

TEACHING IN CONTEXT
USING A MOBILE PHONE SCENARIO

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Abbreviations

A Level	Advanced Level external examinations (AQA Level 3)
ADL	Advanced Distributed Learning, c/f SCORM
AICC (CBT)	Aviation Industry Computer Based Training Committee
A S Level	A S Levels may be taken half way through the course of the corresponding A Level
ASPECT	Adopting Standards and Specifications for Educational Content
AQA	Assessment and Qualifications Alliance
BCE	Before the Common Era (numerically equal to 'BC')
BERA	British Educational Research Association
BTEC	Business and Technology Education Council
CBI / CBL / CBT	Computer Based: Instruction / Learning / Teaching
CCT	Content Creation Tool
CDC	Control Data Corporation, mainframe supercomputer manufacturer (1957 – 1992)
CD-ROM	Compact Disc – Read Only Memory
CERL	Computer-based Education Research Laboratory (at the University of Illinois)
CMR	Communications Market Report (Ofcom)
CPU	Central Processing Unit
CRB	Criminal Records Bureau, a check for previous criminal records, being replaced by DBS, see next entry
DBS	Disclosure and Barring Service (replacing CRB checks from the 1 st March 2013)
GCSE	General Certificate of Secondary Education
IBM PC	International Business Machines Personal Computer
ICT	Information and Communications Technology
IEGMP	Independent Expert Group on Mobile Phones
IET	The Institution of Engineering and Technology
ILLIAC	Illinois Integrator and Calculator

irc	Internet Relay Chat
IS	Information Systems
IT	Information Technology
ITU	International Telecommunication Union
LEA	Local Education Authority
LMS	Learning Management System (see also: Virtual Learning Environment - VLE)
LO	Learning Object
MIS Q Quarterlyly	MIS Quarterly – a peer reviewed scholarly journal covering Information Systems and Information Technology
MMS	Multimedia Messaging Service
MTHR	Mobile Telecommunications and Health Research Programme
OED	Oxford English Dictionary
Ofcom	The Office of the Communications Regulator
Ofqual	The Office for Qualifications and Examinations Regulation
PEL	Prior Experience and Learning
PLATO	Programmed Logic for Automated Teaching Operations
QCF	Qualifications and Credit Framework
RF (CW)	Radio Frequency (Carrier Wave)
SCORM	Sharable Content Object Reference Mode
SMS	Short Message Service – Text Message or Texting (see also MMS)
STEM	Science, Technology, Engineering and Mathematics (subjects)
TCP / IP	Terminal Control Protocol / Internet Protocol
UK	United Kingdom
UNICEF	United Nations Children's Fund
US	United States of America
VLE	Virtual Learning Environment (see also: Learning Management System - LMS)
W3C	The World Wide Web Consortium (W3C) An international community that develops open standards to ensure the long-term growth of the Web
wysiwyg	what you see is what you get

Abstract

This thesis examines the apparent dichotomy between an ever increasing use of modern digital technology by youngsters and a decline in the numbers wishing to study technology related subjects at University. It has been recognised by many Professional Bodies that this trend in turn will result in a major shortage of UK scientist and engineers. The research therefore examined whether a new teaching approach in which the science and engineering that underpins today's technology is described in terms of a typical use case would have a positive effect on changing attitudes and motivation towards continuing to study such subjects.

A set of E-Learning Materials was developed that covered a number of areas of BTEC, A, and AS level ICT modules that described relevant science and engineering within the context of how a text message is sent using a mobile phone. Mobile phone ownership is very high amongst teenagers and text messaging continues to be a dominant application. Structured as a series of six learning objects these teaching materials were used by youngsters aged from sixteen to eighteen in different local schools and colleges. For each session, questionnaire feedback was obtained and the evaluation of these results indicate an encouraging correlation with the hypothesis that learners do respond favourably when science and engineering principles are described within the context of an everyday experience of using technology.

The thesis provides a literature review of the key research work related to teaching in context, a rationale and set of requirements for the development of the new set of teaching materials, the detailed design of those materials, a description of the testing of the materials in schools and colleges and an evaluation of the results obtained from questionnaire feedback

Keywords: contextual teaching, encouraging, enthusing, learning, motivating, pedagogy, science, teaching in context, technology.

1 Chapter One – Introduction

1.1 Introduction

Many of the UK's Professional Engineering and Science Institutions, such as the Institution of Engineering and Technology (IET) publically recognise that the country is short of suitably qualified and trained engineers. Estimates published by the IET suggest that universities are only producing 25% to 50% of the graduate engineers required for the UK economy and that there will be a shortage of 200,000 engineering professionals by 2020. This therefore leads to a requirement for more students to study Science, Technology, Engineering and Mathematics (STEM) subjects in schools, colleges and ultimately universities (IET survey, 2012).

In respect of student recruitment to 'STEM' courses at university level, figures produced by the Higher Education Statistics Agency (HESA, 1997 & 2007), show that whilst the total number of students at degree level study from 1997/98 – 2007/08 increased by 28% rising by almost 400,000 (+ 391,907; from 1,400,000 to 1,800,000 (numbers rounded)), the numbers entering major degree programmes in science and technology based subjects (Computer Science, Physical Sciences, Mathematical Sciences, and Engineering & Technology) did not follow the general upward increase. The numbers of students accepted on science and technology based degree courses during the same period increased by only 22%; from 60889 to 78925. See Table 1-1, (UCAS, 2008).

UCAS Statistics		
Students	Total Number accepted	Accepted for Sciences
1997	276,503	60,889
2007	356,572	78,925

Table 1-1: Students Accepted (UCAS)

Encouragingly, according to the Department for Education examination entries for Science, Technology, Engineering and Mathematics (STEM) subjects at GCSE and

‘A’ Level have risen. However, in March 2013 Lord Willis of Knaresborough reported in the House of Lords:

The Government rightly claimed that there has been an overall increase in STEM qualifiers, and there has been. However, despite modest increases in core STEM subjects, the majority of the increase has arisen from the popularity of so-called soft STEM courses. For example, forensic and archaeological science increased by 349% between 2003 and 2009, while engineering reduced by 3% and computer science by 27%. This trend towards soft STEM helps to explain why on analysis many STEM graduates face employment challenges in traditional STEM careers as core components of their degrees, particularly mathematics, have been studiously avoided. (Willis, 2013).

Interestingly, against the more general decline in the numbers of those wishing to study science and engineering related subjects, continued advances in modern electronics and the World Wide Web has placed ever more digital technology in the hands of older school children and college and university entrants and immersed them in an online world (ITU, 2013). As further illustration of this situation, mobile phone statistics produced by the Independent regulator and competition authority for the United Kingdom (UK) communications industries (Ofcom) show that there are more phones in the UK than people. The latest statistics show 81.6 million mobile subscriptions against the total UK population estimate from the UK Census office of 63.18 million (Ofcom, 2011a, 2012).

The usage of all of this digital technology is being fuelled by software applications such as social networking and mobile computing. For example, 91% of 16 to 24 year old Internet users take part in social networking with a roughly equal gender balance (Ofcom, 2007). Facebook reports registering its 1 billionth user on the 14th September 2012 and in March 2013 the company reported 655 million daily active users. With 48% of youngsters admitting to checking their Facebook profile as soon as they wake up it is hardly surprising that 751 million monthly active users used Facebook mobile products as of March 31, 2013. (Facebook, 2013)

Within the UK, 50% of Internet users now go online using their mobile phones (Ofcom, 2012) and in the twenty years since the first text message was sent, the total number of such messages sent each year now routinely exceeds 150 billion (Ofcom,

2012). Indeed the usage of mobile phones and the dependency that has emerged means that 60% of teenagers admit that they are addicted to their smart phones (Ofcom, 2011b).

These various figures therefore highlight an apparent dichotomy in that on the one hand younger people are more engaged with the usage of digital technology than ever before and yet, fewer are opting to study the subjects that underpin that very technology. When youngsters are increasingly using modern digital technology in their daily lives one might have expected to see an increased interest to study related subjects. In fact the figures would suggest that the opposite is true in that there is almost a growing reluctance to study those subjects.

The research work reported in this thesis is therefore focused on addressing this apparent dichotomy by trying to determine whether a new approach to teaching technology based subjects at pre-University level could have a positive influence on students wishing to continue those studies at University. In particular, the work set out to answer the following research question.

Will learners be more interested, and therefore, enthused to study technology based subjects if the teaching of those subjects is directly related to their daily use of such technology?

To answer this question a learning package was specifically developed for GCSE/BTEC students to determine if the teaching of technical subjects could be improved and made more interesting and enticing if the learning material were to be designed using the context of how a mobile phone works. By explaining the supporting structure of the network and the concepts underpinning the short message service (SMS) or as it is more commonly known, text messaging, that students in this age group use so frequently.

The mobile phone scenario inevitably has to cover subjects such as: radio waves, signal propagation, information encoding and communication protocols. These subject areas are included within AS and A Level GCE and BTEC Level 3 qualifications, which are generally the final level of evaluation before students progress to higher education in

the UK. The goal in developing this learning material was therefore to determine if placing the core technical subject matter within the context of an everyday usage behaviour could improve learning and enhance engagement. Two advantages of choosing the context of text messaging are: its popularity amongst the age group of interest and the fact that females and males both use text messaging equally.

Having established the research question the methodology and design of the project were both considered in terms of producing a set of Learning Materials. These Learning Materials would be: based on the technology involved, use a strong contextual link to the topic, and provide results capable of producing a fair and workable evaluation of the results.

Using context and contextualisation to link to the experience of learners who use their mobile phones to send texts is clearly not dependent on the delivery method of the Learning Materials. So the delivery of this learning material could have been achieved using a number of options; from formal lectures to written worksheets, or by writing and producing a textbook. These options were all considered but it was felt that producing the material for delivery on-screen using an E-Learning package was the most appropriate choice. Indeed, this is a delivery system which would eliminate a number of factors in terms of variation, intended or accidental, should the delivery be undertaken by traditional lectures or classroom sessions. These delivery methods were all considered to have a greater likelihood of variation or inconsistency being introduced across whatever number of sessions would finally be delivered to learners in a classroom. This variation was practically inevitable since any tutor or lecturer would naturally attempt to teach as affectively as possible. To this end they may well, highly understandably, adapt their delivery of the material, even if only in minor ways, so as to best serve the needs of their students.

Having selected on-screen delivery based on these reasons the selection of the authoring tool was not an important factor. The *Sharable Content Object Reference Model (SCORM)* compliant authoring tool, Pedagogue was used to create the learning content as this offered a quick way of generating computer based content that offered a

comprehensive range of functionality. The subject material covered was drawn from the BTEC Level 3 and from parts of the 'A S' level and A level GCE syllabuses from various examination bodies in the United Kingdom.

Having developed the learning package a pilot test was conducted which gave encouraging results. The project material was then trialled with different cohorts of students at local schools and colleges in which the students were studying: Business and Technology Education Council (BTEC) Level 3 ICT, A/S level Computing and Information Technology, and A level Computing General Certificate of Education (GCE) courses. The numbers of students recruited to perform testing and evaluation was higher than expected and should provide a statistically reliable data set. As with the pilot test the overall evaluation provided responses that were statistically and textually similar producing encouraging results tending to support the plan of the experiment involving users with a technology they make very regular use of.

The remainder of this thesis is organised as follows. Chapter 2 presents a general review of the literature on educational theory and practice followed by a more detailed review of contextualised learning and the background and the development of electronic based teaching materials. Chapter 3 outlines the overall methodology adopted for the research and identifies the key requirements that the computer based learning package had to fulfil and includes the approach adopted on ethical issues. Chapter 4 provides a detailed description of the design of the learning material, including references to the adoption of SCORM based standards. Chapter 5 evaluates the test results and feedback obtained from the classroom trials. Finally, Chapter 6 draws the project to a close with the conclusion that answers the original research question and also proposes areas for further work. For completeness, transcripts of text responses from users are included in the Appendix.

2 Chapter Two – Literature Review

This chapter is organised into five sections starting with an Introduction. The Introduction contains two sub-sections dealing with the teaching of science and engineering in the UK. The vast area of educational theory is reviewed and mention is made of personal learning styles. How the use of context is appropriate and the way this term is defined in this thesis. The background and some of the important developments in E-Learning are investigated, with sub-sections on: distance learning, accessibility issues, and software tools available for creating content for E-Learning material. The chapter ends with a summary.

2.1 Introduction

The research question presented in Chapter 1 was: “Will learners be more interested, and therefore, enthused to study technology based subjects if the teaching of those subjects is directly related to their daily use of such technology?”

Motivation for this research comes from work intended to enhance and enthuse young people in the areas of: Science, Technology, Engineering, and Mathematics (STEM). Flowing from this is a perceived need to improve and optimise the teaching style in terms of its context to learners to stimulate and generate involvement within those learners and make learning more effective for them. Following the scientific method based on research, methodology, and finally analysis and evaluation to rigorously test the research question. However, it is equally valid to explain that this was approached from the viewpoint of a technologist rather than as an educationalist. Accordingly, this dissertation is presented for consideration as a experimental piece of research work to guide and improve the best practices of teaching or presentation for technology subjects. Those technology subjects are based at Level 3 of the Qualifications and Credits Framework (QCF) administered by the Office of Qualifications and Examinations Regulation (Ofqual). The literature survey needed to underpin this research must cover: educational theory and practice, teaching, computer based learning and teaching, existing work concerning context and contextualisation in education, all within the relevant area of education in the UK.

2.2 Teaching Science and Engineering in the UK

School education is structured to meet the needs as laid down in the UK National Curriculum. Starting at primary level for children from the age of about five years to eleven years old and followed with secondary education for children between eleven and sixteen years of age. The Education and Skills Act (2008) extended the upper age limit from sixteen years to eighteen years for compulsory education. This was intended to ensure all students were in education or training to the age of eighteen years. The National Curriculum sets out learning objectives for anyone educated in nationally maintained schools and uses four key stages to monitor and control progress during school years, Fig 2.1.

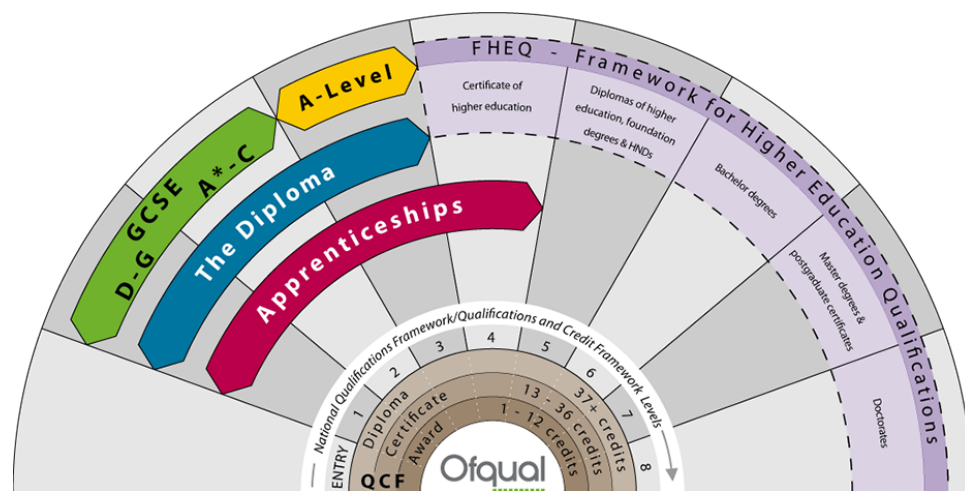


Fig 2.1: OFQUAL - QCF Levels (Ofqual, 2013b)

The first four subjects listed in the National Curriculum (Ofqual, 2013b) are: English, Mathematics, Science, and Design and Technology. Formal assessment tests are conducted on English and Mathematics but Science is no longer tested formally. Progress reports are provided to parents mid-way through and at the end of the different Key Stages.

As students move from primary into secondary education, at about eleven years of age, their timetables and lessons reflect the changes in their educational level. They study Key Stage 3 on entry to secondary school moving on to Key Stage 4. Their performance at this level is evaluated by sitting various externally set and marked examinations. In the main these examinations are for subjects in the General Certificate of Secondary Education (GCSE). Those who earn a GCSE pass at ‘A*’ (A Star, which is the highest mark) down to ‘C’ have an award at QCF Level 2. This level of achievement is also attainable by students following Apprenticeships or training when ‘The Diploma’ may be their target for attainment (Ofqual 2013a).

Further development for students assumes progress and, following the 2008 increase in the compulsory education age limit to eighteen years of age, many continue their studies moving on to QCF Level 3. This may entail a considerable change for many students as they now strive to meet the standards set for ‘A S’ and ‘A’ level GCE examinations. Many of them target other nationally recognised equivalent qualifications, for example, BTEC. Depending on the choice made by students the next educational stage marks their progress from secondary to tertiary level. The traditional academic route into university education after Level 2 (GCSE or equivalent) follows the course of Level 3 Advanced ‘A’ level examinations taken after two years of study (an Advanced Subsidiary (‘A S’) level paper is often sat after one year, hence the term ‘half an A level’). These examinations are generally considered to be best suited to academically able students who are, in the main, aiming for *higher education* to study for a degree (QCF, Level 5 or Level 6).

Vocational education and training beyond secondary education is referred to as *further education*. This aims to train students for their working career and covers both general and specific subject areas. For these learners who gain competence in vocational skills a separate, alternative route is available from the Business and Technology Education Council (Oxford Index, 2011). Business and Technology education is delivered to meet the requirements as set out again under the QCF and is administered by various Awarding Organisations: for example; AQA – City & Guilds, OCR, and Pearson Education Ltd. and

overseen by the Government led Office for Qualifications and Examinations Regulation (Ofqual Register 2013).

The basic knowledge gained up to the end of secondary education in school provides a foundation on which to build for the training of future Engineers and Scientists to study effectively at university and as a basis for their future career. This takes students from Level 4 to Level 6. Level 6 equates to a Bachelor's degree with Honours. This approach to lifelong learning enables all to benefit from the concept that learning never really ends, and as professionals keep themselves up to date with new concepts, developments in their field, and technologies, most will be responsible for maintaining their own continuing professional development.

This project focuses on students working at QCF Levels 2 or 3 as that is the prime area where young people in the UK start to make important decisions on the direction of their future career (Department for Education, 2010).

2.2.1 Usage of technology by age group

Teenagers use modern technology as a normal part of their daily lives. In one of their regular UK communication markets reports Ofcom say:

The correlation between age and mobile phone use is particularly strong, with the proportion of children using a mobile almost doubling between the age of 9 (52%) and 15 (95%). While in 2005 we saw a sharp increase in mobile phone use between the ages of 10 and 11 years, in 2007 the rise is more gradual and starts at an earlier age, with significantly higher usage levels among 9 and 10 year olds; children are acquiring mobiles at a younger age and using them more. (Ofcom, 2008).

A change in the way telecommunications services are used is clear from their Communications Market Report (CMR) (Ofcom, 2012) which highlights that the average UK mobile phone user sent 50 texts per week, showing a doubling of traffic in four years. Ninety minutes per week are used to access the Internet for social networking sites and email or other surfing, while voice call traffic is in the decline. There were reductions of 5% in fixed line calls and for the first time just over a 1% reduction in voice calls from mobile

handsets. Importantly, in this Ofcom CMR report it was noted that: “Teenagers and young adults are leading these changes, increasingly socialising with friends and family online and through text messages despite saying they prefer to talk face to face.” Taking these findings from these reports confirms the thoughts that teenagers in the target audience, about to study at QCF Level 3 are those students who are making frequent use of their mobile phones so using this knowledge seems an obvious point for this project to link into their world.

2.3 Educational Theory and Learning Styles

Ideas, or even ideals, of educating children have changed over time. From ancient Greek scholars such as Socrates (470 or 469 – 399 BCE), Plato (428 – 348 BCE), and Aristotle (384 – 322 BCE) flowed many elements of learning and teaching. While little of Socrates' thought remains in direct literature today, Rowland (2006) argues that the importance of his work continues to fuel academic and educational debate. Plato's interest in the soul, dialogue, and in lifelong education continues to provide educators with views that it is the business of education to discover the aptitudes of different individuals and to progressively develop them for the benefit of society. Dewey, Morris, and Shapiro (1993) comment that Plato's 'Republic' was the most influential early account of education showing how a stably organized society coalesces with individuals doing that for which they have natural aptitude so as to be most useful. Aristotle is considered by Hummel (1993) to be a teacher to whom the full development of the human being includes the development possible through education, that education is sufficiently important as to be controlled by the state, and that learning is a lengthy process – lifelong learning as mentioned above.

Deductive learning, which is a teacher centric method, is styled to present a concept to the learner, maybe as a set of rules. The learner then practices some examples of the concept to 'learn' the 'process'. During the seventeenth century the learning models of Aristotle, whose style of deduction lasted from dates before the common era (BCE), were developed into inductive learning by Bacon (Simpson, 2005). Inductive learning is a more learner centric style where the student is presented with examples of the given concept in order to formulate their own understanding (Bilash, 2011).

Using a combination of these two approaches; deductive reasoning and inductive reasoning, Cohen et al (2007:7) describes research in the areas of natural science as being the “most successful approach to the discovery of truth ...”. Other thoughts about research are: “defined by Kerlinger (1970) as the systematic, controlled, empirical and critical investigation of hypothetical propositions about the presumed relations among natural phenomena.” (Cohen et al, 2007:6)

The development of teaching based on a learners’ own research and experiment, and work coming from the field of psychology, through a long period of time have resulted in the educational theory of ‘constructivism’. A comprehensive definition of constructivism provided by the College of Education at the University of Saskatchewan is introduced by this paragraph:

“Constructivism is a theory of learning based on the idea that knowledge is constructed by the knower based on mental activity. Learners are considered to be active organisms seeking meaning. <Constructions of meaning may initially bear little relationship to reality (as in the naive theories of children), but will become increasing more complex, differentiated and realistic as time goes on.” (USASK, c. <2000)

So the important concept of the work underpinning constructivism in education is how learners build their own understanding from their experiences and interactions. To reflect this concept the focus of teaching has changed over time from being ‘teacher centric’ to become ‘learner centric’. Rarely now does a teacher pour out knowledge from their fount; they facilitate a learning process within the environment they have, mainly the classroom or laboratory, where learners learn their own understanding of a subject through experiencing facets of that subject and building their own learning. Students also have to accept responsibility for their own learning.

This development in understanding evolved following the study and writings of such pedagogical innovators as: Rousseau (1762), Pestalozzi (2010), Piaget (Atherton, 2011a), Vygotsky (1996), and Bruner (Bruner, Goodnow & Austin, 1956), among others that cognitive learning proved effective for most children. <The student is allowed to learn by building their own concepts and understanding from their experiences.

Jean-Jacques Rousseau (b1712 - d1779) and Johann Heinrich Pestalozzi (b1746 - d1827) are both considered to have added to the development of education and to have made great contributions since Socrates. Rousseau differed from the Platonic view of education. Rousseau's ideas flowed from his concern that society grew more corrupt. He proposed education for children, to some extent, to be self-generating and best if carried out away from the city in a rural environment. Rousseau also designed education for children to match what he defined by three stages of child development that he categorised by age (Gutek, 1988).

