQLAppDelegate.h"


@implementation tools

@synthesize titleReminder;

-    (id)initWithNibName:(NSString    *)nibNameOrNil    bundle:(NSBundle
*)nibBundleOrNil
{
    self = [super initWithNibName:nibNameOrNil bundle:nibBundleOrNil];
    if (self) {
        // Custom initialization
```

```
    }
    return self;
}

- (void)didReceiveMemoryWarning
{
    // Releases the view if it doesn't have a superview.
    [super didReceiveMemoryWarning];

    // Release any cached data, images, etc that aren't in use.
}

#pragma mark - View lifecycle

- (void)viewDidLoad
{

    SQLAppDelegate    *boris    =    (SQLAppDelegate    *)[[UIApplication
sharedApplication] delegate];
    [toolsLabel setText:boris.toolsData];

    SQLAppDelegate  *dataCenter2  =  (SQLAppDelegate  *)[[UIApplication
sharedApplication] delegate];
    [titleReminder setText:dataCenter2.titleData];

    [super viewDidLoad];
    // Do any additional setup after loading the view from its nib.
}

- (void)viewDidUnload
{
    [super viewDidUnload];
    // Release any retained subviews of the main view.
    // e.g. self.myOutlet = nil;
}

-
(BOOL)shouldAutorotateToInterfaceOrientation:(UIInterfaceOrientation)i
nterfaceOrientation
{
    // Return YES for supported orientations
    return (interfaceOrientation == UIInterfaceOrientationPortrait);
}

@end
```

COSHH View – Header file (.h)

```
//
//  coshh2.h
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import <UIKit/UIKit.h>

@interface coshh2 : UIViewController {

    IBOutlet UITextView *coshhInfo;
    IBOutlet UITextView *showTitle;

}
```

```
@property(nonatomic, retain) UITextView *showTitle;

@end
```

COSHH View – Implementation file (.m)

```
//
//  coshh2.m
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import "coshh2.h"
#import "SQLAppDelegate.h"

@implementation coshh2

@synthesize showTitle;

-   (id)initWithNibName:(NSString   *)nibNameOrNil   bundle:(NSBundle
*)nibBundleOrNil
{
    self = [super initWithNibName:nibNameOrNil bundle:nibBundleOrNil];
    if (self) {
        // Custom initialization
    }
    return self;
}

- (void)didReceiveMemoryWarning
{
    // Releases the view if it doesn't have a superview.
    [super didReceiveMemoryWarning];

    // Release any cached data, images, etc that aren't in use.
}

#pragma mark - View lifecycle

- (void)viewDidLoad
{

    SQLAppDelegate   *tony   =   (SQLAppDelegate   *)[[UIApplication
sharedApplication] delegate];
    [coshhInfo setText:tony.coshhData];

    SQLAppDelegate  *titleDemo  =  (SQLAppDelegate  *)[[UIApplication
sharedApplication] delegate];
    [showTitle setText:titleDemo.titleData];

    [super viewDidLoad];
    // Do any additional setup after loading the view from its nib.
}

- (void)viewDidUnload
{
    [super viewDidUnload];
    // Release any retained subviews of the main view.
    // e.g. self.myOutlet = nil;
}
```

```
-
(BOOL)shouldAutorotateToInterfaceOrientation:(UIInterfaceOrientation)i
nterfaceOrientation
{
    // Return YES for supported orientations
    return (interfaceOrientation == UIInterfaceOrientationPortrait);
}

@end
```

Email registration – Header file (.h)

```
//
//  emailReg.h
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import <UIKit/UIKit.h>

@interface emailReg : UIViewController {

    IBOutlet UITextField *emailAddress;

}

@property (nonatomic, retain) UITextField *emailAddress;


-(IBAction)noThanks;


@end
```

Email registration – Implementation file (.m)

```
//
//  emailReg.m
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import "emailReg.h"
#import "SQLAppDelegate.h"


@interface emailReg ()

@end

@implementation emailReg

@synthesize emailAddress;

// ********************************************************** USER TAPS
BACKGROUND ***
-(IBAction)resignBackground {
    [emailAddress resignFirstResponder];
}
// ********************************************************** NO THANKS
BUTTON - RETURN TO APP **
```