At a similar period in time, Pestalozzi realised the importance of education being provided by the state to support the development of thought in the evolution of democracy and the need for children to follow a developmental path (Dewey, Morris, & Shapiro, 1993:116) similarly to that proposed by Rousseau (1762) in his book *Émile*.

Elliott and Daniels (2006), note that learning by rote was criticised by English educationalists. Then they reflect back on this and note that the thoughts and practices of Pestalozzi who spent many years practicing his doctrine that "education must follow the natural process of mental evolution."

Piaget's approach, described by Atherton (2011a), is central to the school of cognitive theory known as "cognitive constructivism" which builds towards the modern concept of constructivism as an educational method with general acceptance as being effective and good practice.

There is critical debate about how accurate Piaget was with his Key Ideas, and four stages of cognitive development. Atherton (2011a) gives a concise if rather simplified view of Piaget's Key Ideas. Atherton lists: Classification and Class Inclusion, Conservation, Egocentrism, and Operation and argues that these can be considered as developmental stages in an individual's cognition that demonstrate their progress. For example, a child is unaware of the volume changes in containers of different aspect ratios, or of conceiving that a team shows greater achievement when working together than as individuals. Thinking of these steps as being stages of ability or of development they approximate to the development of

children in an academic and ability sense and also to the educational levels introduced by the QCF.

Other scholars such as Vygotsky and Bruner are referred to as ‘social constructivists’. They have laid more emphasis on the part played by language, particularly dialogue and social interaction between learners enabling and making a specific contribution to their learning process and highlighting the importance communication plays.

According to the Vygotsky Group Online P540 (1996), Vygotsky’s work on psychology was not approved of under the soviet regime and so remained dormant until the 1960s, well after the death of Stalin in 1953. His work resurfaced in Russia as political influences decreased on academic life and Vygotsky’s commentaries on Piaget were belatedly published in the West. Vygotsky’s (1978) work had therefore not been widely studied in the western world but this changed after this collection of his essays was published under the title ‘In Mind in Society’, edited by Cole et al (1978). By the late 1980s Vygotsky’s earlier ideas had become increasingly popular among educationalists in the United States:

The mind ... cannot be understood in isolation from the surrounding society. Man is the only animal who uses tools to alter his own inner world as well as the world around him. From the handkerchief knotted as a simple mnemonic device to the complexities of symbolic language, society provides the individual with technology that can be used to shape the private processes of mind. In Mind in Society Vygotsky applies this theoretical framework to the development of perception, attention, memory, language, and play, and he examines its implications for education. (Vygotsky, 1978).

Atherton (2011b) argues that Vygotsky’s work on social constructivism is summed up by the idea of extending a learner’s ability beyond what they know by extending the boundary of what they ‘can do now’. This aspect of educational theory impacts on the understanding of how students learn and provides guidance for the design of modern educational materials including the delivery of those materials to be more effective and efficient for the student being a further iteration of the learner centric concepts mentioned previously.

Included in his ideas Vygotsky introduced his concept of the ‘Zone of Proximal Development’ (ZPD) which is the name given to his theory that children (and learners in general) are only able to fully understand a concept after reaching a specific point in their own cognitive development. This ‘Proximal Zone’ being the overlap between their own sphere of knowledge and other knowledge or skills they have yet to learn as shown in Fig 2.2: Zone of Proximal Development, Vygotsky (Training Teachers Globally, 2011). As learners make progress and develop they are able to assimilate further knowledge and they learn from others, especially their teachers. The term – More Knowledgeable Other (MKO) – is also used to make the relationship of a teacher, tutor, or mentor clear. Growth in knowledge and capability following learning mentored by a more knowledgeable other (MKO) is also likened to learning together as: watching, helping, being helped a little, and then taking the lead in doing. The important aspect of this from Vygotsky being that learning occurs in the Zone from areas that used to be outside the learners zone.

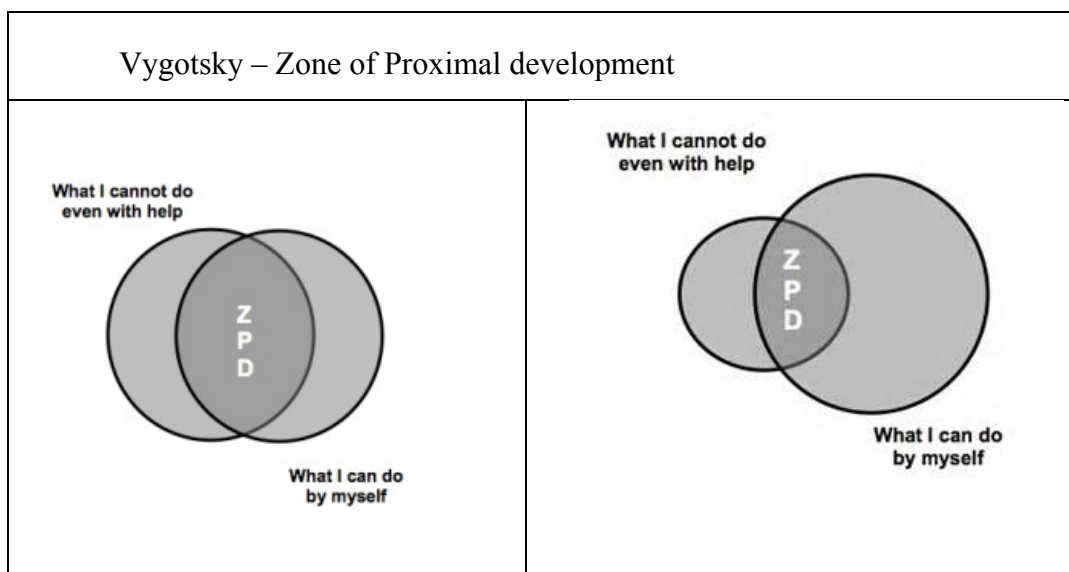


Fig 2.2: Zone of Proximal Development, Vygotsky (Training Teachers Globally, 2011)

Both Piaget and Vygotsky proposed their constructivist theories of cognitive development and although they are often compared the concepts have differences. LeGard (2004) argues that Piagetian theory marginalizes the social contribution to intellectual

development and that consequently the Vygotskian approach offers a more accurate and comprehensive analysis.

One important aspect from the concept of constructivism which is shared by both researchers is that constructivism includes – Active Learning; especially so for younger learners. Also referred to as Learning by Doing, Active Learning has been defined as:

Active Learning; is a term that encompasses a wide range of pedagogic approaches which have been used in both schools and universities over a long period. There is evidence that where we wish to engage students so as to encourage their active engagement in a life-long learning process that promotes reflection and the use of higher order academic skills such as analysis, synthesis and evaluation, this is the path to follow. (McManus, c. 2007)

And thus, Active Learning is one facet of Constructivism as is discussed in the next section.

Because of developments in learning theory and that this project deals with teaching in context some other terms are defined: discovery learning, knowledge building, and knowledge transfer:

Bruner (1961) advocated discovery learning (or inquiry learning) around realistic problems, and that the notion that students should learn through practice, application, and apprenticeship has been with us for centuries and has a similar concept as promoted by Pestalozzi.

Knowledge building includes the concept of adding and extending to what the learner previously understood, or knows, and also developing the ability to transfer that understanding to new situations and cases: “ ... authentic learning contexts help students to develop knowledge that can be transferred and applied to new problems and situations ... ” (Grabinger & Dunlap, 1995)

2.4 Constructivism

As explained previously; rote learning is where facts are simply to be remembered by copying, listening, or reading while in ‘constructivism’ learners build their own knowledge

from their own experiences. From their work in the field of cognition, Piaget (b1896 - d1980) and Bruner (2009) in particular have argued that learning is improved by the active involvement of learners. Further, that this learning in an environment allows learners to 'construct' their own knowledge for themselves and that these building blocks of personal knowledge are essential to the foundation of new understanding.

Piaget's work produced theories about the stages of Cognitive Development in children from birth up to the age of around eleven years. When this was considered alongside Bruner's work in developmental psychology it became the core of a pedagogical concept referred to as constructivism. In his 1996 book, *The Culture of Education*, these arguments were developed with respect to schooling (and more generally to education). 'How one conceives of education ... ' he wrote, ' ... we have finally come to recognize, is a function of how one conceives of the culture and its aims, professed and otherwise.' (Bruner, 1996:ix-x).

Bruner's work on constructivist theory provides a general framework for instruction based upon his studies of cognition. Much of the theory links across to earlier research into child development (especially that of Piaget). The ideas outlined in Bruner (1961) originated from a conference focused on learning in science and mathematics. Bruner illustrated his theory in the context of mathematics and social science programs for young children (Bruner, 1973). The original development of the framework for reasoning processes is described in Bruner, Goodnow & Austin (1956), and Bruner (1983) focuses on studies of language learning in young children.

In explaining how learners learn, particularly for learners of younger years, in addition to the work of Piaget and Bruner, the theories of John Dewey, Marie Montessori, and David Kolb serve as further foundations of constructivist learning theory as will be outlined.

Dewey (b1859 – d1952) noted how experience was valuable to the task of learning. Experiential learning stems from; "all genuine education comes through experience" says Dewey (1938:25). Arguing for the widening of education from a select academic cohort

with separate technical education Dewey, and others, promoted progressive education and battled for this against legislation in the United States of America (Westbrook, 1991).

Montessori (*b*1870 – *d*1952) observed four distinct periods, or "planes of development" (1969), as humans mature. Her planes of development were observed to extend from:

- birth to six years,
- six to twelve,
- twelve to eighteen, and
- eighteen to twenty-four years.

Montessori argued that different characteristics, learning modes, and developmental imperatives active in each of these planes, and called for educational approaches specific to each period (Grazzini, 1988). The educational Montessori Movement still operates on these concepts and is well regarded by many claiming 22,000 schools in 117 countries (Montessori Movement, 2011) and with an unknown number of home educators teaching their children using her theory (Montessori, 2013).

Kolb's (*b*1939 –) contribution about the Experiential Learning Cycle, shown in Fig 2.3: Kolb's Reflective Learning Cycle (Kolb, 1984) may be one of the better-known educational theories today. Like Dewey, Kolb discusses experiential learning in terms of the need for a reflective phase during the learning process (Kolb, 1984). Moving around the cycle from one viewpoint to the next is one simple view of Kolb's Experiential Cycle. There is no reason why a learner should not travel the circle many times for the same or different topics.

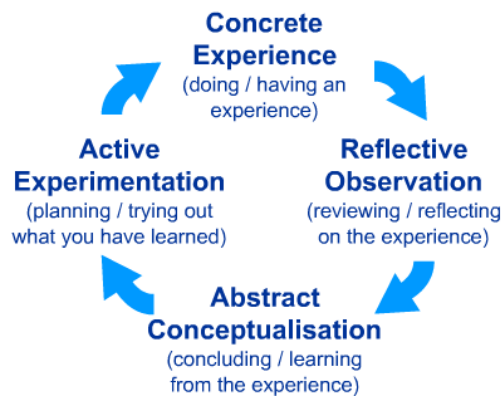


Fig 2.3: Kolb's Reflective Learning Cycle (Kolb, 1984)

So the general outline of thought in current educational practice and theory is to allow students to learn from their experiences. That by building their own concepts and developing their understanding of those ideas a deeper learning becoming available to learners and this allows the most able to progress further along their own learning path while those with other skills can develop their own pace of understanding; which is possibly better suited to their needs. Work on aspects of 'Deeper Learning' is the subject of research in the United States (K-12) with students from elementary level to twelfth grade (UK equivalent is Years 1 – 13) and that teaching should incorporate learner centric instructional programs. In particular priming student motivation by “connecting subject topics to students’ personal lives and interests” and for students to take responsibility for their own educational development and what they should be engaged with (National Academy of Engineering, United States, 2012).

2.5 Learning Theories and Learning Styles

There are many theories about Learning; the online Instructional Design website (Instructional Design, 2011) lists 50 while the 'Learning Theories, A to Z' book lists 500. (Leonard, 2002). The general consensus is perhaps summed up by: learners learn best by being actively involved in the learning process, that interaction with others aids the learning process, and building on their own knowledge base is an important factor. Educators should, where possible, avoid theoretical teaching where students are trying to learn and understand yet only using abstract concepts.

The process of ‘learning’ is generally agreed to have some variations and is individualistic. Educators use different learning styles: for example, active learning, discovery learning, and knowledge building, to provide variety in their delivery of material to learners. Learners also vary. Some grasp one new concept with surprising ease, others may not do so and they may benefit from a different viewpoint being explained. This process may be even more important for the learner if it is self-generated by themselves. Some learners benefit from different analogies being explained on any given topic before they are comfortable in understanding it. Listening and watching are passive ways of learning, and it requires great mental skill to translate what we see and what we hear into knowledge (UNICEF, 1999). Most children learn best when they learn through action. Regardless of the variety, constructivism promotes a student's free exploration within a given framework or structure (Lombardi, 2011). The teacher acting as a facilitator encourages students to discover principles for themselves and to construct knowledge by working to solve realistic problems. Aspects of constructivism can be found in self-directed learning, transformational learning, and experiential learning” (Oliver, 2001).

2.6 Context

This project tests the possibility of linking to a context that the students currently use, text messaging, so that they may be more motivated and enthused to learn about the subject. Context-based learning is a term used to describe teaching by linking the relevance of the material to a context. In terms of project-based or problem solving study being the contextual link.

In daily use the word ‘context’ has a straightforward meaning. When ‘context’ is used in the title of some educational concepts the meaning is more closely aligned to the didactic approach. Context in learning has been written about from a range of science disciplines. In particular, Chemistry and Physics have a number of research publications aligned to this area of research as will be discussed later. In her thesis Gilbuena (2013), following the argument of Sawyer and Greeno (2009), uses the term ‘Situative Learning’ as she argues that all learning is based on some context. However this differs from the use in this thesis in so far as the contextual link is applied to the design of the learning material as

an introduction to encourage and enthuse students to participate rather than to develop a context from which a project or problem is to be solved.

In learning and teaching the word ‘context’ is generally referred to as context-based learning or context-based teaching; generally meaning that the teaching style is based around some real-life context that has relevance to the topic being studied. Other pedagogical styles are used as may be considered appropriate by way of encouraging students along their own learning pathway. This constructivist style falls into the active learning category and may often be using problem-based learning or case-based learning. These didactic approaches are intended to promote and enable life long learning and generate transferable skills and knowledge.

Using such didactic design may well add to the workload involved in preparing the course as teachers strive to include suitable topics and scenarios. Whitelegg and Parry (1999) explain how context may have several meanings. From a broadest definition of the social and cultural environment in which the student, teacher, and institution are located, to a narrower view of context being a focus on an application of a physics theory for the purposes of illumination and reinforcement. So almost all teaching can be categorised as context-based and so context remains firmly as one of the standard tools to be used by a teacher. Establishing a context can be a valuable teaching tool providing many opportunities to relate new concepts to existing knowledge and experience. Further, Whitelegg and Parry cite both Murphy (1994), and Hennessy (1993), reporting that research on context-based learning suggests that it has the potential to increase students’ interests if appropriate contexts are used; contexts that post-16 students are interested in and relate to their out - of - school or -college activities. Their project tested material for A-level and AS syllabuses as well as science and engineering based General National Vocational Qualifications (GNVQ). Taking advantage of the links between subject areas so the units titled: ‘*Physics for Sport*’ and, ‘*Physics on the Move*’ used similar knowledge (Newton’s laws) but showed how they were affected by the different contexts. After three pilot trials in different post-16 schools and colleges in England and Wales in 1995, several features of the material were revised and re-designed. In general students liked the contextual approach and wanted to see it taken

further. A second project on the Australian Victorian Certificate of Education (VCE) physics course was evaluated but differences of opinion arose over the understanding of the 'contexts' used and the assumptions made about the students' ability to transfer knowledge learned in one context to another. A number of participant teachers seem to have kept old style teaching as their key value and merely included applications and everyday examples into their traditional physics lesson plans in an attempt to make the subject more relevant. "The success of the course depends heavily on the teachers' enthusiasm for the approach; some choose to ignore it and although they may appreciate it makes physics more interesting for their students, some do not believe that it helps understanding." Major difficulties also arose when setting assessment questions. Examiners felt it was necessary to use the same contexts that had been used during the learning process feeling it was not 'fair' to expect the students to transfer their knowledge between contexts. This led to considerable disagreement between the members of the assessment panel. Two opposing views, one suggested the need to construct 'fake contextual questions' to satisfy the difficulties of applying knowledge across new contexts or situations, while the other view was of the value of having '... the subtleties and ambiguities of the real-world' to be dealt with, and that for some students this complexity of applying the principles of physics in real situations made it easier rather than harder to grasp the meaning of physics (Whitelegg and Parry citing Hart's 1997:8 conference paper). Determining the context was concluded to be essential for future research. This aspect of transferable knowledge appears to be paramount to the authors in establishing the validity of the teaching in context technique.

Prince and Felder (2006) consider Inductive Teaching and Learning Methods and how traditional deductive instruction in engineering changes teaching to encompass a more modern learning style. They refer to the development of an inductive approach based around; inquiry learning, problem-based learning, project-based learning, case-based teaching, discovery learning, and just-in-time teaching. Teachers and students also recognised that "teaching by telling" has its place. Indeed once motivated by these techniques learners often accept that the knowledge they need may be passed across to them very effectively by lecture and tutorial sessions. This 'Active Learning' promotes the learner centric approach of inductive teaching and learning options previously described and

equally promotes learners having responsibility for their own learning and development. The final summary of their work reports that the collective evidence favouring the inductive approach over the traditional deductive pedagogy is conclusive (Prince & Felder: 2006:23). The advantages are summed up to include: “that students adopt a deep learning approach (meaning-oriented) as opposed to a surface (memorisation-intensive) attitude, that intellectual development is promoted helping students acquire the critical thinking and self-directed learning skills that characterise expert scientists and engineers”.

Kelleher & Pausch, (2007) concentrate on generating enthusiasm and interest in computer programming. The subject has recorded a decline of up to -50% in computer science enrolment at research universities. There is also a level of inequality referenced to the Taulbee Survey (Zweben, 2005) between genders with nearly 85% of Bachelor’s degrees being awarded to men. Recognising that learning to program is a difficult endeavour, their approach was to use a gaming context with a focus on writing and using computer games. A ‘drag and drop’ style of coding was adopted using a tool called ‘Storytelling Alice’ which avoids syntax errors being input by users. Success for the project was claimed on the basis of girls being more active and using the computing platform out of core times. The girls who used ‘Storytelling Alice’ expressed a stronger interest in taking a future ‘Alice’ course. Informal user testing suggests that Storytelling provides similar motivation for boys

Bennett et al (2005) examined context-based and conventional approaches to teaching chemistry and analysed views from 228 respondents. The teaching experience for those respondents showed a mean of eighteen years for those teaching the traditional A level course. Staff trialling the new style course, referred to as ‘Salters’, had between four and ten years experience of presenting context-based type material.

Responses were obtained by questionnaire following a pilot test and these were evaluated using a mixed method approach that combined qualitative and quantitative data to provide a fuller understanding and interpretation of the results. Context-based teaching and learning, arguably two sides of the same issue, fall into the general category of Active Learning as mentioned above. An important aspect of their research was Student motivation in which they noted that:

“Salters teachers rate motivation in their classes significantly higher than the teachers of course A ... ” and also that: “ ... even the latter feel that the context-driven course would increase students’ interest in chemistry”.

Being learner centric, Active Learning puts more work on the teacher by way of material, preparation, and flexibility in providing appropriate resources for learners at the appropriate time. But, perhaps the greatest workload comes from the assessment and evaluation of students in such circumstances. Academic and technical content was a factor that received critical comment from both groups of teachers. There was criticism of a lack of conceptual knowledge mentioned for both styles of presentation. The just-in-time delivery for the ‘Salters’ course had pros and cons as a ‘drip-feed’ style of facilitation by teaching staff could be an advantage for some pupils; yet others were critical of the ‘disjointed at times’ feelings they had when only part of the knowledge was provided. The research concludes that particularly influential factors appear to relate to perceived benefits in relation to student motivation for teachers considering adopting a context-based approach to teaching (chemistry). Further that this motivation is both immediate (a local issue in their chemistry lessons) and shows an increased number of students electing to study chemistry at university.

A similar approach to the teaching of Physics in schools and colleges by Taasoobshirazi and Carr (2008) identified three major limitations of research on context-based physics. They highlighted the difficulties for the design of a context-based curriculum. Experience gained from their research led them to recommend that Learning Materials are realistic, interesting, and familiar. To achieve this for all students in a group of any size poses fresh questions for each group involved. Overall Taasoobshirazi and Carr remained unconvinced that context-based instruction should be used in the classroom for the teaching of physics.

Taasoobshirazi and Carr (2008) reviewed further other related studies that have used contextual, real-world problems in the teaching of physics which have yielded the following observations:

There is evidence that context-based instruction in mathematics has been found to suppress transfer of knowledge to other contexts (Bassok, 1997). This is thought to occur because the knowledge becomes context-bound and not easily transferred

to other similar situations (Renkl, Mandl, & Gruber, 1996). There is a lack of research examining whether students better transfer the knowledge and skills learned in context-based instruction to various contextualized, real-world problems when compared to traditional physics instruction.

They also refer to two studies implementing contextualized instruction that included a measure of achievement and a control group (Murphy et al., 2006; Wierstra & Wubbels, 1994) reporting that:

... both used abstract textbook problems to assess students. Testing whether context-based instruction better promotes transfer to contextualized real-life problems would require a study that includes both a context-based instruction group and a traditional instruction group as well as a good measure or measures of transfer to contextualized real-life problems. This research has yet to be done.

For the focus of this thesis, the word ‘context’ is used in the sense of being one in which the learners are more than likely to be extremely familiar with and hence, its use becomes a tool for providing a storyline along which appropriate technical and scientific principles are explained. Used in this way to piggy-back on the technology being used almost without thought by the users for the complexity the technology contains, and showing how there is an end product which is popular and commercially successful and from which careers can flow as a way to meet the focus of this research.

2.7 E-Learning

For any research project information retrieval has to be carefully managed. Sixty years ago that must have been a very different experience and one insight to the future was a machine, The Memex, conceived to tackle such difficulties (Bush, 1945). Computer Based Teaching (CBT) developed during the 1960’s, although it had its earliest origins as early as the mid-1950’s. Since then it has been known under various titles: Computer Based Learning (CBL), Internet-based training or learning, web-based Training or Learning. In this thesis all of these terms are included under the general title of E-Learning.

The first large-scale example of E-Learning was called ‘PLATO’. The name was originally chosen for its obvious connection to the Greek Philosopher; but the ‘backronym’ (an acronym formed after the event) was created from ‘Programmed Logic for Automated Teaching Operations’.