```
-(IBAction)noThanks {

        [self dismissModalViewControllerAnimated:YES];
}

-    (id)initWithNibName:(NSString    *)nibNameOrNil    bundle:(NSBundle
*)nibBundleOrNil
{
    self = [super initWithNibName:nibNameOrNil bundle:nibBundleOrNil];
    if (self) {
        // Custom initialization
    }
    return self;
}
// ********************************************************
- (void)viewDidLoad
{
    NSUserDefaults *defaults = [NSUserDefaults standardUserDefaults];
    [defaults   setObject:@"DONE"   forKey:@"firstRun"];   //Change   the
defaults flag to show App has already run first time.

    [super viewDidLoad];
    // Do any additional setup after loading the view from its nib.
}
// ********************************************************
- (void)viewDidUnload
{
    [super viewDidUnload];
    // Release any retained subviews of the main view.
    // e.g. self.myOutlet = nil;
}

-
(BOOL)shouldAutorotateToInterfaceOrientation:(UIInterfaceOrientation)i
nterfaceOrientation
{
    return (interfaceOrientation == UIInterfaceOrientationPortrait);
}

@end
```

Database access – Header file (.h)

```
//
//  DBAccess.h
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import <Foundation/Foundation.h>
#import <sqlite3.h>
#import "Product.h"


@interface DBAccess : NSObject {

}

-(NSMutableArray*) getAllProducts;
-(void) closeDatabase;
-(void) initializeDatabase;
```

```
@end
```

Database access – Implementation file (.m)

```
//
//  DBAccess.m
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import "DBAccess.h"


@implementation DBAccess

sqlite3* database;

//_____________________________________________________________


-(id) init
{
    if ((self = [super init]))
    {
        [self initializeDatabase];
    }
    return self;
}

//_____________________________________________________________

-(void)initializeDatabase {

    NSString *path = [[NSBundle mainBundle]
                      pathForResource:@"newDental"
                      ofType:@"sqlite"];

    if (sqlite3_open([path UTF8String], &database) == SQLITE_OK)
    {
        NSLog(@"Opening Database");
    }
    else
    {
        sqlite3_close(database);
        NSAssert1(0, @"Failed to open database: '%s'.",
sqlite3_errmsg(database));
    }
}
//_____________________________________________________________

-(void)closeDatabase {
    if(sqlite3_close(database) != SQLITE_OK) {
        NSAssert1(0, @"Failed to close database: '%s'.",
sqlite3_errmsg(database));
    }
}
//_____________________________________________________________

-(NSMutableArray*) getAllProducts {
    //The array of products that I will create
    NSMutableArray *products = [[[NSMutableArray alloc] init]
```

```
autorelease];

    //The SQL statement that I execute against the database
    const char *sql = "SELECT
Article.ID,Article.Title,Author.Name,Article.Introduction,Division.Div
isionName,Article.Image,Article.furtherInfo,Article.videoURL,
Article.Coshh, Article.Tools,Article.Safety FROM
Article,Division,Author WHERE Author.AuthorID=Article.AuthorID AND
Article.DivisionID=Division.DivisionID";



          //The SQLite statement object that will hold our result set
    sqlite3_stmt *statement;

    //Prepare the statement to compile the SQL query into byte-code
    int sqlresult = sqlite3_prepare_v2(database, sql, -1, &statement,
NULL);

    if (sqlresult== SQLITE_OK)

    {
        while (sqlite3_step(statement) == SQLITE_ROW) {
            // allocate a product object to add to products array
            Product *item = [[Product alloc] init];

            // The second parameter is the colum index (0 based) in
the result set
            char *title =               (char
*)sqlite3_column_text(statement, 1);
            char *author =              (char
*)sqlite3_column_text(statement, 2);
            char *introduction =        (char
*)sqlite3_column_text(statement, 3);
            char *division =            (char
*)sqlite3_column_text(statement, 4);
            char *image =               (char
*)sqlite3_column_text(statement, 5);
            char *furtherInformation =  (char
*)sqlite3_column_text(statement, 6);
            char *videoURL =            (char
*)sqlite3_column_text(statement, 7);
            char *coshh =               (char
*)sqlite3_column_text(statement, 8);
            char *tools =               (char
*)sqlite3_column_text(statement, 9);
            char *safety =              (char
*)sqlite3_column_text(statement, 10);
            char *thumbnail =           (char
*)sqlite3_column_text(statement, 11);