Fig 2.4: Plato V Terminal, (Wikipedia 2013)

This was a large computer-based educational system created at the University of Illinois Control Systems Laboratory which ran on mainframe computers and users had online access in real-time. Plato II had a live demonstration on 11th March 1961 and the project survived until PLATO IV (with some PLATO V terminals) was closed down in 2006. Fig 2.4: Plato V Terminal, (Wikipedia 2013) displaying the 'RankTrek' application. This was capable of combining simultaneous local micro processor-based computing with remote mainframe computing. The monochromatic plasma display had a characteristic orange glow. Infra-red sensors mounted around the display watch for a user's touch input. From 1967 a funding stream was arranged through the National Science Foundation that permitted the prime movers of PLATO (Bitzer & Johnson; 1971) to set up the Computer-based Education Research Laboratory (CERL) at the University of Illinois. The mainframe network was custom designed and built and pre-dated Internet technology (TCP/IP) and for some time had more users than the Arpanet (the precursor to the internet which was developed under the United States Department of Defense). Hundreds of courses from elementary (primary) level to university level in Language, Mathematics, Music, and Science based subjects were served to thousands of students over the period 1961 until 2006. The elementary-mathematics demonstration included enough course-work to allow students to work on PLATO for about 30 minutes each day throughout the school year. (Example of archived screen shot, Fig 2.5: PLATO 'green screen' Chemistry module (Wikipedia, 2013)

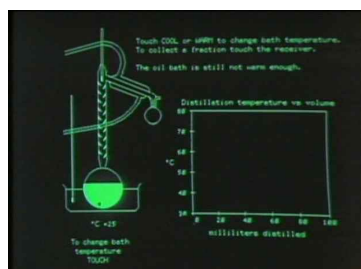


Fig 2.5: PLATO 'green screen' Chemistry module (Wikipedia, 2013)

Despite considerable investment by the private computer company CDC (Control Data Corporation) the project finally closed due to it being too costly.

An early United States Army Education report on E-Learning authored by Shlechter of the U.S. Army Research Institute, for the US Army referred to Computer Based Instruction (CBI) and noted some evidence of CBI being more effective in the training of: “poor quality recruits in some areas of gunnery and artillery.” Further, Shlechter (1988) recognised the potential benefit of CBI as a supplement to instructor led training. In particular CBI caters well with the repetitive nature of some rote learning sequences. The machine could wait patiently for answers and thus free up tutor resources for other tasks. Machines can be programmed to respond to right or wrong answers, but the level of inter-activity depends on the capability of the hardware and software, and the system design (Shlechter, 1988).

As computer technology advanced so too did the techniques and delivery methods for distance learning using electronic systems. These changed from being simple screen content with mostly one-way communication to the user; referred to as a mono-media system, to systems that allow multi-media and interaction with users. This allows for a wider variety of media in terms of images and sound. The early mono-media systems needed separate feedback routes to support student – tutor involvement. Modern day Virtual Learning Environment (VLE) and Learning Management System (LMS) now allow interaction at a completely different level with: online real-time messaging, blogs, forums, the electronic submission of coursework and assignments, and the statistical monitoring of

access, presence, and participation (Stanney et al, 2003). The terms Virtual Learning Environment (VLE) and Learning Management System (LMS) are used inter-changeably in this thesis.

2.7.1 Distance learning

Distance learning dates back many years, and was aligned with early correspondence courses. Selected subjects, for example shorthand, were advertised as early as 1728 (Wikipedia, 2013b) beginning with traditional correspondence (written) courses. Since then distance learning in Australia for example has evolved with technology; through Short Wave Radio links (from 1951), wireless Internet technology (from 2003) and onwards to E-Learning (Australian Education, 2007). Hicks, Reid, and George (1999) highlight the need for consistency in course learning material and how content and context must be used to help learners to learn. Learners are able to set their own pace as they study the material. Generally the E-Learning course material is referred to as ‘Learning Objects’ and the whole course being referred to as a ‘Learning Unit’.

Gibson (2001), then at Macquarie University, writes about: E-Learning that as IT and Communications Technology become ever more present in learning environments and agrees with Maddox (*sic*), et al (1997) in identifying two distinct types of application for E-Learning which have been categorised as: Type I and Type II. (*c/f* Maddux, 1997).

Type I E-Learning uses computing to make traditional teaching methods easier or more efficient. User involvement is relatively passive, and the programmer largely predetermines what happens on the screen. The type I applications merely parallel conventional instruction and may be thought of as “programmed learning events” (Maddux, 1997) for example patiently providing drill and practice exercises.

Type II E-Learning employs computers to make available new and better ways of teaching children. The user is the most important actor in the interaction and is the primary controller of what happens on the screen. Problem solving and other thinking skills are emphasized, and the computer is employed as a tool to aid cognitive processes. Examples of Type II would include “programming, simulations, and word processing”. Type II

applications take on the greater task of emphasising the: "... creation of new knowledge using exploration, discovery, and collaboration, through use of the computer as a self-directed learning tool controlled by the learner. (Maddux, 1997)"

Laurillard (1993) looks to update machine led teaching practices by adding both new media and new technology using a five-step approach to the development of material irrespective of the subject area. The five steps listed as her Template for the design of teaching emphasises.

- 1 Describe the Teacher's conception
- 2 Elicit the Student's conception
- 3 Pre-empt the teacher's re-description of the conception.
- 4 Elicit the student's re-description.
- 5 Define the interaction best suited to achieving the desired learning outcome.

Various interactions exist to conclude the desired learning process in the final stage (Point 5). For example: the task maybe re-defined or ensuring that a goal has been achieved. Further, suitable feedback may be used to generate greater self-confidence of understanding for the learner.

In a report prepared for the National Center for Education Statistics in the US, Bell and Federman (2013) recently published their conclusion that "the use of E-Learning in postsecondary education has expanded rapidly over the past decade, and all indicators suggest that growth will continue in the years to come."

This prediction from the United States is in agreement with recent statistics from the UK showing that we have the largest E-Learning industry in the EU, with more than 400 companies specialising in E-Learning for the corporate learning market alone. Usage levels amongst learners and organisations continue to move forward strongly. Indeed E-Learning is the only part of the corporate training market that is growing. Market forecasts indicate that expenditure on corporate E-Learning is growing at over 6% per year, and many E-Learning developers are reporting sales increasing by over 20% per year. So E-Learning is becoming more popular in the UK". (E-Learning Centre, 2013)

E-Learning is reported by Chadwick (2013) to be widespread in Europe and the US, where 70% of the world's E-Learning is utilised and is currently showing great growth in emerging markets. The rapidly developing countries of India and China are also experiencing major growth in the E-Learning sector. Signs are of continued expansion into the future so the use of this technology for this project seems to be a natural development in using the tools available for modern education.

2.7.2 Accessibility

Legislation in the UK and following educational good practice means being aware of the need to make web pages accessible to all users, whatever their level of disability. Developments in computing enable technology to be a useful tool in education. Guidance provided by the World Wide Web consortium (w3schools.com, 2013) helps to inform and educate web page design to meet the legal obligations (Equality Act, 2010) of ensuring accessibility for all users. Most educational establishments now rely on some form of Content Management System (CMS) to manage the amount of online and web based material and for the users they serve in terms of: course material, online submission of material, and other information processing and facilitation tasks, which may include online 'chat' and other collaborative applications. In educational use the CMS is often referred to as a Virtual Learning Environment (VLE) or Learning Management Systems (LMS). These are commonly found in educational establishments for course work and student support and typical examples include; Blackboard (2013) one of the leading commercial packages, and Moodle (2013) an open-source collaborative software option.

2.7.3 Content Creation Tools and Authoring Tools

Tools used for the development and authoring of Learning Materials are generally referred to as Content Creation Tools (CCT). E-Learning Authoring tools may be considered to be a sub-set of this larger group of Content Creation Tools (Paulsen, 2002).

The two important tasks are the preparation of teaching content and how best to display such content. For the preparation of the material, it is recommended to use an authoring tool that generates SCORM directly. If the content is exported to SCORM correctly, it can be used in multiple viewers, assessable in a multiple LMS and fully reusable as a unit of learning.

Examples of authoring tools are:

Adobe Captivate	http://www.adobe.com/
Articulate QuizMaker	http://www.articulate.com/
CDSM Pedagogue and Thinqi	http://www.cdsm.co.uk/
Course Lab	http://courselab.com/
CCM Eddy	http://www.ccm-solutions.com/
eXe Editor	http://exelearning.org/
Hunter Stone Thesis	http://www.hunterstone.com/
Raptivity Authoring Tool	http://www.raptivity.com/
RELOAD Editor	http://www.reload.ac.uk/
Westcliff Data Myles	http://www.westcliffdata.co.uk/
Wimba Course Genie	http://www.wimba.com/

The E-Learning Authoring Tool Pedagogue was made available to this research via the Salford Education Authority. Pedagogue was available from CDSM Interactive Solutions in Cardiff, S Wales. It allows material to be produced as text, image, and in audio formats and will produce a SCORM compliant file that provides for interoperability so that Learning Materials will integrate with most VLE or LMS software running in most educational establishments. Pedagogue has a proven track record as an Authoring Tool, being used by Cambridge University Press (CUP) in building their Global University presence on the Internet. They claim to be the “main commercial provider for English as a foreign language E-Learning worldwide” (CDSM, 2013). In addition to CUP, Honda have developed their Europe wide training system based around their own LMS using CDSM’s latest authoring tool named ‘Thinqi’ (CDSM, 2013).

2.8 Summary

This chapter has reviewed the teaching of Science and Engineering within the UK and the usage of technology pertinent to students in their pre-university age group. An overview has also been presented of some of the background underpinning educational theory and how learning styles can assist learning by matching how people learn and encouraging their participation in Active Learning. The important aspects of context and contextualisation were defined and set into context for this project and with other uses of them as educational concepts, and in the wider field of educational practice. How E-Learning evolved from various aspects of education and how this is pertinent to this research is discussed. Finally, consideration is given to the need for Content Creation Tools, the importance of accessibility and standards compliance for system interoperability. There is evidence to support the use of context based teaching as an effective learning tool, although the research shows there are differences of opinion on its effectiveness. E-Learning is still emerging as an educational tool or educational method of content delivery and is likely to evolve further possibly changing quickly in line with the speed of developments in mobile and social computing which is a whole separate area of study.

The next chapter will examine how contextualised learning and E-Learning have been used in order to address the research question that was presented in chapter 1.

3 Chapter Three – Methodology

3.1 Introduction

Following on from the literature review presented in the previous chapter, this chapter will describe, critically evaluate, explain and justify the design and methodology used throughout this research project. Commencing with an outline of the research focus and the wider frameworks within which the research is located and then identifying the research strategy in terms of methodology, methods and management of the project will be explained. Other important areas covered are the ethical considerations including safeguards around the gathering, evaluation, and analysis of results obtained from students.

3.2 Research Focus

This research project focuses on the question:

Will learners be more interested, and therefore, enthused to study technology based subjects if the teaching of those subjects is directly related to their daily use of such technology?

Motivation for this research project originates from concerns widely expressed of a lack of qualified engineers and science students despite the plethora of technology surrounding them as was detailed in Chapter 1, and various educational projects intended to raise the profile of STEM subjects (Science, Technology, Engineering and Mathematics).

To answer the research question the following objectives were established:

- To carry out a review of relevant literature and educational research.
- To design a set of Learning Materials using a contextual concept to meet the needs of appropriate courses at Level 3 of the QCF.

- To author the learning material to an appropriate standard.
- To deliver the Learning Materials to students.
- To address the ethical considerations associated with evaluating the effectiveness of the materials on students learning.
- To gather and analyse the results obtained from the evaluation and hence conclude with an answer to the research question.

Much academic literature has been written about research methods and following good practice this chapter explains the planning of the results taking account of risks and bias to both fairly and accurately report the outcome. Cohen et al (2007) promote the overview framework shown in Table 3-1: Educational Research Framework (adapted from Cohen et al, 2007) as an aid in planning any research project, and this proved most helpful.

Preparatory Issues	>	Methodology	>	Sampling and Implementation	>	Piloting	>	Timing and Sequencing
Constraints, purposes, foci ethics, research question	>	Approaches, reliability and validity	>	Reliability and validity, pre-piloting	>	Re-evaluation	>	

Table 3-1: Educational Research Framework (adapted from Cohen et al, 2007)

3.3 Learning Material Design

In order to address the research question a set of Learning Materials are to be authored and evaluated with students. Therefore, it was important to choose an appropriate method for evaluating this research project. To that end, four options were considered: Serial, Parallel, a Teaching Staff survey, and running an evaluation in class with students, which will be referred to as an educational experiment.

Of the options listed serial testing would involve the setting up of a test group of learners to use material in the style developed against a control group of learners who would be taught in another style. This scenario could produce suitable data but would need to be conducted widely and over a comparatively long time. Assessing the preferred time period

for this scenario as being over three or four years this was not a workable option for this project and also contained the risks that the abilities of different groups of learners would be difficult to factor out of the experiment and other risks were of changes in teaching styles and changes in course content during the period of the experiment.

Secondly, as an alternative to serial testing, parallel testing would take up less time as the group using the new style material and the control group could be taught at the same time, thereby shortening the time needed to run the evaluation. However, the delivery would be more arduous and would probably have to involve different teaching staff. These variable factors would make it difficult if not impossible to assess all the variations introduced by differences in personal delivery styles and teaching abilities.

A third option considered was to involve experienced teaching staff directly. By using their knowledge of students' performances over time and asking them to use the material and then assess the outcome of the study in relation to how this style and delivery of material was perceived by their students. Firstly to consider if their students were enthusiastic and interested when this style of material was introduced, and also to consider the examination results achieved from both historical and current data. The difficulties of this approach include the changes that almost inevitably flow from teaching staff refining the style of contextual delivery even within a narrow framework, and the subjective nature of their final assessment of the project. These risks, and the risks of bias and unreliability when asking for recall of memories about previous classes and their abilities were considered too great.

Finally therefore, the fourth choice was to select a number of test groups of students who would trial the material and provide their own responses, and this was established as a working option to run the evaluation, or as it now becomes called, an experiment, conducted in class.

A decision was taken to develop the Learning Materials as an E-Learning package that could be delivered either within a classroom environment or online. The material would be developed using a SCORM compliant authoring tool called Pedagogue, access to which

was provided by the Salford Education Authority who work closely with the University on several learning and schools based projects and were a partner in this research project. The Pedagogue system is designed to be easy for content creators to use and offers a broad range of interactive options for engaging learners. Personal knowledge, which was confirmed in many discussions with experienced colleagues who regularly teach in classrooms, indicates the difficulty of working consistently from a script even in a formal lecture session. This thought was agreed to be the case even when a lecture is given strictly from notes with limited interaction between the lecturer and students. Hence, a further advantage of adopting an E-Learning approach was that the presentation of the Learning Materials would be identical to all students participating in the research. Existing and accepted good pedagogical practice includes using analogy and reflection to the knowledge and experiences that learners have previously gained or assimilated (Barnett, & Hodson, 2001).

It was decided to base the contextual nature of the Learning Materials and the courses for which it would intend to cover on the technology of the second generation of mobile phone systems that introduced the SMS text message facility to the world. This has undoubtedly been the most important application after the success of the first generation of mobile phones that used analogue technology and the statistics on the numbers of SMS text messages used were provided previously in chapter 1. The project needed to develop the Learning Materials around scenarios involving the everyday use of mobile phones and specifically the sending and receiving of SMS text messages and formulate an evaluation strategy to test the research question.

The process of sending and receiving a SMS text message is summarised in Fig 3.1: SMS Text Message Infrastructure. In order to communicate via a mobile network, each mobile phone must first establish a connection with their host network. This is achieved using radio communication between the antenna on the mobile phone and the nearest mobile network mast. A formal registration process follows to validate the mobile and its user. Thereafter the mobile phone is authorised to use the services provided by the network, which include sending and receiving text messages. The nature of the design of the mobile phone network restricts a text message to 160 characters in length. Software on the mobile phone

enables the user to type their message and for this to be encoded as data suitable for transmission over the mobile network. Once composed, each SMS text message is actually transmitted to a SMS server provided somewhere on the mobile network. Onward delivery of this message to the recipient requires the location of the recipient's mobile phone to be determined and to confirm it is actively connected to a network. Once these have been established, the SMS text message can be transmitted from the SMS server to the recipient's phone, which will alert the user to let them know they have received a new message.

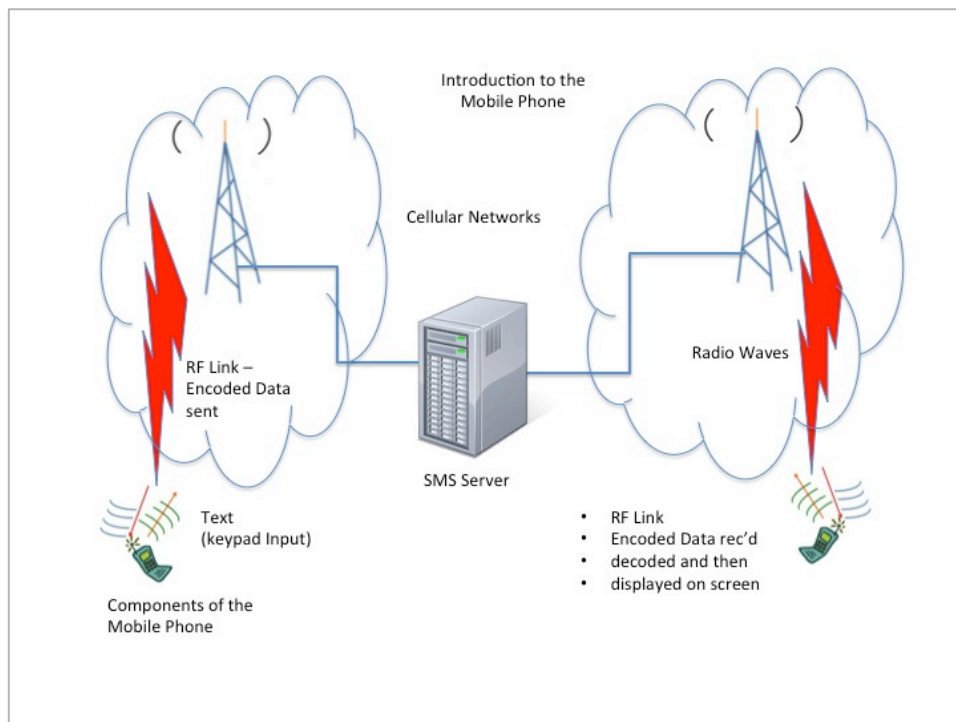


Fig 3.1: SMS Text Message Infrastructure

The Learning Materials were to be designed to meet the requirements of the A, A S, and BTEC, course content for Level 3 qualifications. Specifically a mapping exercise has been carried out to demonstrate how the text messaging scenario has relevance to AS Level

for Information and Communication Technology (AQA, 2009), A Level Computing (AQA, 2009), and BTEC Level 3 Diploma in IT (edexcel, 2011). The results from this mapping exercise are summarised in Table 3-2: Mapping Mobile Phone scenario to Qualifications that clearly demonstrates how the SMS text messaging scenario covers a breadth of relevant topics from each qualification.

Adopting the mobile phone scenario has relevance for the A S module on Information and Communication Technology (ICT) course (2009) which is described as covering, “The characteristics of information systems, hardware, software and communications which allow effective solutions to be achieved”. Specifically Table 3-2: Mapping Mobile Phone scenario to Qualifications, provides a mapping of some of the relevant syllabuses from the key elements of the SMS text message scenario.

Key elements of the SMS text message scenario	AS ICT	A Level Computing <u>Units</u>	BTEC Level 3 Cert in IT - <u>Units</u>
The process by which a plain text message is converted into data suitable for transmission over a mobile network.	Knowledge Information and Data	U 3.1.2 – Data Types, bytes U 3.1.3 – Binary	U21 Data Analysis and Design
To understand how a mobile network is able to provide text messaging services to users.	Capabilities & Limitations of ICT	U 3.1.3 – ASCII & encoding	U5 Managing Networks & U9 Computer Networks
To appreciate the internal components that comprise a mobile phone and what capabilities collectively they provide.	Capabilities & Limitations of ICT	U 3.2.3 – Machine Level Architecture U 3.2.4 – Hardware Devices	U12 IT Support, U13 IT Troubleshooting & repair, & U19 Computer Systems Architecture
To appreciate that a mobile phone and network uses radio frequency communication but only a limited number of frequencies are available for the whole country.	Limiting factors in ICT Systems	U 3.3.6 – Communications & Networking	U10 Communication Technologies

To appreciate the limitations of radio coverage within different physical environments.	Limiting factors in ICT Systems	U 3.3.6 – Communications & Networking	U9, U10, & U12 (above)
To appreciate how the popularity of text messaging and how this has transformed the way in which people communicate.	Impact of ICT; social and commercial	U 3.2.7 – Economic & Social Issues	U4 – Impact of IT on Business systems
To understand how the mobile phone enables people to communicate in a variety of ways.	The roles of communications system	U 3.2.7 – Economic & Social Issues	U3 Information Systems & U4
To understand how a mobile network is structured and why a cellular architecture is essential to provide nationwide coverage. To understand what systems are required within the network in order to provide and support the SMS text messaging service.	Network environments	U 3.3.6 – Communications & Networking, Network Topology	U9 & U10
To consider the human interface provided by a mobile phone and hence, how this has been used to facilitate the sending and receiving of SMS text messages.	Human Computer Interface (HCI) – machines	U 3.4 – HCI design, usability, types and context, feedback	U23 - HCI

Table 3-2: Mapping Mobile Phone scenario to Qualifications

3.4 Evaluation

Planning for evaluating the outcome of the experiment started during the early research so that this could be included in the overall strategy. Research data can be obtained in a number of ways, from observation, interview or perhaps the simplest and most economical method, by use of a questionnaire. Planning for the Learning Materials to be tested by users in a classroom environment or online the basis of the evaluation would be either qualitative or quantitative. The decision to test in class was a major factor in deciding

to gather information by asking users to provide feedback immediately after the end of a testing session. This would apply equally if the test were to be run online or in a classroom or laboratory. Tick-box or scale marking to be made at the time should encourage a good response rate and the relevant information would be fresh in the mind of the respondent.

3.4.1 Qualitative Methods and Quantitative Methods.

The two main methods of evaluation available within research are; qualitative methods and quantitative methods.

Qualitative research, has been defined broadly as: "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification" (Strauss and Corbin, 1990:17). In addition, Creswell (1994) describes qualitative research as a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem so appeared pertinent to this study. He also argues that since the only reality is that constructed by the individuals involved multiple realities exist in any given situation (Creswell, 1994:5).

Quantitative research may appear to be more reliable as the statistics can be accounted in great detail. As such, Boardman (1993:85) suggests:

'Quantitative research is usually described as 'hard' research which uses rigorous methods of data collection and analysis, resulting in 'objective' findings. Research of this kind tests preconceived hypotheses already deduced from a known body of theory. The data collected are normally analysed for statistical significance in order to verify, modify or reject the hypotheses.' (Boardman, 1993:85-88)

3.5 Mixed Method research

It is possible to intermingle the two main research methods, qualitative and quantitative. This option is given the title of Mixed Method Research, and it is argued by Creswell (2004) that Mixed Method Research gives greater validity to the results. This mixed method evaluation approach was chosen for this project once it was decided that student evaluation would be conducted by questionnaire in which they would be asked to provide both numerical and textual responses. Combining the two methods automatically

provides a level of validation of the responses as the content of individual responses can be cross-checked in a data editing session before compiling the base data for evaluation.

3.6 Validation and Reliability

Creswell (1998) refers to the need to robustly test the research to achieve a validated result less likely to be biased or skewed by external or internal factors. He identifies eight procedures for verifying qualitative research findings:

- *prolonged engagement and persistent observation*
- *triangulation*
- *peer review or debriefing*
- *negative case analysis*
- *clarification of researcher bias (reflexivity)*
- *member-checking*
- *rich, thick description*
- *external audits*

and recommends that any research study employ at least two of these procedures.

The design of a questionnaire will use concepts from this list in the evaluation phase. Having a range of questions that require a numerical answer and others that encourage a textual answer offers the opportunity for a researcher to be immersed in the project. This allows them to impart a qualitative aspect from their own perceptions of the textual responses as they are able to compare and contrast these with the numerical responses. This goes some way to addressing a number of the points raised in Creswell's list: triangulation, negative case analysis, member-checking, rich, thick description, and to some extent, clarification of researcher bias. Additionally, there is a cross-checking element of quantitative data with the qualitative responses that provides an automatic level of cross-checking during evaluation.

3.7 Learning Material Requirements / Design

The learning material being developed for this research project would need to satisfy the following requirements:

- *The Learning Materials must run on a college or school computer lab machine.*

- *The Learning Materials would need to be presented in a form that would be engaging to the target student audience.*
- *These Learning Materials needed to cover the learning outcomes needed to suit various qualifications based at Level 3 of the QCF.*

3.8 Ethics

The project involved contact with students and once research and people meet the subject of ethics has to be considered. All participants in any research project are afforded a protective set of rules, laid out at the University of Salford under the overarching concept of “... protecting the University, researchers and research subjects”. (University of Salford, 2013)

The British Educational Research Association (BERA) Guidelines (BERA, 2011) and additional guidelines from the University of Salford were considered and adhered to. The University of Salford ethics form was submitted prior to research commencing. Information regarding the purpose of the study, the main features of the design and the right to withdraw from research were shared with all participants. Permissions from staff at the other participating colleges were obtained on the grounds of themselves or one of their colleagues acting as a ‘responsible other’, and they were fully aware of the nature of the data being collected as a result of the experiment being run at their College. Confidentiality and anonymity were assured. Evaluation responses were collected on paper and this has been stored securely following the principles within the Data Protection Act (HMSO, 1998). The paper records are not accessible to any other party. The research participants were not perceived to be vulnerable adults, and should any issues of disclosure have arisen these would have been appropriately addressed.

The researcher holds numerous enhanced level CRB (now replaced by DBS) checks. Care would be taken when introducing the material to the students to emphasise the entirely voluntary nature of the evaluation process, that they were free to participate or not and that no action would occur should they exercise this choice. They were also informed how they could exercise their right to have their evaluations removed from the study at any time.

Evaluation was undertaken at colleges who contributed by allowing their students to access the Learning Unit and to freely provide feedback.

3.9 Summary

Having outlined the focus of the research project and the priorities two criteria were established as critical. The Learning Materials would be accessible on a college computer and presented in a form that would be engaging to the target student audience, and that these Learning Materials must cover the learning outcomes of suitable sections of the qualifications previously identified; based at Level 3 of the QCF. It may be that other courses will also be covered but that decision will be left to any users, ideally when guided to this by their tutors. Planning for evaluating the experiment was a central task that needed to be considered and prepared. The next chapter will provide a detailed explanation of the design of the Learning Materials that were developed for the research.

4 Chapter Four – Implementation

4.1 Introduction

Following on from the methodology described in Chapter 3, this chapter will examine in detail the design of a set of Learning Materials used to evaluate the key research question being addressed.

Will learners be more interested, and therefore, enthused to study technology based subjects if the teaching of those subjects is directly related to their daily use of such technology?

This learning material should engage the users and using the context of sending and receiving a text message, attempt to encourage and enthuse the study of science and engineering principles. The materials must also be relevant to the A S and A Level in Computing and BTEC Level 3 ICT syllabuses previously outlined.

A decision had been taken to use the CDSM Pedagogue Content Authoring Tool for the development of the Learning Materials.

4.2 Learning Materials Design Philosophy

Using the educational theories and best practices described and explained in Chapter 2 as a basis for the design of the Learning Materials the overarching philosophy is to build on the students existing knowledge base and use this as a starting point to develop their learning further. This relates to social constructionism aspects of active learning; Vygotsky's work (1978) that examined how learners benefit from learning in a situation where they can construct their own understanding of a new concept by adding this to the knowledge base they have at the start of the exercise. Similarly, Bruner (1996), and others, have researched cognitive development and, as with Vygotsky, recommend that presenting Learning Materials to a student needs to be done so in such a way that they can assimilate

the step up in knowledge level by building on their experiences and expand their own sphere of understanding.

The learning material, the whole of which may be described as a Learning Unit, is broken down into a set of smaller interlinked Learning Objects (LO). This follows the best practice linked to both capturing the attention of a learner and holding their attention span, and attempting to cater for their personal learning styles (Nehme, 2010).

Adding further to the background and design of the learning material, individuals often have their own preferences about the style, or the channel, they like best for receiving information. As there is some evidence supporting personal preference with regard to the 'channel' used to convey information the learning material is provided with a number of different Learning Styles as was mentioned in Chapter 2.

Consistent with David Kolb's (1984) experiential learning cycle each Learning Object has an introduction and conclusion and also explains where the Learning Object fits within the overall story of sending and receiving a text message. Kolb proposed this four-stage learning process as a model that is often referred to in describing experiential learning (Brooks, 1995 and McGill & Beaty, 1995 who are both cited in Oxford Brookes (2000)). There is nothing to prevent learners repeating this experiential cycle. Some learners benefit from repeating their journeys around the reflective cycle and it is thought that may establish or help build their knowledge in their experiential learning. This theory asserts that without reflection we would simply continue to repeat our mistakes.

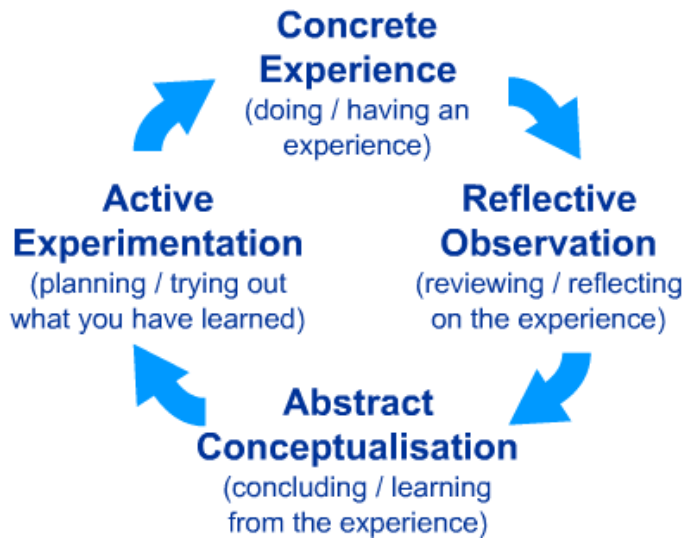


Fig 4.1: Kolb's Experiential Learning Cycle (Leeds, 2013)

Laurillard's (1993) template for the design of such learning material comprises five aspects:

- 1 Describe the Teacher's conception.
- 2 Elicit the Student's conception.
- 3 Pre-empt the teacher's re-description of the conception.
- 4 Elicit the student's re-description.
- 5 Define the interaction best suited to achieving the desired learning outcome.

Each of the five steps in this template were carefully considered and applied to the design of each LO in the following manner.

Point 1 – each Learning Object begins with an introduction explaining what it will cover.

Point 2 – is not explicitly addressed because these Learning Materials are designed for teachers to use within a structured learning environment. The foundation of the student's knowledge is neither assumed nor presumed allowing the course or class teacher to determine the student's readiness to study them.

Point 3 – Interactivity – the features of Pedagogue are used to design a varied set of interactive reviews, exercises, and mini tests.

Point 4 – the features of Pedagogue provide feedback on a set of mini tests that are embedded within the LO. Feedback is given in terms of correct answers, and where appropriate, learners are allowed a small number of further attempts by the student. Progress through the Learning Object is dependant on the user providing correct answers, however, should the correct answers not be provided after a pre-set number of attempts the answers are provided and the student may recap the previous work as often as they wish.

Point 5 – using an appropriate Pedagogue tool from one of the different styles available, and selecting the most appropriate one in the design of the mini tests.

Each Learning Object contains some research questions. In addition to expanding a student's ZPD (Zone of Proximal Development, Vygotsky, 1978) and this has direct relevance to active learning. This is recommended because of how this allows people to take more responsibility for their own learning, providing an activity that takes learners beyond that which was absolutely necessary. Prince & Felder (2006) argue that this helps develop critical thinking and increase their self-directed learning skills.

Accessibility, or 'making the on-screen web pages user friendly' was a design aspect addressed in Chapter 2. Pedagogue caters for individual user preferences in terms of screen and foreground colour and font sizes. Within the mini tests users are tasked to manipulate icons or other 'text holding boxes' on screen and are not required to directly enter text. This non-reliance on text entry further addresses issues of accessibility. Equally, providing feedback after each assessment offers users a progress check (Kelleher & Pausch, 2007). Where appropriate, in addition to the presentation of 'text on screen', Pedagogue provides a choice of multimedia elements that allows the use, where appropriate, of an animation, audio or video. In addition, images can be configured with interactive elements.

4.3 Learning Materials Design

The Learning Unit has been broken down into six Learning Objects with each focused on the following subjects, see Table 4-1: Learning Objects:

LO	Title
1	Introduction to Mobile Phones
2	Components of a Mobile Phone
3	Introduction to Radio Waves
4	More about Radio Waves
5	Encoding
6	Cellular Networks

Table 4-1: Learning Objects

Considering Fig 4.2, the six LOs explain many of the different aspects of the technology and workings of the mobile phone system. LO1 provides the introductory overview of a text message travelling across the mobile phone network from one handset to the recipient's cell phone. This is used to place various elements of the technology underpinning the concepts of radio transmission, data being input by the sender, and that the mobile phone network provides the communication infrastructure supporting this. LO2 explains the Components of a Mobile phone suitably grouped to provide a consistent and understandable concept to the learner. Both LO3 and LO4 deal with the theory and practice of radio wave propagation including: frequency, wavelength, modulation and signal coverage. LO5 explains the need for data to be encoded and the background to the SMS text messaging system that was made available to subscribers on modern digital mobile phones. LO6 explains the concepts used in designing and constructing the Cellular Network and how subscribers get access to the mobile phone network and how their text messages are handled across the network.

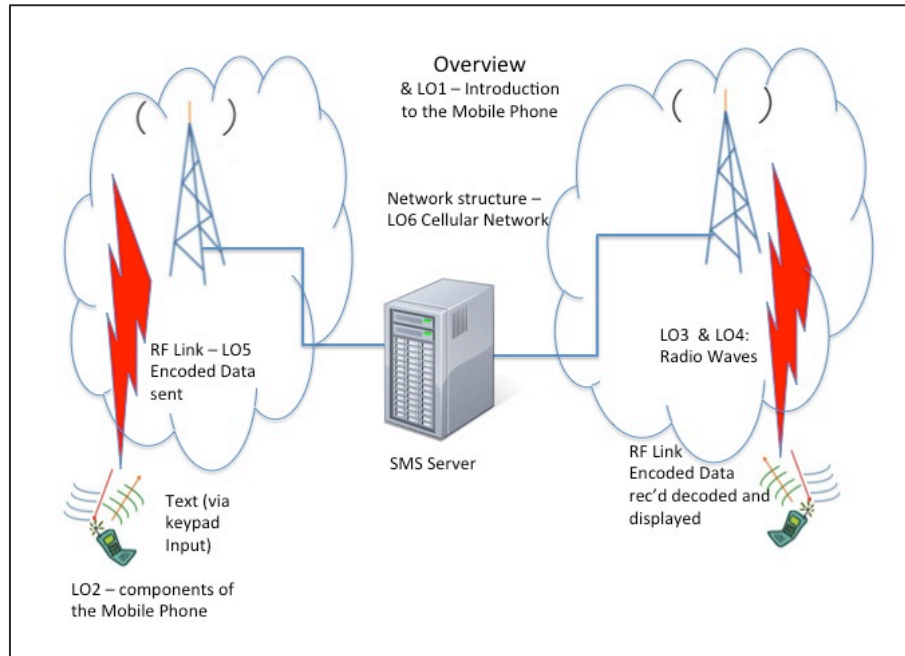


Fig 4.2: Text message to 'Tez', An Overview of the system

Each LO begins with a general introduction and a graphic that shows where each LO fits within the overall structure of the Learning Unit as shown at the bottom of Fig 4.3: which shows a typical screen shot of a Pedagogue 'page'.

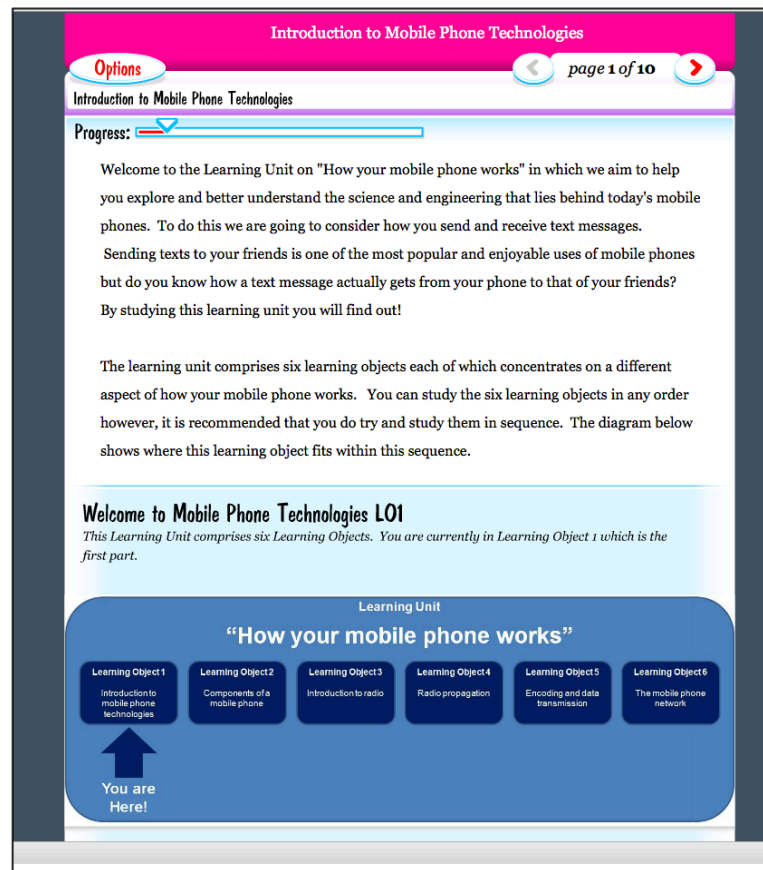


Fig 4.3: Screen Shot Page 1 of LO1 Introduction

Each page provides the user with access to the on-screen display choices under options, at the top left of screen and is followed immediately below with the LO title and a progress bar showing how far through the LO the current page is. The LO Title is repeated as a header line across the top centre of each screen and the page numbering is shown at both the top right and lower right. This is helpful as page length varies.

Progress to the next page within the LO is controlled by the forward arrow shown in Fig 4.4: Page forward / backward icon. Progress forward will often depend on successful

completion of an interaction or mini-test. The file does not allow forward progress unless questions on the current page are answered correctly or the number of allowed attempts has been reached.

Progress to the next or previous screen is indicated by the use of this page turn icon / image Fig 4.4: Page forward / backward icons.



The detail of each of the six LOs will now be explained with specific reference to how the various features provided by Pedagogue have been exploited to provide an appropriate educational experience.

4.3.1 LO1 – introduction to the mobile phone

The aim of this LO is to provide a general introduction to the Learning Unit and to explain the general context of the text messaging scenario. Overall it comprises ten Pedagogue pages, but these pages do vary in length.

The LO has an introductory page, shown in


Fig 4.3: Screen Shot Page 1 of LO1 Introduction. All LOs begin in the same manner with a first page welcoming the reader to the LO.

The second page, Fig 4.5: LO1 Page 2, provides the intended Learning Outcomes and in the case of the first Learning Object, LO1, this is to introduce the subject of sending a text message to a friend. This friend is referred throughout the storyline running through all six LOs, as the genderless ‘Tez’.

Introduction to Mobile Phone Technologies

Options page 2 of 10

Introduction to Mobile Phone Technologies

Progress: 

Learning Outcomes

.....


If you own a mobile phone then you are very likely to have used its texting function. In this learning object we are going to investigate the technologies needed to send and receive a text message - properly known as SMS (Short Message Service) messaging.

To do this we are going to follow the journey of a text message from a phone to a friend called "Tez".

At the end of this learning object you will:

- Have a basic knowledge of the key components required for mobile phone communication
- Have an insight into the growth of mobile phone communication worldwide

Let's now see how we text Tez!



Mobile phones

Fig 4.5: LO1 Page 2

As can be seen from the screen shot of this page Fig 4.5: LO1 Page 2, graphic elements may include photographs, in this case 'Mobile phones' which are providing background information and to help 'set the scene' of the storyline being recounted. The

task of illustrating technical material in the optimum style to benefit the communication of ideas to learners is a complex balance between using images that add to rather than distract from the learning process and not overloading the content with graphic items for the sake of effect or other less valuable reasons (Clark & Lyons, 2010).

This page introduces the topic using a short video clip of the process involved to send a text message – to their friend ‘Tez’. The section is introduced with a brief description and the user has to operate the ‘play’ button to run the video sequence. Pedagogue automatically presents the user with a standard interface comprising the usual: pause, play, and fast wind / rewind buttons,

Video clips may contain sound but this feature was rarely used to reduce noise in school labs; where experiences shows most machines are not fitted with sound cards in any case.



Fig 4.6: Video Clip - sending a text to 'Tez'

On Page 5 of LO2 the animation is used to explain the nature of radio frequency energy being propagated between a mobile phone handset and the local mobile phone network mast. Without specifically stating so the animation indicates that the wave like propagation of this energy spreads out across the intervening distance between the two parts of the mobile phone network as shown in Fig 4.7: Propagation of radio frequency energy. Running the animation shows circles of increasing radius to give an impression of radio frequency energy propagating or radiating out from the radio transmitter, and hence being capable of being picked up by a radio receiver.



Fig 4.7: Propagation of radio frequency energy

Having viewed the video and animation, the user's understanding is checked by means of a mini test that presents to the user a set of actions that must be followed in order to send a text message. These actions are displayed in a random order and then the user must place them into the correct chronological order. The process by which this is done is to use the in-built 'Drag and Drop' feature of Pedagogue – which will be described in more detail within section 4.3.3.

This was followed by a second mini test that was designed to ensure that the user is able to differentiate between the concepts of a mobile phone operator and a mobile phone network service provider. Within the UK there are now only four actual mobile phone network service providers but many more operators because multiple operators can share the services of one network. The user is presented with a list of operators and is asked to identify those that are actual network service providers.

Following the two mini tests, a new animation examines the ‘end to end’ nature of how a text message is transmitted from the sender to the receiver. Users have a ‘play’ option that animates a text message input on a mobile phone. Clicking on the ‘Next’ icon to the lower right corner of the animation screen runs through a sequence of five steps used to describe and inform about the passage of a text message. By having to click to progress forward, users control the timing they prefer to view this fairly complex clip by clicking on the on-screen button labelled ‘Next’ for each stage. They have the option to re-run the whole sequence once they reach screen five at the end of the sequence. Three of the screens are reproduced in Fig 4.8: Mobile Phone SMS Message System Overview. The full animation is available on the CD supplied with this thesis.

Screen	1 of 5	3 of 5	5 of 5
Image			
Text	A 'play' hotspot is available to left of handset. The Text reads: If you send a text message to Tez, your mobile phone sends a radio signal to a mast on the mobile network.	From here your text message is transmitted to a central SMS server where it is stored. The network is mostly connected by copper cable and optical fibre	Finally the message is transmitted from the mast to Tez's mobile.
Screen	2 of 5		4 of 5
Text	The message is transmitted by wire from the mast to the operator's mobile network	The text message is sent from the store to the mast closest to Tez's mobile phone	

Fig 4.8: Mobile Phone SMS Message System Overview

The use of animation was selected to demonstrate the concepts involved for learners who prefer the visual explanation to suit their learning style, and also for other learners who benefit from multiple channels of information.

Page 7 of the Learning Object recapitulates the material to provide time for reflection as with Kolb's learning cycle in order to strengthen the learning process. Three areas of the material are reviewed.

On Page 8 of the LO, users are moved a further step forward along the learning path by reviewing this LO and offering them some suggested resources for further or future personal research.

Two important points that need to be taken into account is firstly that many IT networks in schools and colleges block embedded hyperlinks; and secondly, Pedagogue does not allow cut and paste from the screen. The resources from this page provide an introduction to the International Telecommunications Union who provide a comprehensive range of statistical data relating to the adoption of IT and communications technology. Questions then encourage the users to examine this ITU data in order to identify, for example, which country has the most mobile phones? This provides teaching staff and learners some optional material they can follow-up with giving a mini-research project needing to evaluate some detailed statistical information and decide how to present it.

All LOs finish in the same manner with the penultimate page providing a summary of the LO and its associated Learning Outcomes and the final page showing the credits

4.3.2 Learning Object 2 – components of a mobile phone

The aim of LO2 is to introduce eight basic components used in a mobile phone and to show how these components are controlled by an Operating System to work in designed way as a mobile communications device. The decision was made to deal with ‘component blocks’ within the device to add to the concept of modularity, and observe some of the advice from Laurillard in detailing the technology involved. To some extent this is akin to using a black-box description to explain the workings of the various component blocks. As one of the longer LOs it comprises 14 pages.

Fig 4.9: Major components of a mobile phone, shows a block diagram of a mobile phone designed to form the basis for this section. The major components comprise: Battery, Central Processing Unit (CPU), Keypad, Memory, Microphone, Radio, Screen, and Speaker.