            // set all the attributes of the product
            item.ID = sqlite3_column_int(statement, 0);

            item.title =                (title)                 ?
[NSString stringWithUTF8String:title] : @"";
            item.author =               (author)                ?
[NSString stringWithUTF8String:author] : @"";
            item.introduction =         (introduction)          ?
[NSString stringWithUTF8String:introduction] : @"";
            item.division =             (division)              ?
```

```
[NSString stringWithUTF8String:division] : @"";
            item.image =                (image)                 ?
[NSString stringWithUTF8String:image] : @"";
            item.furtherInformation =   (furtherInformation)    ?
[NSString stringWithUTF8String:furtherInformation] : @"";
            item.videoURL =             (videoURL)              ?
[NSString stringWithUTF8String:videoURL] : @"";
            item.coshh =                (coshh)                 ?
[NSString stringWithUTF8String:coshh] : @"";
            item.tools =                (tools)                 ?
[NSString stringWithUTF8String:tools] : @"";
            item.safety =               (safety)                ?
[NSString stringWithUTF8String:safety] : @"";
            item.thumbnail =            (thumbnail)             ?
[NSString stringWithUTF8String:thumbnail] : @"";


            [products addObject:item];
            [item release];
        }
        // finalise the statement to release its resources
        sqlite3_finalize(statement);

  }

    else {
        NSLog(@"Problem with the database");
        NSLog(@"%d",sqlresult);
    }

    return products;
}

//_____________________________________________________________


@end
```

Product – Header file (.h)

```
//
//  Product.h
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import <Foundation/Foundation.h>


@interface Product : NSObject {

    int ID;
    NSString *title;
    NSString *author;
    NSString *introduction;
    NSString *division;
    NSString *image;
    NSString *furtherInformation;
    NSString *videoURL;
    NSString *coshh;
    NSString *tools;
```

```
    NSString *safety;
    NSString *thumbnail;
}

@property(nonatomic) int ID;
@property(nonatomic, retain) NSString *title;
@property(nonatomic, retain) NSString *author;
@property(nonatomic, retain) NSString *introduction;
@property(nonatomic, retain) NSString *division;
@property(nonatomic, retain) NSString *image;
@property(nonatomic, retain) NSString *furtherInformation;
@property(nonatomic, retain) NSString *videoURL;
@property(nonatomic, retain) NSString *coshh;
@property(nonatomic, retain) NSString *tools;
@property(nonatomic, retain) NSString *safety;
@property(nonatomic, retain) NSString *thumbnail;

@end
```

Product – Implementation file (.m)

```
//
//  Product.m
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import "Product.h"


@implementation Product

@synthesize ID;
@synthesize title;
@synthesize author;
@synthesize introduction;
@synthesize division;
@synthesize image;
@synthesize furtherInformation;
@synthesize videoURL;
@synthesize coshh;
@synthesize tools;
@synthesize safety;
@synthesize thumbnail;

@end
```

App delegate – Header file (.h)

```
//
//  SQLAppDelegate.h
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import <UIKit/UIKit.h>

@interface SQLAppDelegate : NSObject <UIApplicationDelegate> {

    NSString *data;
    NSString *urlData;
```

```
    NSString *toolsData;
    NSString *coshhData;
    NSString *safetyData;
    NSString *titleData;
}

@property (nonatomic, retain) IBOutlet UIWindow *window;

@property (nonatomic, retain) IBOutlet UINavigationController
*navigationController;

@property(nonatomic) BOOL firstRun;

@property (copy, readwrite) NSString *data;
@property (copy, readwrite) NSString *urlData;
@property (copy, readwrite) NSString *toolsData;
@property (copy, readwrite) NSString *coshhData;
@property (copy, readwrite) NSString *safetyData;
@property (copy, readwrite) NSString *titleData;