The major components of a mobile phone

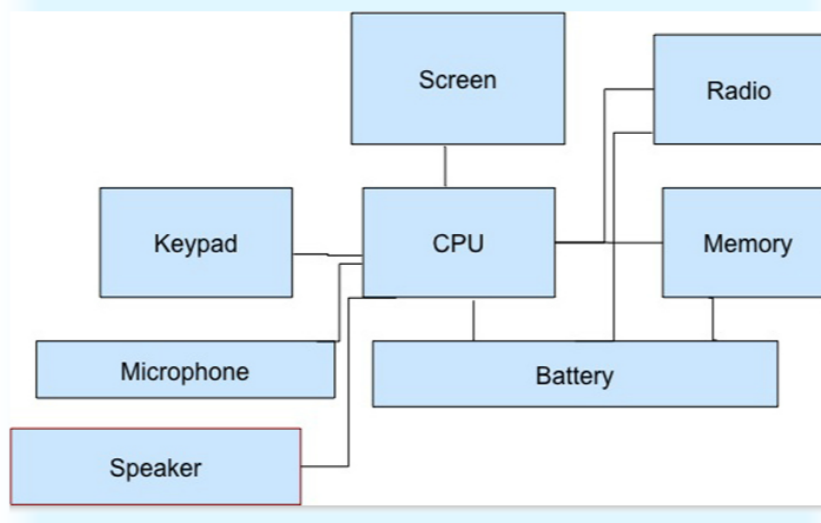


Fig 4.9: Major components of a mobile phone

A description of each component included in this component list details the level of knowledge being targeted and a paragraph or so is used to explain and place each of the eight identified component blocks in context for the reader. The operating system was not listed with the physical components but is included on Page 4 of this LO with this brief explanation: “The phone's operating system is 'hidden', constantly running in the background, so many users never even realise that it is there!”

Changes in the shape and the location of the antenna on a mobile phone are one of the most noticeable features when older and newer mobile phones are compared visually. Screens have changed a great deal too since the early days of the mobile phone. This is explained and a number of photographs used to display these changes.

A ‘hotspot’ activity requires users to mouse click on an area of the screen that contains a hidden ‘hotspot’ link. This asks learners to think about the logical placement of the speaker and microphone and their placement within the confines of a mobile phone. The image of a well-known but now older style of mobile phone is presented, Fig 4.10: Image, with Hotspots displayed, after user response, asking the user to click on the microphone and speaker locations. This presents a ‘tricky’ motor task for the student to consider and it is

difficult to be precise enough to pass this test with full marks, most users are awarded 67% since this particular image has three possible areas to click on, when users are only asked for two of them! This task seems to be more challenging for some than others and depends on personal dexterity skills and the settings for the mouse on the computer they are using.



Fig 4.10: Image, with Hotspots displayed, after user response

4.3.3 LO3 – Introduction to radio,

The aim of LO3 is to introduce the basic principles of radio communication and signal propagation, which is essential for connecting a mobile phone to the mobile network, and the material is covered in 12 pages.

Using an analogy between sound and light there is a simple introduction to radio frequency (RF) energy, and a Multiple Choice Question to set the scene based on a quote from an old film: “ ... in space ‘no-one can hear you scream’.” See Fig 4.11.

A Multiple Choice

From the list below select the correct answer and then click on 'Check Score' to see if you are right!

1. It is said that in space 'no-one can hear you scream'. Is this because:

- There isn't anyone out there to hear you?
- Space is a vacuum so there are no air molecules
- It's too cold for sound to travel
- It's just too far away

Instructions **Reset** **Check Score**

Light also travels as waves but, unlike sound, light waves *can* travel through space! This is because light is not a pressure wave. Light is what is called an electromagnetic wave. Electromagnetic waves are self-propagating waves that are formed from electric and magnetic fields.

Fig 4.11: In space, no one can hear you scream!

Only one answer from four is needed. The answer is likely to be well known and so it is provided after only one attempt. Introducing the students to the concept using this context seems appropriate and they should be able to appreciate that there is a spectrum of different frequencies in play. Their prior knowledge of the electro-magnetic frequency spectrum is checked using one of the interactions available within Pedagogue. Here we see an example of Drag and Drop using sequencing. This fits well with the topic and the graphic image provides clues to the answer. This interactivity is used in this question to reinforce the sequence of the spectrum and follows Laurillard's (1993, 2004) advice on interaction and content researched previously in Chapter 2.

This again makes use of 'Drag and Drop' and the detail of this process is that users use a mouse click to select an on screen object whose position is then under their control

while the mouse button is held down, known as ‘dragging’. The user is then able to manipulate the position around the screen. This allows objects to be repositioned in ways familiar to users of ‘wysiwyg’ control and mouse pointers provided in many modern software applications. Pedagogue offers different options for the interaction and these vary from selecting and moving one object to an answer box area on screen, and different choices are available to the author of the page, to positioning the objects in an appropriate sequence. This can be useful if there is a logical sequence to be learned about a concept being taught as was shown previously. So the ‘Drag and Drop’ interaction is the process of manipulating objects on screen, and comes in a variety of different flavours: for example, ordering horizontally, or selecting an item from a group to find the correct response to a question. Some research has shown Drag and Drop to be a popular interaction (Reichelt, 2006).

This next mini test uses Drag and Drop – Ordering with the ‘horizontal’ option. Users sequence the answer boxes on screen placing them into the appropriate order to ensure the sequence is correct, in this case in increasing order of the frequency of the radio wave.



Fig 4.12: RF Spectrum

The horizontal format of the image Fig 4.12: RF Spectrum is used with the Drag and Drop activity described previously, and the screen is shown in Figure 4.13 - Drag and Drop Horizontal Ordering. The question is answered by ordering the response boxes horizontally in the appropriate sequence, in this case that of increasing frequency of radio energy.

A Drag and Drop Horizontal Ordering

Place the following seven devices in order of the electromagnetic frequency that they use. Start with the lowest frequency device on the left.

Four empty blue boxes are provided for the answer.

A horizontal scrollbar is located below the empty boxes.

Below the scrollbar, the following devices are listed in boxes: Radio, Microwave oven, TV remote control, Torch, Sunbed, and X.

Another horizontal scrollbar is located below the device list.

At the bottom, there are three buttons: **Instructions**, **Reset**, and **Check Score**.

Figure 4.13 - Drag and Drop Horizontal Ordering

After starting with frequency, wavelength is introduced telling learners how the basics of Wavelength, Speed and Frequency are related through the following equation:

$$\text{Speed of light} = \text{Wavelength} \times \text{Frequency}$$

The relationship of wavelength to antenna length is explained and further interactive mini-tests are provided in order for learners to confirm for themselves that they have understood the concepts covered.

Next, the subject of modulation is described by means of a graphic as shown in Fig 4.14: Modulation.

Modulation by: Amplitude, Frequency & Phase

The animation below shows the effect of applying amplitude, frequency and phase modulation to a radio wave. Click the Next button to see each type of modulation in turn.

Carrier Wave
Data to encode
0 1 1 0 0 0 1 1
Next

If you are unsure about how the animation above works click the "Instructions" button for help [INSTRUCTIONS](#)

The animation below shows the effect of applying amplitude, frequency and phase modulation to a radio wave. Click the Next button to see each type of modulation in turn.

Carrier Wave
Data to encode
0 1 1 0 0 0 1 1
Amplitude Modulation
Frequency Modulation
Phase Modulation
Next

If you are unsure about how the animation above works click the "Instructions" button for help [INSTRUCTIONS](#)

By clicking on the 'Next' button the animation runs one of the subsequent three modulation lines providing a graphical illustration of the differences in the modulation method.

Fig 4.14: Modulation

Modulation happens when information is added to a radio frequency wave. The original wave is deliberately changed by the addition of the extra information it has to carry. The first line shows the sine wave form of the carrier frequency, then a series of '0's and '1's to be added to the carrier wave. Then there are three pictorial representations of different modulation methods, starting with Amplitude Modulation, then Frequency Modulation, and ending with Phase Modulation. These three different waveforms add in sequence so the learner may consider the impact of the information being added to the RF Carrier wave.

Following this graphic is a further mini-test using the Drag and Drop interaction but this time 'with distractors'. The Drag and Drop feature of Pedagogue when used with 'distractors' simply means that more answers are provided than required. Hence, the distractors are actually wrong answers but they may be very convincing possibilities. The inclusion of these distractors tests a user's cognitive skills to increase their concentration and thinking about the task in hand from the detail included in the material, Fig 4.15: LO3 - Drag and Drop with Distractors. In this example, only one selection is allowed from the four

options. Choosing distractors carefully allows the author to fine-tune the level of checking and feedback during these interactions to suit the needs of the subject and the learner.

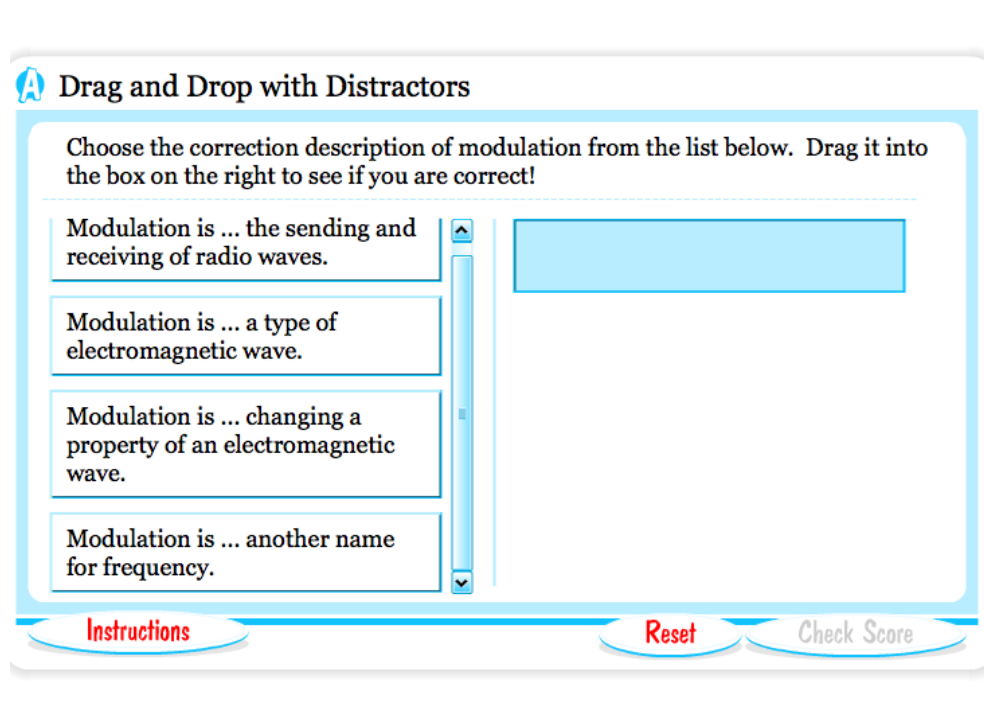


Fig 4.15: LO3 - Drag and Drop with Distractors

Under ‘Review’ on Page 9, two questions are used as recapitulation of the subject matter in support of the learning outcomes, and to provide learners with a starting point for their own reflection. The learner is introduced to the topic of Digital Radio and asked about the diverse transmission methods used in broadcasting. Referring readers to the Ofcom web site and Digital Radio on the Internet as a starting point for their research.

4.3.4 LO4 – Introduction to Radio Waves

The aim of LO4 is to explain how radio frequency energy is transmitted by waves and why this is important to the operation of a mobile phone. It comprises 12 pages. The Learning Outcomes are stated on Page 3: “In this Learning Object we are going to investigate how your mobile phone produces and uses radio waves to communicate.”

This LO begins with a review of the terms of wavelength and frequency that were first introduced in LO3. This is important as these concepts are important to the understanding of this LO and it cannot be assumed that a user has completed LO3 before commencing LO4. Knowledge of this inter-relationship is used to build on with an understanding of why antennas are made to a resonant length. The quarter-wave antenna is the basis of this and then learners are introduced to the concept of the ‘patch’ antenna design that moves users away from the rod antenna of yesteryear enabling the case to contain the antenna. The added advantage of directivity helping to keep RF energy away from the users head is also referred to.

Frequencies in use around the globe are explained, hence modern phones may well be described as ‘quad-band’, and that the fourth generation technology for mobile phones (4G) was being evaluated long before its market introduction was tested in 2013.

The concept of RF energy travelling wavelike and unimpeded is told and that the energy becomes so small it may not be possible to recover the signal as it dissipates throughout space. Directivity of the patch antenna is covered and then the learner is provided with a progress check not used previously with a multiple-choice question with multiple correct answers. Of the four statements offered, two are correct with the remaining answers being deliberate distractors. As there are only two correct answers attempts are limited to two before the answers are supplied Fig 4.16: LO4 - Antenna pattern, advantages.

A Multiple Choice

Click on all the right answers.

1. Why is changing the radiation pattern from a mobile phone a good idea?

- Uses less battery power to communicate over the same distance
- Limits your exposure to radio waves.
- It allows you to use your phone anywhere in the world.
- You don't have to speak so loudly into your mobile phone.

Instructions **Reset** **Check Score**

Fig 4.16: LO4 - Antenna pattern, advantages

Antenna radiation patterns are explained to show how directivity may be beneficial to cellular network operation in various locations to optimise the signal path. The advantages of this directivity gain being reciprocal for both transmit and receive. The problems of poor signal coverage is then dealt with using the diagram in Fig 4.17: Radio Transmission blockages to highlight the difficulties of terrain and buildings blocking radio transmissions, along with the problems of RF shielding found in metal structured buildings and other massive objects. An explanation of signal reflections is also included.

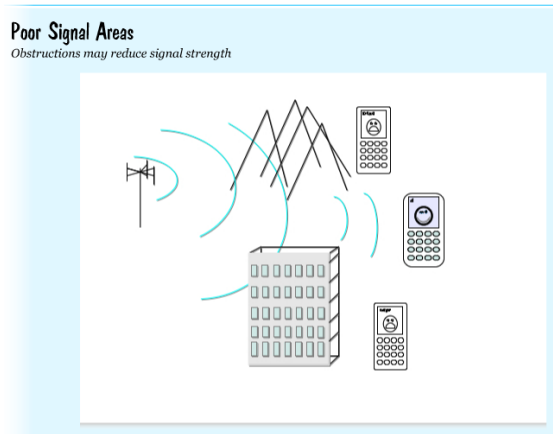


Fig 4.17: Radio Transmission blockages

A mini-test using Drag & Drop Ordering on the subject of Propagation is used following this section to reinforce the learning and to encourage learners to think widely around the issues of radio frequency transmission in terms of what may prevent a signal from being received. The two questions are shown in: Fig 4.18: RF Absorption and Fig 4.19: RF Propagation.

The second of these interactions is a straightforward selection of a radio button to answer a multiple-choice question with one correct answer from the three options offered. These two mini tests are included to reinforce understanding of the topics addressed this LO, radio energy being absorbed by objects and the clear signal propagation available from a mast overlooking a flat landscape.

A Drag and Drop Ordering

Drag the 'materials' to the place in the ordering queue placing those with the lowest effect on Radio Waves nearer the top

Brick House	
Building, framed and clad in metal	
Timber Shed	
Cardboard Box	

Fig 4.18: RF Absorption

A Multiple Choice

Select the location where your mobile phone signal could travel the longest distance?

1. Thinking about the terrain and the proximity of mobile phone antenna masts and antennas select one answer where your mobile phone signal should travel the longest distance. Will anything "get in the way" of the signal path?

- In a busy city centre
- Along a motorway route crossing flat country fields
- In a narrow valley surrounded by high mountains

[Instructions](#) [Reset](#) [Check Score](#)

Fig 4.19: RF Propagation

The final page provides Review and Research topics covered within this Learning Object. See – Fig 4.20: LO4 - Review & Research Questions

Review & Research Questions

1. Faraday cage - Wikipedia
2. Effects of radiation on people – MTHR and IEGMP reports
3. Directional/smart antennas and TOA/AOA – Wikipedia
4. Electrical length of the antenna (propagation factor)

[Research question: What is the amplitude of an electron's 'wiggle' during production of a radio wave?

1. Less than one hundred-millionths of a metre
2. A millimetre
3. Ten centimetres
4. Equal to the length of the wire]

[Research question: What is meant by the 'electrical wavelength' of an antenna?]

http://www.direct.gov.uk/en/HomeAndCommunity/TechnologyInYourHome/DigitalTelevision/DG_10031260

Fig 4.20: LO4 - Review & Research Questions

References are given for two organisations and also reference is made lower down the page to the [direct.gov.uk](http://www.direct.gov.uk) web site for Technology In Your Home in giving learners further areas of related interest from which to pursue their own research.

4.3.5 LO5 – Encoding & Data Transmission

The aim of LO5 is to explain that a text message comprises a series of characters and that these characters need to be converted into a form that can be transmitted using radio by

a mobile phone. This process of conversion uses encoding to change characters into data that must then be transmitted. This LO is 14 pages in length.

This therefore includes a description of how characters are converted into data using GSM 3.38 (a derivative of ASCII) and how data can be encoded into “0’s” and “1’s” by modulating a RF Carrier wave. By way of providing some contrast to the meticulous work needed to accurately encode manually, the use of short-forms in modern texting practice is also included since this saves characters and the original SMS text messages were limited to 160 characters. Mobile phones using modern operating systems cater for more or less endless messages that are automatically split and concatenated.

The need for a character set including mundane characters such as the <space> character is explained and shown in text format as: “textlikethis! – the ‘space’ character is very important.”

The importance and the benefits available coming from careful implementation of Human Computer Interface work that has been applied to the design of mobile phone handsets is mentioned in terms of the screen display echoing characters input at the keypad / keyboard providing users with the ability to carefully check their message content.

A Drag and Drop exercise, Fig 4.21: LO5 Drag & Drop Pairs Matching activity using matching pairs of characters and their GSM Code 03.38 decimal equivalent.

A Drag and Drop Pairs

Using the GSM code table (repeated below) drag the decimal number code to match the letters and number below for 'cul8r'

108	117	56	99
114			

c	u
l	8
r	

Instructions **Reset** **Check Score**

Fig 4.21: LO5 Drag & Drop Pairs Matching activity

The table is repeated on this page (Page 9) and the GSM 03.38 code table is repeated to provide the user with this relevant data on screen and users are then introduced to the need for binary conversion from the full GSM 03.38 table.

A summary of the material covered in the LO is provided and the LO concludes with some optional research topics and summarises the session with the need for: characters, conversions to binary and an appreciation of the wider aspects of modern electronic communication possibilities. This is displayed in a text box Figure 4.22: LO5 Summary and Conclusion.

Let's check how our text message is dealt with on a phone connected to the network:

- user types message using keypad
- message is encoded and stored in memory
- Look-up Tez's phone number in memory (or type in at keypad)
- user issues the send instruction (SMS sent to Tez)
- radio carrier wave is modulated with the encoded message, and the message is sent over the first 'radio' link
- o NB, this is only the first of a number of 'hops' across the network
- the mobile network then takes care of delivering the message to Tez, so:
 - o if Tez's phone is switched on and in range of a cell, the message is sent by radio to their handset from that cell,
 - o if Tez is not within range of a cell, or their phone is switched off, the network / control stores the message for a period. If Tez's phone registers on the network before the message is deleted the message will be transmitted as above.

For a research activity you may find it interesting to see how many different sorts of encoding you can find?

Many different codes / encodings have been used:

- Morse, and then
- BAUDOT / Teletype / RTTY - used in communications before the computer era
- ASCII & EBCDIC - used in computer data processing - within and across networks

Since the vast increase in computer and data communications following the expansion of the internet, the www, and domestic broadcast and communication technologies, other encoding standards are in day to day use over computer networks both large (WAN) and small (LAN and WiFi)

Objectives

This module / section explained the term encoding and its relationship with modulation in terms of data transmission in sending a text message across the whole mobile phone network.

Figure 4.22: LO5 Summary and Conclusion

4.3.6 LO6 – Cellular networks

The aim of LO6 is to introduce the concept of the mobile network and to explain how such networks are built and operate with specific relevance to how text messages are sent. It is 11 pages in length.

The introduction covers the background and rationale for a cellular network being suitable for mobile telephony. Consideration of frequency distribution and re-use is taken into account and the need for handovers as phones travel from the coverage area of one cell into a neighbouring cell. Examples of the content from this LO are shown in Figure 4.23: LO6 - Multiple Choice Question on Network Coverage considering the aspect that a percentage of the population will far exceed the ground coverage.

A Multiple Choice

Select the correct answer to this question.

1. What do mobile phone operators mean when they refer to network coverage?

- The percentage of people who live within range of their network
- The percentage of the country's landmass that is within radio coverage of their network?

[Instructions](#) [Reset](#) [Check Score](#)

Figure 4.23: LO6 - Multiple Choice Question on Network Coverage

Cellular frequencies

These three diagrams, A, B and C, show part of a cellular network. The number in each cell represents the frequency being used within that cell. In the question that follows you need to examine closely these frequency allocations and determine which combination is not valid.

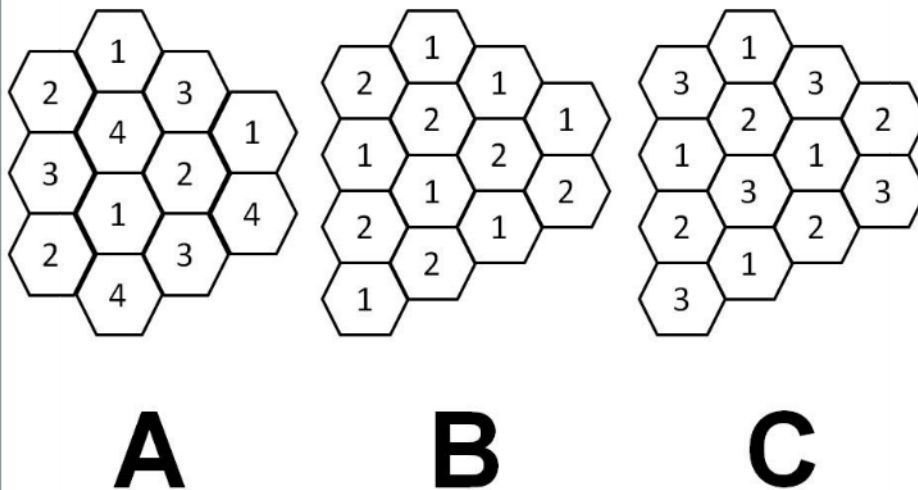


Figure 4.24: Cellular Network, Hexagons and Frequencies

Here the question tests the important understanding that the learner grasps the concepts that it is the cellular nature of the network allowing different frequencies in neighbouring cells to improve the mobile phone signal handling of the network. This fits well with the principles of E-Learning and of providing feedback to the learner.