@end
```

App delegate – Implementation file (.m)

```
//
//  SQLAppDelegate.m
//  SQL
//
//  Copyright 2012 Peter Gough. All rights reserved.
//

#import "SQLAppDelegate.h"

@implementation SQLAppDelegate


@synthesize window=_window;

@synthesize navigationController=_navigationController;

@synthesize data;
@synthesize urlData;
@synthesize toolsData;
@synthesize coshhData;
@synthesize safetyData;
@synthesize titleData;
@synthesize firstRun = _firstRun;

- (BOOL)application:(UIApplication *)application
didFinishLaunchingWithOptions:(NSDictionary *)launchOptions
{
self.window.rootViewController = self.navigationController;
    [self.window makeKeyAndVisible];

    //==============
    //Check to see if this is first time app is run by checking flag
we set in the defaults

    NSUserDefaults *defaults = [NSUserDefaults standardUserDefaults];

    if (![defaults objectForKey:@"firstRun"]){
        //flag doesnt exist then this IS the first run
```

```
        self.firstRun = TRUE;
        NSLog(@"First run");

        //store the flag so it exists the next time the app starts
        [defaults setObject:@"RAN" forKey:@"firstRun"];

    }else{
        //flag does exist so this ISNT the first run
        self.firstRun = FALSE;
        NSLog(@"NOT first run");
    }

    [[NSUserDefaults standardUserDefaults] synchronize];
    //TO TEST: delete the app on the device/simulator
    //run it - should be the first run
    //close it - make sure you kill it and its not just in the
background else didFinishLaunchingWithOptions wont be called
    //just applicationDidBecomeActive
    //2nd run it should  self.firstRun = FALSE;
    //============

    return YES;
}


- (void)dealloc
{
    [_window release];
    [_navigationController release];
    [super dealloc];
}