A further example of a summary is provided from this Learning Object in Figure 4.25: Example of summary - LO6

Example of a: Summary – taken from LO6 Cellular Networks:

- What have we discovered?
- In order to provide a network that covers both the population and country, mobile phone networks comprise cells that vary in size.
- Each cell contains a radio mast that communicates with your mobile using radio.
- The frequency used in each radio cell must be carefully chosen to ensure that it does not interfere with adjacent cells.
- The radio mast is connected to a Radio Network Controller (RNC) and RNCs are connected to each other to form what is termed the core network.
- Within the core network, a mobile phone operator maintains an Authentication Centre which checks that both your phone (IMEI) and you (IMSI) are allowed access to their network. This is indicated to you by virtue of the fact that your operator's name appears on your mobile screen after it has been switched on.
- Your operator knows where your mobile is located because the identity of the cell in which it is located is stored within the operator's Home Location Register (HLR). The HLR maintains a record of where your phone is and therefore tracks your mobile as it moves through the network.
- When you send a text message, it is sent to your operator's SMS Service Centre where it is stored. From here it is then retransmitted to the destination mobile. If the destination mobile is switched off then the message remains in the Service Centre.
- Should the person you are sending a text to is located on a different network then the message will be sent from the SMS Service centre of your operator to that of the destination's operator and then onwards to their mobile.

Figure 4.25: Example of summary - LO6

4.4 Summary

Educational theory and best practice as reviewed in Chapter 2, were taken account in the design of the E-Learning Materials. An authoring tool, Pedagogue, was used to prepare the materials and the various features of Pedagogue were exploited as appropriate within the Learning Materials to produce an engaging and varied educational experience for the users. The completed Learning Materials comprised six Learning Objects, each of which took a different aspect of how text messages are sent using mobile phones. A user can study the LOs in any order and each extends the user's knowledge by encouraging them to continue their studies in order to answer a set of research questions.

The material set out to engage with students in the coursework area of technology and science, who were working at Level 2 or Level 3 of the QCF. Examples from each LO have been selected and presented in this chapter to provide an insight into how they were designed and how they appear within Pedagogue. However, the complete set of LOs is included within the CD at the end of this thesis.

Having produced the LOs, they were then evaluated at a selection of schools and colleges. Details of that evaluation and the results obtained are presented in the next chapter.

5 Chapter Five – Data, Analysis and Evaluation

5.1 Introduction

Following the methodology presented in Chapter 3, the learning material described in chapter 4 was evaluated. The proposed method of testing was to ask students to run some or all of the Learning Material and to provide their reactions to the style of the learning through the use of a questionnaire. Questionnaire design needs to be undertaken logically and carefully, and has to be addressed in terms of ensuring as far as possible that any results are non-biased and that the results can be shown to be fair and equitable.

An evaluation strategy was therefore developed that comprised a pilot phase, the design of a suitable questionnaire, organisation of a series of practical sessions within schools and colleges and the detailed analysis of the results obtained.

5.2 Evaluation strategy

As explained in Chapter 3 four options were considered in the process of evaluating the experiment: Serial, Parallel, a survey of Teaching Staff, and running an experiment in class. The first three of these options were discounted in terms of requiring too much time or that they had the risk of introducing too many variable factors that could have brought the accuracy of the evaluation process into question. The decision therefore was to evaluate the learning material via experiments carried out in the classroom.

Various options can be used to obtain user feedback. Interviews and observations are two main tools used but a questionnaire has advantages of saving time both in data collection and data processing. A questionnaire should also minimise any difference in approach or bias resulting from the use of any other data collection tools.

Cohen et al in their (2007:505) book, *Research Methods in Education*, suggest that the researcher needs to consider five aspects in their approach to a statistical evaluation:

- 1 What scales of data are there?
- 2 Are the data parametric or non-parametric?
- 3 Are descriptive or inferential statistics required?
- 4 Do dependent and independent variables need to be identified?
- 5 Are the relationships considered to be linear or non-linear?

Cohen et al, (2007) explain that interval scales and ratio data generally provide parametric data, and as the participants would be selected by virtue of their current choice of AS, A Level, or BTEC courses, in Computing or ICT it was considered a suitable method to compare the results of the survey as one block of data from which a descriptive analysis of the nature of the participant responses would be valid.

The Likert type scales provide ordinal results that also allow the respondent flexibility in providing their response(s) through an interval scale. The term ‘interval scale’ as used by Cohen refers to the ‘regular and equal interval between each data point’ (2007:502). Further Cohen et al (2007) cite Cohen and Holliday (1996): that it follows logically that this exact and same interval between data points interval scales are also referred to as equal-interval scales. It was also considered that dependant and independent variables need not be identified and that the relationships of the responses were not significant at this stage if they showed linear or non-linear relationships within the study.

The responses received have no meaning in terms of pure number. Respondents were free to select values from these scales so a purely quantitative tool was used to provide the merest suggestion of qualitative subtlety. Any differences in the marks awarded in response to the questionnaire were at the sole discretion of the participant. Acknowledging that there are risks of respondents tending to ignore the extreme ends of any marking scale; and also that they may chose the safety factor of giving a middle point mark (Cohen et al, 2007:327). The decision was to use a scale of 0 to 9, which provides ten scale divisions and importantly, no middle mark. Evaluation was to be undertaken at schools and colleges who contributed by allowing their students to access the Learning Unit and to freely provide feedback. Care would be taken to introduce the material and the researcher to the students.

Ethical considerations meant that it was essential to emphasise the completely voluntary nature of the evaluation process, and how respondents were able to exercise their right to have their evaluations removed from the study at any time.

The use of numerical answers allows the researcher to gather considerable quantities of quantitative data, but being simply ‘numbers on a sheet’ concerns will remain about how accurate and valid the results are. The alternative face of research is ‘qualitative’ and that requires a different approach to obtaining the responses from participants. The questionnaire was designed around a single sided A4 sheet of paper so participants would not feel it was going to be too onerous a task to complete. The main questions were confirmed in the design phase, three open answer questions were included. Using a measure of both qualitative and quantitative aspects adds the benefit of improving the statistical validity of any research exercise (Cohen et al, 2007) so this was included in the design of the questionnaire as mentioned previously in Chapter 3 under Mixed Methods.

5.3 Pilot phase

Pilot testing for any data gathering research task is regarded as ‘crucial’ by Cohen et al (2007:341). Cohen sees the testing of any questionnaire as an opportunity not to be missed and lists most areas of the questionnaire as being tested during this process. The questionnaire designed for this experiment was trialled accordingly and at the same time the opportunity to ensure that the material also worked as intended in college and school computer laboratories whatever IT and network installations were in use.

With one of the LOs complete the opportunity to run a pilot test was arranged to run at Cronton Sixth Form College, a part of Riverside College, Runcorn. The purpose of the pilot test was twofold. Firstly, to assess that the design of the LO and approach adopted to presenting the material was appropriate for the target age group. This was important to establish before significant additional work had been undertaken in authoring the remaining LOs. Secondly, a pilot test allowed the approach to evaluation and questionnaire design to be assessed before full-scale evaluation was to be undertaken. The learning material was loaded onto personal computers in one of Cronton College computer laboratories and

fourteen students from a mix of three courses; AS and A Level Computing, and BTEC Level 3, Information and Communications Technology, participated in the pilot test. The learning material was presented to the students with a brief introduction about both the project and the required ethical considerations. After the material was used participants were asked to complete a questionnaire, the design of which was based on Research Methods in Education (Cohen et al, 2007) and followed the information gathering diagram in Fig 5.1.

Questionnaire Design

Design & Layout seen on screen		
Accessibility – colour options	}	L10
Background knowledge		
PEL	}	L10
Explanations & Technical Content		
Easy to read / follow?	}	L10
Understandable?	}	
Interesting?	}	
Did relating the topic to the story of sending a text help		
Understand the technical content	}	L10
Make the experience more interesting	}	
Did the questions help you understand the subject when used as		
Progress checks	}	L10
Further research	}	
What did you: Like Most / Like Least / Any other comments		
Like most about it	}	Open Questions (3)
Like least about it	}	
Any other comments	}	
Do you use a mobile phone: Yes / No Make / Model ____ / ____		
Added after pilot test		

Figure 5.1: Questionnaire Design

The Introduction notes and an example of the questionnaire as used in the pilot test are included at Appendix B and Appendix C.

Two abbreviations are used in this diagram: PEL standing for Prior Experience and Learning, and 'L10' which indicates that numerical answers would be collected using a Likert scale of 10 intervals (0 – 9).

Following this pilot test the responses were analysed in terms of the rating scale marks and the written responses to the open answer questions. In both the scale ratings and the written comments received the responses were interpreted as being positive and encouraging which provided positive feedback to continue with the authoring of the remaining LOs and the feedback provided was useful enabling a minor refinement to be added to the questionnaire, which will be described in detail in the next section.

5.4 Evaluation design

The questionnaire was the prime means by results obtained from the research would be collected and analysed. The opportunities to ask myriad questions can tempt the unwary into a long questionnaire, but the focus of the research was to discover if the style of the learning material answered the Research Question:

Will learners be more interested, and therefore, enthused to study technology based subjects if the teaching of those subjects is directly related to their daily use of such technology?

The risk of bias (Cohen et al, 2007), in any direction, must be understood whether designing a questionnaire or in any interaction to obtain feedback for analysis. Even the ideological standpoint of the researcher can inadvertently create bias. Having considered the information needed to establish the relevance of the experiment, risk in this area was hopefully minimised

The aspect of the learners' level of prior experience and knowledge relevant to this area of learning was not tested before they used the material developed for this experiment, but learners would be asked to indicate by a self-evaluation of their own level of prior knowledge in the subject area prior to using the Learning Materials.

Using a mixed-method approach to the evaluation was determined in Chapter 3. .
The questionnaire was designed to address five key areas, these were:

- Design and layout
- Their prior knowledge
- Explanations and technical content
- How a text message storyline helped, and
- If the progress checks and the research questions were helpful.

Using the diagram in Fig 5.1, the question structure was refined using iteration to control the number of and the length of questions while obtaining sufficient and suitable response data. Nine questions were designed and worded so that they followed the same 'style'. This Likert Scale was used in assessing the responses statistically. Marking on a Likert Scale limits responses to statements or values, so the next design question is how many degrees of variation to allow for the scale. Using values was considered to be more efficient than worded responses in terms of final data collation. Scales may be coarse, using a short scale, often based on five degrees; or a longer and finer scale allows finer differences to be obtained and provide greater variation for evaluation. The middle point mark was avoided by using an even number of degrees on the scale (Cohen et al, 2007:326 et seq). The design was finalised as a ten-point scale from '0' (low) to '9' (high). Respondents were given the following guidance for each of the questions: "Please circle your preference marks using the scale of 0 – 9 where:

0 = did not like / lower / lowest & 9 = best / better / liked very much"

In addition to these scale questions, seeking the benefits of the mixed-methods approach it was decided to include three open text questions. Three open questions were chosen to complement the nine questions asking for numerical answers. The first and second of these questions would ask participants for their 'most liked' and 'least liked' aspects of the material:

- “Which aspect did you like most about the material in the Learning Unit / Object?”
- “Which aspect did you like least about the material in the Learning Unit / Object?”

And, a ‘catch-all’ question leaving comments completely open to the respondent:

- “Please add any other comments you feel might be relevant:”

These three open questions proved an interesting and valuable resource to assist with the analysis of the data. The version of the questionnaire used for the trial test is shown in Fig 5.2: Questionnaire for Pilot Test.

The final version of the questionnaire changed little; the only addition being one final question asking if the respondent used a mobile phone, in order to establish if the supposition of these students being regular users of this technology. A copy of the final questionnaire is at Appendix B.

Please circle your preference marks using the scale of 0 – 9 where:
 0 = did not like / lower / lowest & 9 = best / better / liked very much

No.	Area	Scale
Design and layout on screen:		
1	Colour choice for background and / or text	0 1 2 3 4 5 6 7 8 9
Your prior knowledge in this area		
2	What level of knowledge in this area would you say you had prior to using this material?	0 1 2 3 4 5 6 7 8 9
Explanations and technical content – was it:		
3	Easy to read or follow?	0 1 2 3 4 5 6 7 8 9
4	Understandable?	0 1 2 3 4 5 6 7 8 9
5	Interesting?	0 1 2 3 4 5 6 7 8 9
Do you think that relating how a text message is sent to a friend helped you:		
6	Understand the technical content?	0 1 2 3 4 5 6 7 8 9
7	Did this make it more interesting?	0 1 2 3 4 5 6 7 8 9
Did the questions help you to better or further understand the subject when they were:		
8	Used as progress checks?	0 1 2 3 4 5 6 7 8 9
9	For further research?	0 1 2 3 4 5 6 7 8 9

Which aspect did you like most about the material in the Learning Unit / Object?

Which aspect did you like least about the material in the Learning Unit / Object?

Please add any other comments you feel might be relevant:

Fig 5.2: Questionnaire for Pilot Test

After completing the six Learning Objects and a minor revision to the questionnaire the introduction sheet was revised to suit ant new locations for the testing sequence in light of experiences obtained during the pilot phase.

Students at two establishments in the North Cheshire area evaluated the material. These Colleges both provide courses relevant to the material, and the Colleges were very happy to assist.

5.5 School and college sessions

Two colleges were chosen within which to carry out the evaluation of the completed learning material. These were Cronton Sixth Form College at Runcorn and Priestley College in Warrington.

5.5.1 Cronton Sixth Form College

Cronton College is part of Riverside College, Runcorn, England. Riverside College is a further education college that was established from the merger of Halton College and Widnes & Runcorn Sixth Form College in August 2006. Riverside College now has two campuses in Widnes and one in Runcorn (Cronton College). The college provides a range of courses including GCSEs, A Levels, BTECs, Apprenticeships and Access courses. This College participated in the pilot test described earlier when 14 of their students tested the material and after running the materials the students tested the questionnaire. They remained willing to participate in the full evaluation. A total of 44 of their students took part in a full evaluation held in March 2013, and staff and students at the college were most welcoming throughout the evaluation.

Ofsted inspected the College in 2010 and awarded them a grade 2 marking. Since then the college has many new staff and new leadership. The Ofsted report includes some details of the demographics relevant to the surrounding catchment area:

The college recruits a high proportion of learners from areas of social and economic deprivation and many learners aged 16 to 18 arrive with relatively low GCSE grades. Two schools in the local area have sixth forms. The percentage of learners from minority ethnic groups is around 4%, which is about twice the proportion resident in the borough. Unemployment rates are similar to national averages but more people have been unemployed in the long term and many have poor health. (Ofsted: 2010)

5.5.2 Priestley College, Warrington –

Priestley Sixth Form and Community College is a sixth form college located on Loushers Lane, Warrington, England. It also offers adult courses, professional training on another site, and is an associate college of the University of Salford. A total of 83 students from the College participated in the evaluation. Ofsted last inspected Priestley College in 2010 awarding a grade 1 marking. The College is delightful to visit and the Ofsted report mentions the local demographics as:

... The vast majority of learners were white British, with about 5% of minority ethnic heritage. The majority of learners aged 16-18 study level 3 courses, with a small proportion studying at level 2, and a few at level 1. The college offers courses in most curriculum areas, including health and social care, science, mathematics, information and communication technology, humanities, social sciences, arts, languages, sports and business (Ofsted: 2007).

Testing at the two establishments provided a total of 127 evaluations in addition to the 14 responses conducted during the pilot run. These participation details are summarised in Table 5-1: Colleges participating in the research

The researcher attended Cronton Sixth Form College where LO material was loaded onto personal computers in the computer labs, and the sessions were introduced personally. At Priestley College the learning material was loaded onto their Moodle powered Virtual Learning Environment (VLE). The researcher did not attend the evaluation sessions at Priestley College; these sessions were introduced by their staff. This helped minimise inadvertent bias from the researcher

Making the Learning Material available over the college's VLE allowed students at Priestley College a more flexible schedule in that they were able to access the materials within their own time or during periods apart from their timetable. All responses were paper-based, with students completing a questionnaire and returning them at the end of their interaction with the material.

Participating College or School	Course	Date	Numbers in study:
Pilot Test, Cronton, July 2012	A AS & BTEC	2/7/2012	14
Cronton Sixth Form College (part of Riverside College, Runcorn);	A AS & BTEC	26/3/2013	44
Priestley College, Warrington;	A AS & BTEC	12 – 15/3/2013	83
Totals		- Pilot - Main - Total	14 127 144

Table 5-1: Colleges participating in the research

Responses were collated by the researcher and safely filed in accordance with the policies of the University of Salford.

5.6 Results

Using a mixed method approach as explained previously allows the responses to be considered and compared from both aspects of qualitative and quantitative data. This process has been shown to contribute a level of validation and reliability to the evaluation process (Cohen et al, 2007). Firstly, the quantitative test data was reviewed in terms of how the respondents rated their experience of using the Learning Objects. Secondly, the qualitative data from the questionnaire will be used, as indicated in Chapter 3, to confirm the validity and reliability of the quantitative responses; and this may also elicit nuances of interest captured by the three open questions included in the questionnaire.

The first stage in analysing the data from the questionnaire responses was to plot the answers to all nine quantitative questions onto a single graph as shown in Fig 5.3: Composite Graph of response volumes. The trend curves resulting from this indicate that the various cohorts of students show little variation and so it was decided to interpret the results ‘en bloc’.

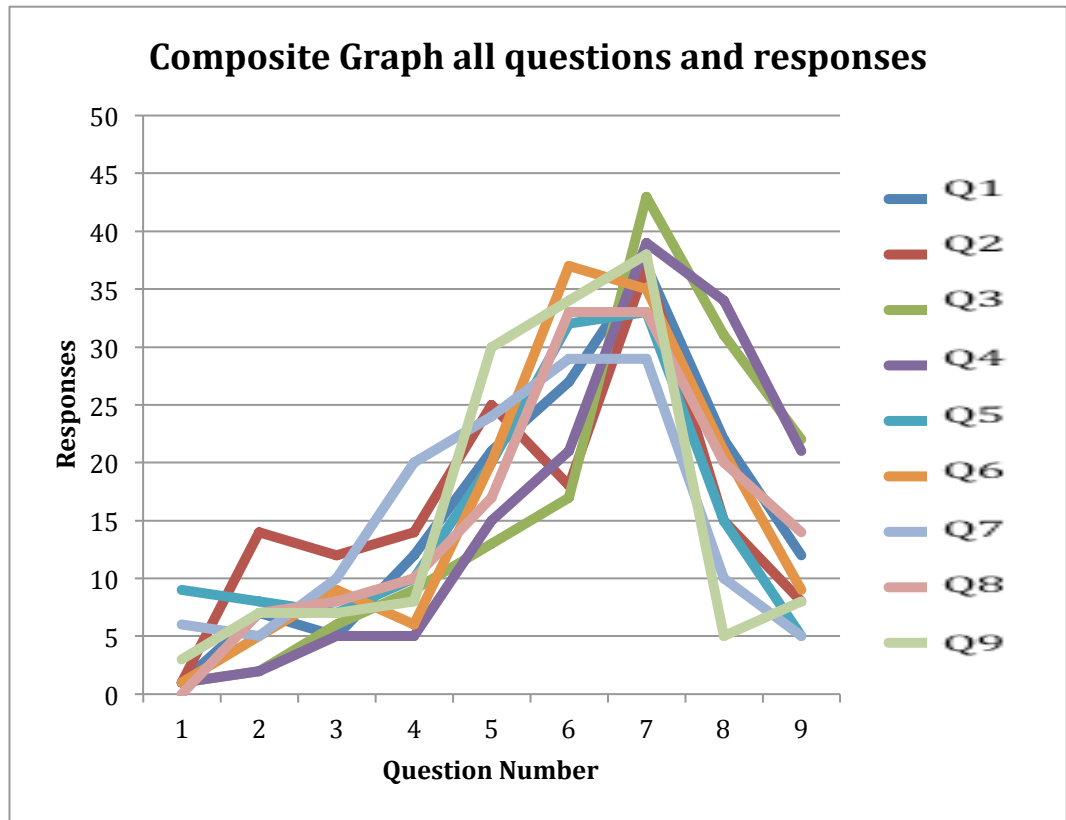


Fig 5.3: Composite Graph of response volumes

The response to each of these nine questions will now be evaluated in detail.

5.6.1 Question 1 – ‘Design and screen layout’

The first question was a general question asking about the design and layout of the screen. It asked respondents to score the "colour choice for background and/or text". The results are presented in Fig 5.4: Question 1 Responses

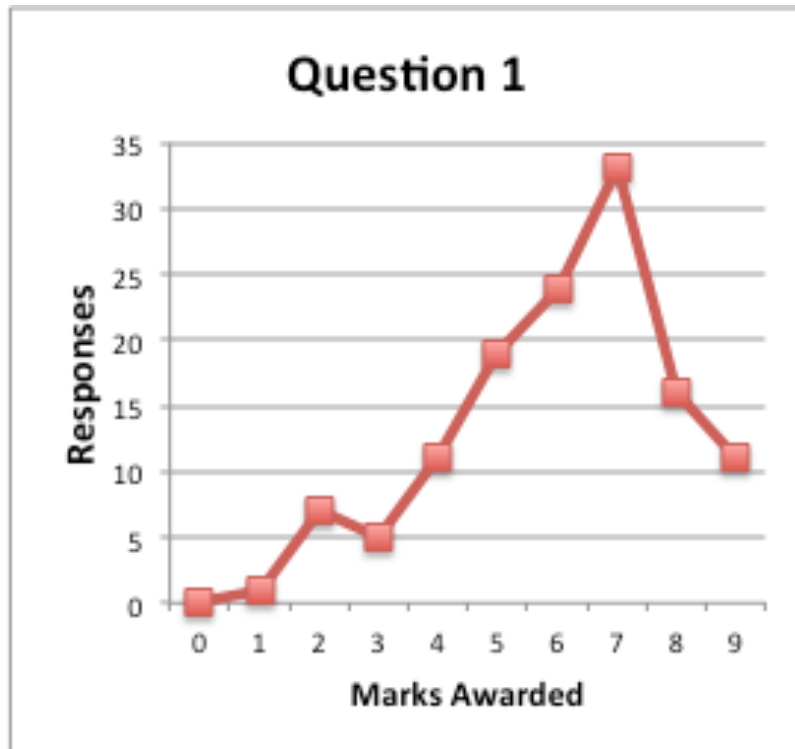


Fig 5.4: Question 1 Responses

The majority of responses were in the third quartile, and more were above this sector than were below it.

5.6.2 Question 2 – ‘Prior Knowledge’

The second question sought to determine the prior knowledge of the participants. It asked respondents to state: “What level of knowledge in this area would you say you had prior to using this material?”

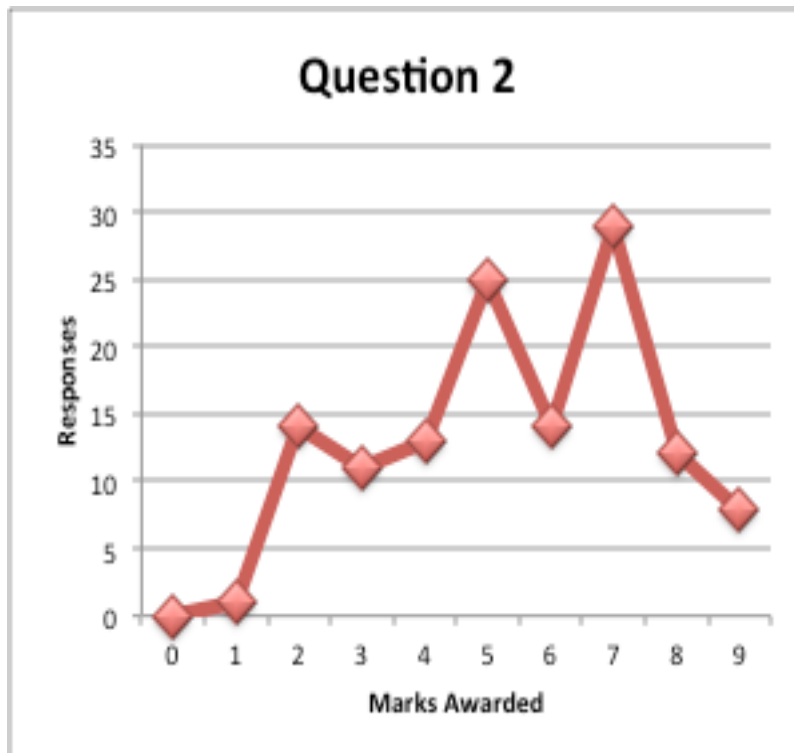


Fig 5.5: Responses to Question 2

The responses to this question are presented in Fig 5.5 which shows that there are many more responses above the centre line with peaks for values returned of: '5' and '7'. So the subject matter may not have been overly challenging.

5.6.3 Question 3 – 'easy to read or follow'

The next set of three questions were concerned with the quality of the explanation of the technical content within the learning material. Question 3 asked whether the material was "easy to read or follow?" The results from the respondents are presented in Fig 5.6: Question 3 responses.

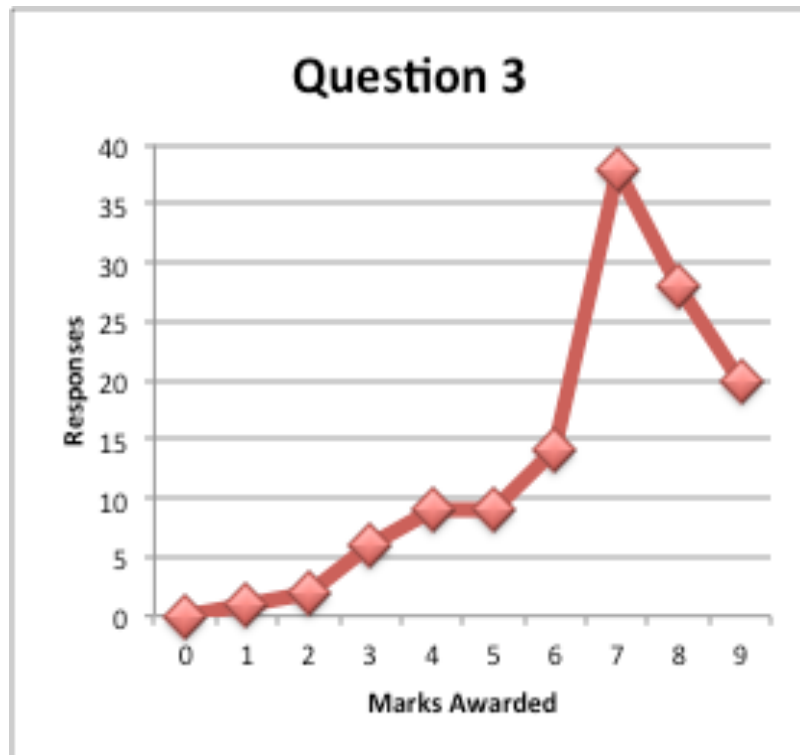


Fig 5.6: Question 3 responses: 'easy to read / follow'

Here responses indicate conclusively that the vast majority of participants were of the opinion that the material was easy to read or follow. Higher marks range from '6' to '9' with a good proportion of marks being '8'.

5.6.4 Question 4 – 'Understandable?'

Question 4 asked whether the material was "understandable" and the responses are presented in Fig 5.7: Question 4 Understandable?

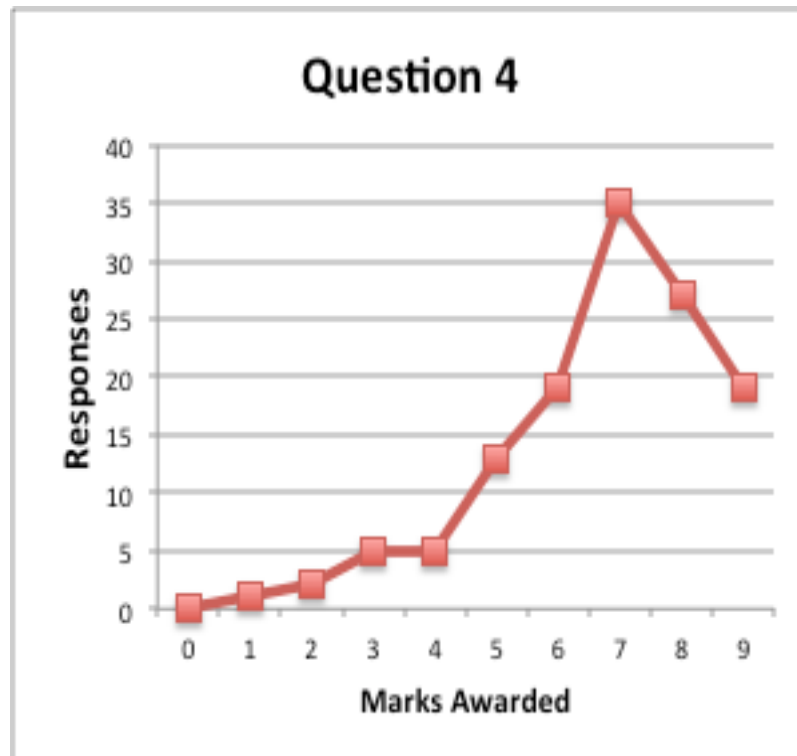


Fig 5.7: Question 4 Understandable?

These results for this question are encouragingly consistent with those for question 3 but with slightly more responses in the third and fourth quartiles.

5.6.5 Question 5 – ‘Interesting’

Question 5 was the third of the three questions focusing on the technical content of the learning material and it asked whether the users found the material "Interesting". The responses are presented in Fig 5.8: Question 5 responses.

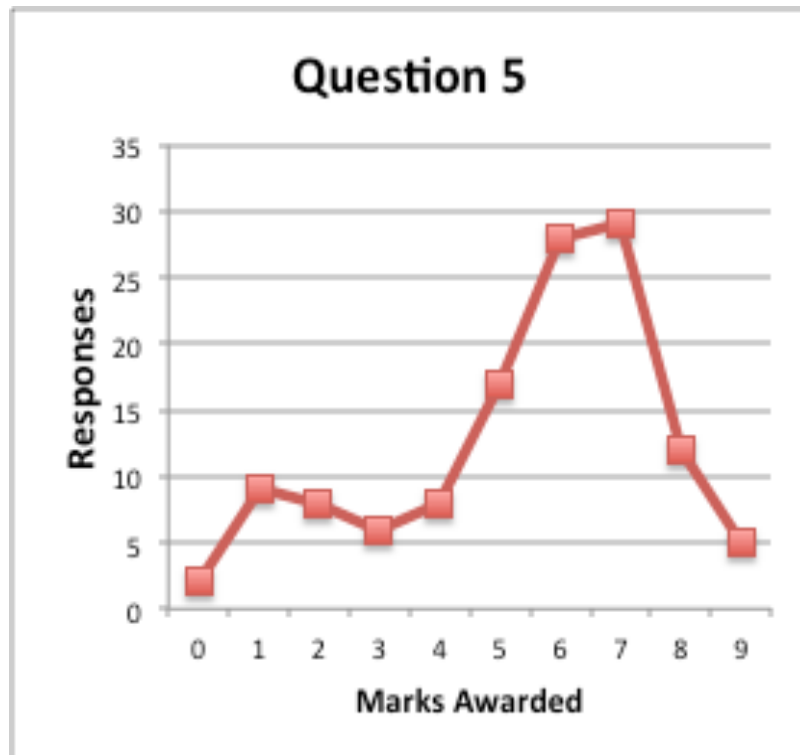


Fig 5.8: Question 5 responses

The material was clearly widely reported as being interesting which is an important reflection for one of the goals of the Learning Materials and that was to provide a high level of engagement. Students will surely be more engaged if they find the material to be interesting.

5.6.6 Question 6 – ‘did the storyline help you understand the technical content?’

The next two questions of the questionnaire focused on the key aspect of the context of the Learning Materials. That is the use of the text messaging scenario as the basis of presenting technical information. Question 6 asked whether the scenario helped to

"understand the technical content" and the results are presented in Fig 5.9: Question 6 responses.

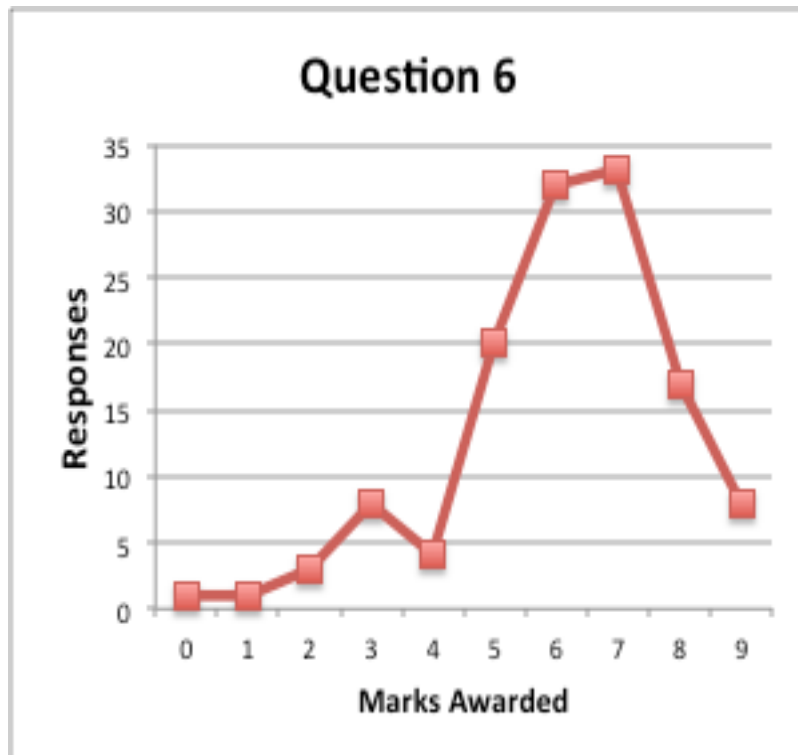


Fig 5.9: Question 6 responses

Importantly, these responses do provide strong evidence that the text messaging context was an important and positive factor with a peak response at 7 and with 71% of all responses graded at level 5 or above.

5.6.7 Question 7 – ‘Did the storyline make the material more interesting?’

Question 7 continued to explore the importance of the text messaging context and asked "did it make it more interesting?" The responses are presented in Fig 5.10: Question 7 responses.

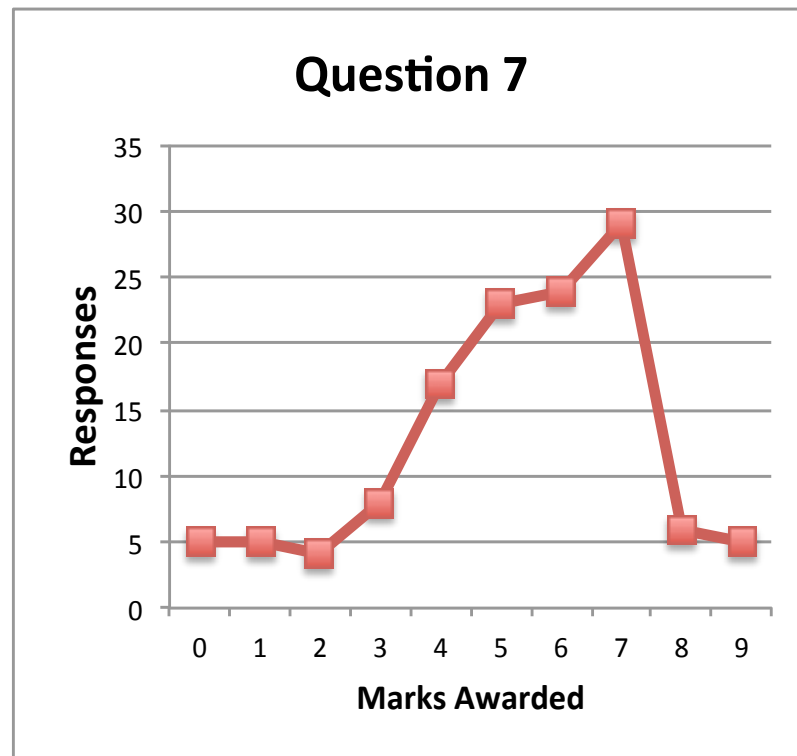


Fig 5.10: Question 7 responses

It seems the responses to this were just as clear as those for question 6. The detail of the graphs do differ but the overall trends are similar with the responses to question 7 showing strongly that a large majority of the responses were in agreement with the statement that the use of the storyline of sending a text message was helpful in terms both of understanding the technical content presented and that it was interesting.

5.6.8 Question 8 – ‘questions used as progress checks’

The final two questions within the quantitative section of the questionnaire focused on the use of the embedded mini tests and research questions. These were intended to allow users to assess their own understanding as they progressed through the Learning Materials and provided feedback to them so that they could gauge their own progress. Question 8 asked whether the mini tests had been helpful in terms of being "used as progress checks?" The results are presented in Fig 5.11: Question 8 Responses.

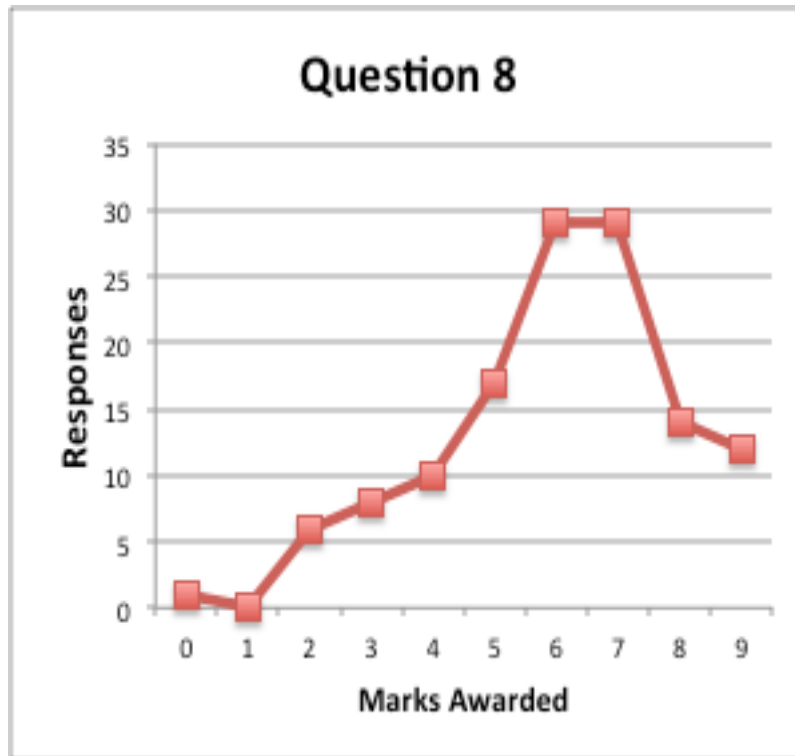


Fig 5.11: Question 8 Responses

The results clearly show that the respondents did feel that these mini tests were helpful as a means of providing a check on their progress through the materials.

5.6.9 Question 9 – ‘Research questions – any added value?’

Finally, question 9 followed on from question 8 and focused on the value of the research questions that were included as a means of encouraging the users to extend their learning and continue their interest beyond the confines of the material being presented in each Learning Object. Question 9 asked if the embedded questions had been helpful "for further research?" The responses are presented in Fig 5.12: Question 9 responses

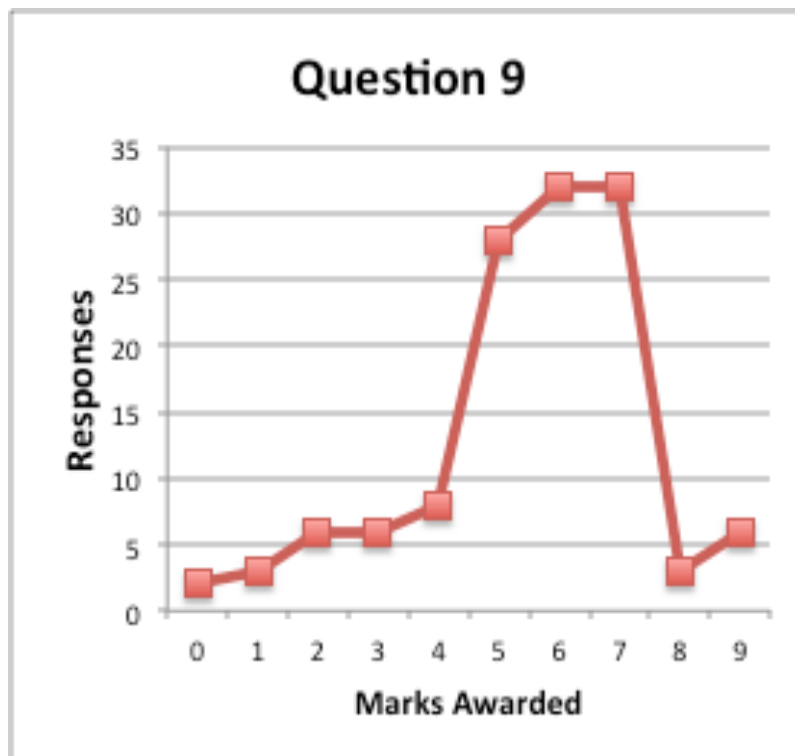


Fig 5.12: Question 9 responses

Once again the responses show a high level of support for the questions as a means of motivating and supporting further research.

5.7 Open Questions: Coding & Categorisation

Following the nine questions that required quantitative answers were three open questions. Respondents were encouraged to provide written answers within the space provided. Answering these questions was voluntary and they were designed to produce responses based on personal feelings and help provide a greater understanding of the users experience. More specifically to try to discover if the user was consciously or unconsciously learning and if this resulted from the style of contextualisation applied to the material in the LO. Their responses were in the main valuable but need to be interpreted fairly and openly.

Cohen et al (2007) provide guidance that content analysis using coding and categorising plain text responses holds a set of risks. Acknowledging the risks Cohen et al (2007) suggest that the whole process follow a sequence of eleven steps.

1. Define the research questions to be addressed by the content analysis
2. Define the population from which units of text are to be sampled
3. Define the sample to be included
4. Define the context of the generation of the document
5. Define the units of analysis
6. Decide the codes to be used in the analysis
7. Construct the categories for analysis
8. Conduct the coding and categorising of the data
9. Conduct the data analysis
10. Summarising
11. Making speculative inferences

The first 4 steps were considered in the design of the evaluation strategy and in practice this means that the data was collected as intended, the answers to the three open questions were freely written out by the participants. Step 5 is to start to define units we chose to suit our needs in analysing the data. The smallest element of material, the coding unit, may be as small as a one-word answer. For example, one participant wrote: 'boring'. The largest element will be that sentence or two that turn out to be the largest unit accepted as one unit. For steps 6 and 7, the written answers were transcribed into electronic text, and the content was then to be parsed, by the researcher, into defined categories to collate a more manageable data set. Step 8 produced the categories to be used. These were assessed initially by parsing the transcribed data and grouping responses by similar themes. This produced five or six categories for each of the three open questions and it was decided that no further categorising was needed since sufficient detail would be available from the next step in the process to make reasoned judgements from the results and to also provide some level of validity to the quantitative data evaluated above.

Step 9 operated from a frequency count within each of the categories for each of the three open questions. Step 10 is to summarise the data and step 11 will be used in the final evaluation summary in conjunction with the quantitative data summaries. This would allow

the qualitative data to be interpreted more simply and it also allowed a better indication of the validity and reliability of the quantitative data.

5.7.1 First Open Question

The first open question asked, "What aspect did you like most about the material in the Learning Unit / Object?"

Ninety categorised comments from 76 respondents (representing 60% of the participants) were coded into six categories labelled: Interactivity; Appearance & Layout; Interesting & Informative; New knowledge; Easy and previous knowledge; and Boring. This means that 51 users (40%) did not contribute any views. Having categorised each response, totals show the largest response Fig of 28% was for 'New knowledge'. Figures of 26% for Appearance and Layout and 24% for Interactivity were indications of approval. 'Interesting & Informative' follow in order at 20%.

The final two categories account for only 2% of the answers and reflect the responses that of two users, one found the material 'easy' and the other commented that it was 'boring'. It is not known why 51 users chose not to respond. The question asked for the aspect liked most by the users, and the response rate may skew the overall figure, but this needs to be taken into account with the number of responses (or those not offered) to Open Question 2. This data is shown graphically in Fig 5.13: Open Question 1 responses.

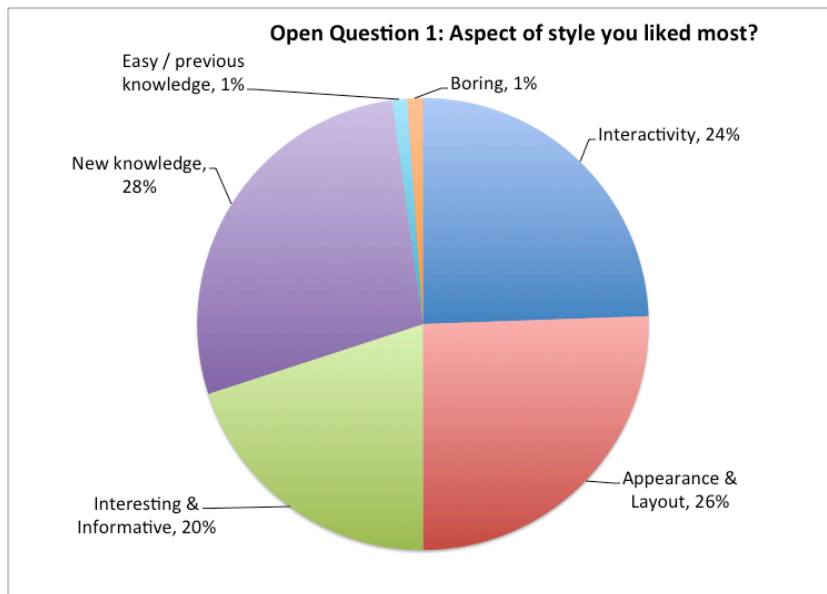


Fig 5.13: Open Question 1 Responses

5.7.2 Second Open Question

The second open question asked, "What aspect did you like least about the material in the Learning Unit / Object?" Of the 127 evaluations analysed 74 users (58%) responded to Open Question 2, meaning that 53 users (42%) did not. The response rate may skew the overall figure, but this needs to be taken into account with the number of responses (or those not offered) to Open Question 1. As the size of the response rates to these two Open Questions are almost equal they appear to almost balance one another out; so drawing any firm conclusion from the number of responses is not helpful. The responses to this question were coded into five categories that comprised: Text, quantity and knowledge depth, Appearance & Layout, Positive response to a question asking for negative responses, 'Too easy', and Technical detail. The unusual categorisation of "Positive response to a question asking for negative responses" should be explained. This second open question was specifically worded asking users to highlight the aspect of the Learning Materials they liked least. Two of the responses answered this question by saying that there was so little they

disliked it was all material they did like which adds to a positive view of the experiment overall.