@end
```

Appendix 6 – Raw cohort data

2011-12

Student Name	5305CW	5305 cw -P	5305pcw	5306EX	5306EX - P	5306 pex
Student 1	63	64	59.6	58	58	59
Student 2	74	73	77.4	49	49	49
Student 3	57	55	62.6	49	55	30
Student 4	55	51	65.6	34	34	33
Student 5	61	70	35.2	49	51	44
Student 6	63	68	48.6	35	35	36
Student 7	62	68	45.4	37	32	52
Student 8	58	64	40.4	33	32	35
Student 9	73	72	76.4	61	61	62
Student 10	70	68	76.8	56	52	68
Student 11	78	79	75.4	60	61	58
Student 12	78	85	55.8	41	38	49
Student 13	65	64	68.4	51	48	59
Student 14	68	69	65.8	30	32	24
Student 15	60	54	77.2	55	58	47
Student 16	67	64	77	57	56	59
Student 17	60	53	81.4	41	41	40
Student 18	61	60	64.2	45	43	50
Student 19	81	83	73.8	65	62	75
Student 20	60	61	57.6	44	44	44
Student 21	46	45	48.4	33	33	33
Student 22	62	60	68	40	40	40
Student 23	68	67	71.2	52	55	44
Student 24	67	61	84.4	63	60	71
Student 25	74	72	79.8	56	55	59
Student 26	64	68	52.8	40	42	34
Student 27	72	77	58.4	69	67	76

Student 28	66	67	61.6	34	32	40
Student 29	54	45	80.6	47	51	35
Student 30	63	66	55.2	51	52	47
Student 31	76	74	82.6	49	50	47
Student 32	80	82	75.2	53	48	68
Student 33	63	63	63.4	46	49	36
Student 34	67	65	71.8	50	49	52
Student 35	79	80	76.4	67	67	66
Student 36	67	65	72.2	38	40	33
Student 37	61	59	67.4	53	54	49
Student 38	56	65	30	34	35	31
Student 39	65	61	75.8	50	50	51
Student 40	73	72	77.4	57	58	53
Student 41	30	19	62.6	38	39	36
Student 42	63	62	66	50	51	48
Student 43	71	67	84	65	65	66
Student 44	56	52	68.4	38	33	54
Student 45	69	66	77.2	55	50	70
Student 46	53	55	48.2	46	44	51
Student 47	69	72	59.4	39	36	47
Student 48	85	84	88	64	65	61
Student 49	58	60	53	41	40	44
Student 50	80	78	87.2	62	55	83
Student 51	70	71	68.4	48	43	63
Student 52	71	68	78.6	48	41	68
Student 53	61	56	77.2	51	49	58
Student 54	75	71	86.4	61	57	73
Student 55	68	71	58.6	44	41	52
Student 56	64	58	82.2	55	53	61

Student 57	58	54	69.2	52	48	63
mean	65.58	64.91	67.58	48.93	48.07	51.51
St dev	9.34	11.00	13.30	9.92	9.90	13.64
Max	85.00	85.40	88.00	69.00	67.33	83.00
Min	30.00	19.13	30.00	30.00	32.00	24.00

2012-2013

Student Name	1022, CW	1022, CW-P	1022, CW	1022, Ex	1022, ex -P	1022, PEX	1022 Module Mark
Student 1	61	60	63	39	41	34	48
Student 2	61	54	83	38	41	28	47
Student 3	67	60	89	51	51	52	57
Student 4	75	71	88	76	75	79	76
Student 5	79	73	98	78	78	77	78
Student 6	61	57	73	41	41	40	49
Student 7	66	63	74	42	42	41	52
Student 8	48	42	66	30	28	37	37
Student 9	72	67	88	51	51	50	59
Student 10	63	58	79	43	42	46	51
Student 11	62	57	77	48	50	41	54
Student 12	73	67	91	55	52	63	62
Student 13	59	54	74	48	47	50	52
Student 14	70	68	77	62	60	69	65
Student 15	56	51	70	31	27	44	41
Student 16	55	53	61	42	44	36	47
Student 17	71	68	80	66	64	73	68
Student 18	53	57	42	31	35	18	40
Student 19	68	65	78	37	34	47	49
Student 20	60	56	72	50	46	63	54
Student 21	65	60	79	50	42	75	56
Student 22	68	63	84	56	57	53	61
Student 23	81	75	100	65	61	77	71
Student 24	85	81	98	83	80	92	84
Student 25	71	68	81	55	54	59	61
Student 26	59	54	74	45	44	48	51
Student 27	59	54	75	48	45	56	52

Student 28	62	59	72	37	39	31	47
Student 29	65	62	73	41	35	59	51
Student 30	50	50	49	33	36	24	40
Student 31	68	59	95	56	56	57	61
Student 32	64	72	41	52	47	68	57
Student 33	55	51	66	37	38	33	44
Student 34	60	53	80	36	35	40	46
Student 35	64	57	84	52	48	65	57
Student 36	68	63	83	45	46	41	54
Student 37	61	55	78	45	42	55	51
Student 38	75	71	87	48	47	52	59
Student 39	65	58	86	42	37	58	51
Student 40	66	59	86	34	33	36	47
Student 41	69	62	90	51	47	63	58
Student 42	60	49	93	42	38	55	49
Student 43	58	54	70	35	36	33	44
Student 44	74	68	91	54	50	66	62
Student 45	72	67	87	50	43	71	59
Student 46	67	63	78	40	42	33	51
Student 47	62	60	68	38	34	49	48
Student 48	59	60	57	44	42	51	50
Student 49	64	62	70	49	51	44	55
Student 50	62	61	66	34	30	45	45
Student 51	66	62	79	34	29	48	47
Student 52	65	58	87	44	42	49	52
Student 53	74	68	93	59	58	61	65
Student 54	64	62	71	39	42	29	49
Student 55	66	62	79	52	45	74	58
Student 56	63	59	76	31	28	40	44

Student 57	75	69	92	62	58	75	67
Student 58	63	56	84	50	44	67	55
Student 59	56	57	53	32	29	40	42
mean	64.92	60.69	77.59	46.76	45.06	51.86	54.02
St dev	7.33	7.08	12.93	11.84	11.75	15.61	9.57
Max	85.00	80.67	100.00	83.00	80.00	92.00	84.00
Min	48.00	42.00	41.00	30.00	26.67	18.00	37.00