The totals for each of these categories are presented in Fig 5.14: Open Question 2 responses. The largest response category at 25% was for 'Text: in terms of quantity and knowledge depth', and 23% least liked the Technical detail. 20% complained about the 'Appearance and Layout'. The final two percentages totalling 3% were the result of three comments that the questions were too easy or perhaps that the respondents provided a 'rogue answer'. This question was intended to produce negative comments but two participants answered this with a positive comment. Combining the three major components of this data: $(25\% + 23\% + 20\%) = 68\%$ of the responses from the data grouped in this way were critical of the quantities of text, the knowledge depth of that text, the appearance and layout, and the technical detail. The replies to Open Question 1 show that slightly more people were in agreement or had a positive view of the material than wrote negatively about this. Responses critical of the amount of text may be balanced against the positive comments from those other responses. From the responses that were critical of the appearance and layout it would appear that at least some of these users were not aware of the accessibility features available to personalise the screen in terms of colour and font although this information was in the introduction.

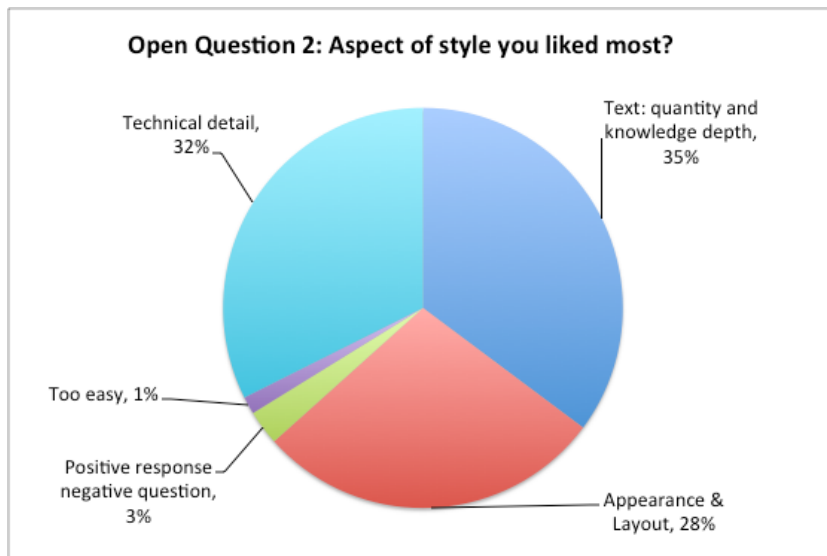


Fig 5.14: Open Question 2 responses

5.7.3 Third Open Question

The third open, ‘catch-all’ question asked respondents to: "Please add any other comments you feel might be relevant?" Of the 127 evaluations analysed 19 users (15%) responded to Open Question 3, meaning that 108 users (85%) did not provide any further comments they felt to be relevant. Responses were coded into the following six categories: Text: quantity and knowledge depth; Appearance; Inaccurate; More questions to reinforce learning; Boring; and Other. The quantities of responses against these categories are shown in From Fig 5.15: Open Question 3 responses. Of these, the largest at 35% was against the ‘Text: in terms of quantity and knowledge depth’, and 30% least liked the ‘Appearance and Layout’. These are in support of the criticisms expressed in response to Open Question 2 however one of these critical responses is on the same evaluation sheet as one of the critical comments to Open Question 2. The category for ‘Other comments’ produced 20% of this ‘catch-all question’. The final three percentages totalling 15% were the result of three comments. Firstly that the questions were boring or that the material was inaccurate while the third comment requested more questions to reinforce learning.

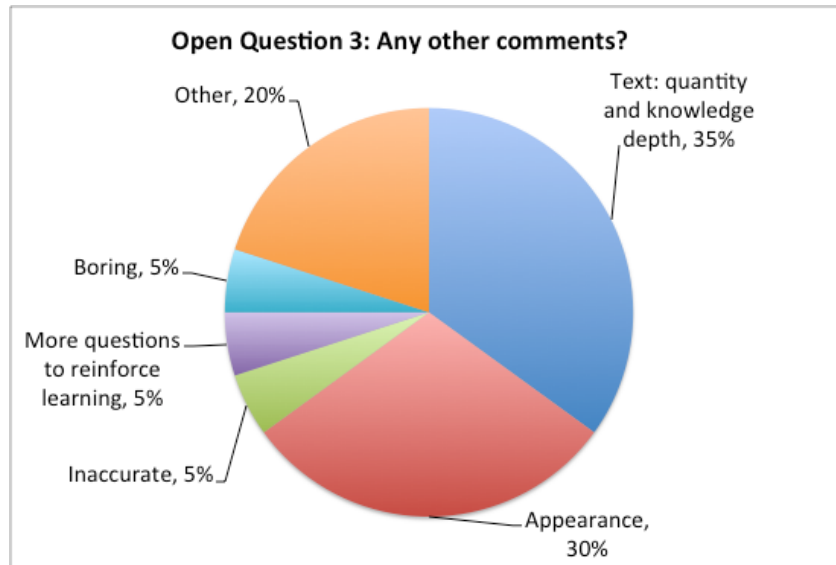


Fig 5.15: Open Question 3 responses

Most of the open text comments made did not respond to the educational techniques used with the main thrust of responses that the material was too wordy or needed changes to suit the personal preferences of the students. Some of these comments were in support of comments provided in response to one of the previous two Open Questions, but the numbers of responses to this question and in this category are small.

However, the overall pattern of responses that were pertinent to the research question was consistent. The responses also showed that users did feel the approach adopted, that of using a storyline about the transmission of a text message, provided a context with which the users were highly accustomed to using and was interesting.

Transcriptions of these responses to the three open questions are included verbatim in the Appendix A.

5.8 Mobile Phone Ownership and Usage

The question of the students being regular users of mobile phones was answered by most of the participants. Of the 121 responses to: “Do you use a mobile phone?” 93.7% said they did with only 4.7% not giving a reply, thereby supporting the assumption of the usage of this technology within the target audience to be very high.

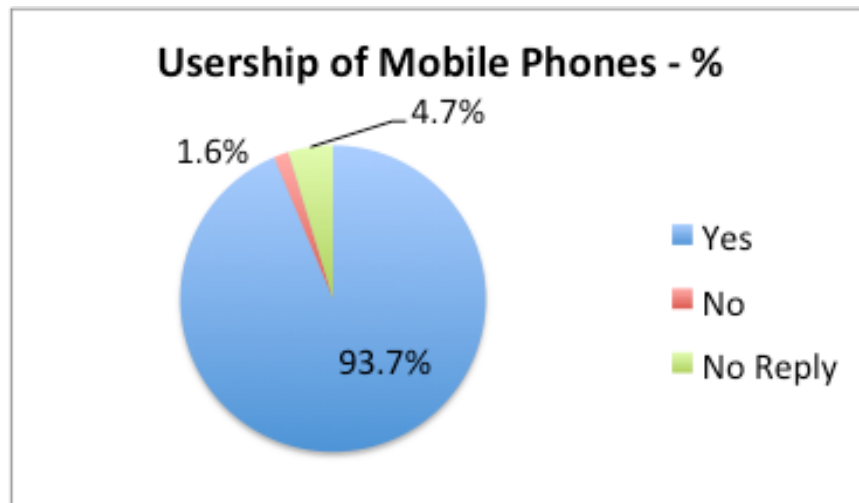


Fig 5.16: Mobile Phone Usage

5.9 Interpretation and Validation

The quantitative data was tabulated and a graph prepared showing the results of each cohort of testers overlaid onto one background it shows a generally consistent ‘shape’ of the individual graph lines.

Fig 5.17: Composite Graph of answers to questionnaire. These show different colours from each cohort of students from either Priestley or Cronton who participated in the evaluation. The students attended randomly so the grouping is purely administrative. This consistency of graph lines provides some level of confidence that most respondents were assessing the material and responding to the questionnaire in their own way and this begins to build confidence for using these responses in assessing the merit of the project.:

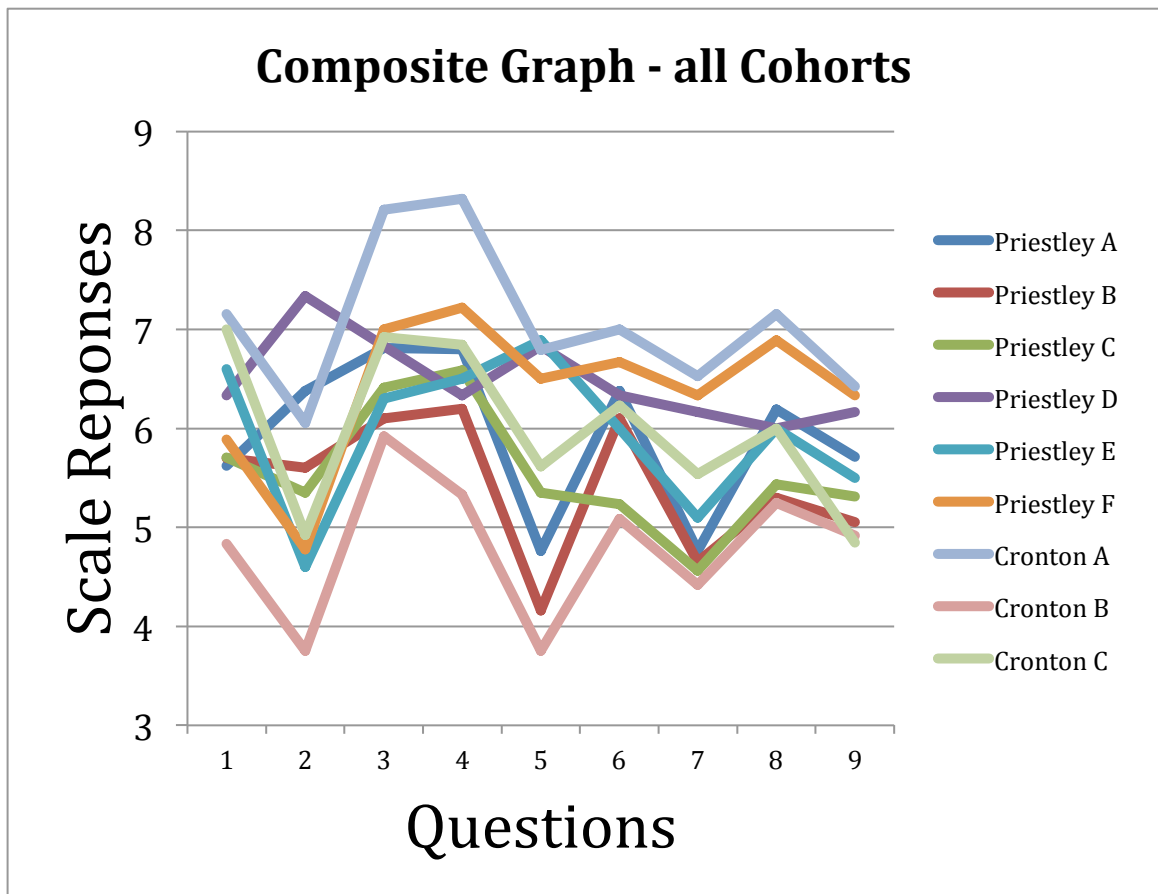


Fig 5.17: Composite Graph of answers to questionnaire

The overall shape of the graph lines of averaged responses shows considerable agreement between the nine groups in the evaluation process. Some points on the graph lines vary from the majority and may have noticeably different values or even go against the trend of the pattern.

Priestley Group D responses on the questionnaire follow the pattern of graph lines from all respondents except for a peak, at 7.33, in response to Question 2. This question asked for a self-evaluation of the learner's prior knowledge in the area of learning, and is the only indication from any group showing that they perceived they possessed a higher level of knowledge than was marked by any of the other groups.

The major difference shown in this series of graph lines comes from the responses provided by students in the first group, 'A' from Cronton. These are noticeably different from the general pattern of the graph lines at Question 3 and Question 4. These two questions ask learners for their response to the question about 'Explanations and technical content'. Specifically, Question 3: 'were the explanations and technical content easy to read or follow?' While Question 4: 'were the explanations and technical content understandable?' These responses with higher than average figures for these two questions tends to indicate a positive response that the learners particularly liked the style of the material in the area of it being both easy to read or follow and understandable.

Total responses Table 5-2: Statistics – Arithmetic Mean and Standard Deviation figures:

Question No.	Average Score Marked	Standard Deviation (population)
Q1	6.07	1.86
Q2	5.46	2.06
Q3	6.76	1.80
Q4	6.75	1.73
Q5	5.42	2.21
Q6	6.13	1.75
Q7	5.24	2.10
Q8	6.02	1.90
Q9	5.55	1.85

Table 5-2: Statistics – Arithmetic Mean and Standard Deviation

Low numbers in the standard deviation statistics indicate that more scores were closer to the arithmetical mean of the data. The total possible number of responses from the 127 evaluations is: $127 \times 9 = 1143$. Of these only 275 (24.06%) were lower than the ‘5’ mark (<5) and this provides a further measure of confidence in the statistics supporting the approach adopted for the project.

Analysis of the data shows that the material was generally felt to be interesting and enthusing by these groups of AS A Level and BTEC students. A few negative comments were received. Some were about the level of communication and that there was ‘too much text’ being a common thread. Others comments appear to originate from a misunderstanding of the use of the accessibility options when using the files produced via the authoring tool Pedagogue. Considering the main line of complaint based on the quantity of text presented

there was general support for the design and the style of the learning material as is clearly reported. For students going into higher or further education to study STEM courses at degree level they will encounter a great deal more text than was presented throughout this Learning Unit. On balance the evidence provides support for the aims expressed as objectives throughout the research project.

5.10 Summary

Having started with a design philosophy and evaluated the data from the project and checked that the data was valid to a level of acceptability the final question must be: does the data provide useful answers, or at least indicators, to the research question? A pilot test, which led to a minor revision of the questionnaire, showed that the research strategy appeared to provide a solid basis for running the larger experiment. The overall impression is that the responses were favourable to the style of the material in the main as will be discussed in the next and final Chapter – the Conclusion.

6 Chapter Six – Conclusion

The rationale for this project was established in Chapters 1 and 2, and research of the available bodies of work in this area were reported, looking in particular at the background of educational and learning theory, and development of E-Learning with associated technologies. Following good practice a methodology was constructed following guidance from the literature research, choosing the most appropriate delivery mechanism, and ethical considerations were applied to safeguard volunteering participants in the experiment. The implementation of the work was written out through Chapter 4: The design and compilation of the evaluation process, and creating a tool for collecting and collating response data following exposure of the material to students following appropriate courses is covered in Chapter 5. Pilot testing was built in to the process as a cross check – firstly of the assumptions made about the testing philosophy and of course the design of the material.

The Research Question posed by this work was:

“Will learners be more interested, and therefore, enthused to study technology based subjects if the teaching of those subjects is directly related to their daily use of such technology?”

The answer to this is provided by the results of the evaluations carried out with 127 college students and specifically their answers to questions 6 and 7 of the questionnaire that focused on the use of the text messaging scenario as the key context of the Learning Materials. The answers to these two questions were presented in Chapter 5 as figures 5.9 and 5.10 and from which it is clear that the overwhelming majority of respondents felt that this context had both aided their understanding of the material and made it more interesting. Although this analysis is based on the experiences of only 127 college students this group does nevertheless represent cohorts from relevant AS and A Level and BTEC courses. This therefore is an encouraging result and provides evidence to suggest that learners will indeed

be more interested when the teaching of a subject is directly related to something that they use on a daily basis.

With regard to whether students will be more enthused to study technology based subjects as a result of adopting this style of contextual learning, question 9 of the questionnaire asked about undertaking further research. These results were presented as

Fig 5.12: Question 9 responses' within chapter 5 and once again show an overwhelming majority felt that the materials had been a source of motivation for undertaking further research into the subject. This of course, does not imply or provide any guarantees that these students would be motivated to study any other technologically related subjects.

In summary, the research that has been carried out has provided sufficient evidence to suggest that adopting a contextualised approach to teaching has the potential to further enthuse and motivate students.

In terms of future work it would be interesting to extend the work presented in this thesis to a much larger and diverse group of students, to undertake a longer study in which the impact on individual academic performance could be measured and the impact on progressing to higher education. It would also be interesting to examine other scenarios within ICT to determine if the same principles can be applied with the same degree of success and from there to extend the work more generally into other areas of Science, Technology, Engineering and Mathematics.

7 Appendix

7.1	APPENDIX A – TEXT RESPONSES	113
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7.1 Appendix A – Text Responses

Verbatim quotes of answers to the three open questions on the Evaluation sheet.

Open Question 1 – What aspect did you like most about the material?

*It was interesting and ... I enjoyed it all**

Colour options

The diagrams give you a good idea of what the unit is about

The info about the chosen subject

The information about Mobile networks

I liked the multiple choice questions

The questions

The data and encoding side of it.

The drag and drop questions.

The diagrams helped me to understand what it was that was being explained in the text

The Radio aspect I liked was about , how old radio is exist

Learning how a text message is sent

Learning about radio and how its transmitted

The presentation was good because it had questions and

I liked the part where it told you how texts don't go directly to the phone they have to go through a tower

The interactive features

The multiple choice questions that make it more interactive

How easy it is to follow. Very clear

The multiple choice questions

I found it interesting how texts work

The questions

How does the text leaves the phone¹

How the whole layout is centered

Page 5. It has an animation, an image and a suitable amount of text (LO1)

It was easy to understand

The favourite of mine was a research question one

The games, that help you learn

The games that help you learn more easier

Interactive features

Good info but boring

The layout , how it was presented

Diagrams

The questions and diagrams

The CPU System
The friendly images and questions ideas are good.
How it explained everything step by step²
Easy to follow [x2]
The bit with the radio
It shows the history of phones in an image
It was great I enjoyed it [LO3]
Most likely was the one with Radio waves and the mobile phone
The memory part
I liked the part where it told you how far and the speed it takes to send a message
Most things
The interactive diagrams were helpful
The layout
Electromagnetic wave multiple choice
Learning stuff
It was very informative [LO3]
The text is easy to read
The electromagnetic spectrum
Information on light and sound waves
Most likely was the modern mobile phones antenna
The information it gives out is good and informative³
Image is a little interesting and easy to read
Antenna radiation
Disappearing antennas
The one that I liked was the one with Binary Coding
Multiple choice [x2]
The explanation of how binary numbers worked was interesting
I liked the way it was layed out
It is good and very clear to read
Letters being converted to binary
All of it⁴
Easy to understand the material [x2]
Most that I liked was the one about Mobility.
Explanation of radio cells
Multiple choice
It was easy to learn new things that you wouldnt normally know
In the Radio Propagation my most faviate was it was easy to learn new things as there was a bot if information
The multiple choice section on the Cellular Architecture page
Multiple choice section

Open Question 2 – What aspect did you like least about the material?

**It was interesting and ... I enjoyed it all*
It was the aspect about How does the text message leave the phone
I thought most of it was not interesting because there was too much text
To much reading and to much information
The Blocks of Text
Fairly boring. Un-interesting
Not that interesting – needs to more intriguing
More images should be used. too much text
The animations
their was too much text
Large Blocks of Text
Where does the text go when it has left my phone1 Same respondent
Colour scheme
On the questions, they have a limit to how many times they can be answered,
this pressures people
The part about monics (harmonics?) with antennas
The one with keypad and screen
The lot of text no easy to read
The blocks of text
Too much text
Not very interesting
Not exciting or intrested
Large paragraphs of text > needs to be more broken down
The Dial numbers for areas
The colour scheme is very sickly and some of the questions are unnecesary .
– Why is town dialing codes important? How would we know?
It was long winded at points2
Colours and themes
Page 7 displayed only one image and rest was text, this can be off-putting
Least likely was about Modulation
Learning about the Audio & output
Little things
Not as interesting. Can be complicated at times [Radio Prop]
Not entertaining
Questions were very simple – didn't need to read before answering. Too
much common sense - Boring
Sine waves
Not learning stuff
There wasn't much use of imagery [LO3]
Needs more coloure and better colours
Least one was the one with So I could use my mobile on the moon then?
I like how it displays a good amount of information, not so much that it
becomes boring

That there isn't enough pictures to keep it interesting
The way it is set out is hard to understand
Bad choice of colour
Dipoles length
Horizontal radiation pattern
The least one that I liked was the one with , sending message to Tez.
Unclear flow of information
The decimal index table was not explained clearly. Difficult to understand
Decimal table
It's a little childish e.g the fonts ect
I didn't like the coding table
Cul8r
Long daunting paragraphs
Long paragraphs
Too much text Add more diagrams
The video about how to send a message.
There was too much text.
Data transmission
Having to read the masses of text.
Having to work out the calculations on the fourth page, for the second activity
Too much information. Could be simplified.
None of it
Color scheme is annoying and the web content should fill the whole page
The least that I liked was the one: What happens when you switch your phone on?
To much information for just starting to learn about the subject
It was a little confusing having big blocks of texts
It was very time consuming, there was too much text and too many tasks you had to complete

Open Question 3 – Please add any other comments you feel might be relevant:

To make it short and don't fill it with with information
blocks of text where to large and where boring to read through
it took me a step closer to enlightenment
good info but boring
Again – The colours are too much, calmer colours would be more effective
LO2 index file actually opens LO3 instead.
Didn't find any of it useful, in fact, it was wrong! [LO2]
No thank you.
Could do with more colours
Too text heavy

Long paragraphs were hard to concentrate, and the answers were usually too close to the questions to be challenging (sic)

The colour option is good

Include more colour variations and text fonts

Include more colours in the text to make more important information stand out.

Try to explain things as simply as possible

More tasks and questions and less text

I took on more step to heaven baby one step closer to you 4

First page has a huge gap

Some of the answers were coded into more than one category for the qualitative analysis, so the total numbers were gleaned from the actual returned question sheets.

Appendix B – Introduction to ‘Text Tez’

Project to write material to: enthuse, encourage, and stimulate learning in technology.

Using the story of sending a text message to a friend, called Tez.

Our grateful thanks to your College and staff for their help – and of course – YOU!

- You are free to chose not to help
- You retain the right to withdraw at any time

To ensure your right to withdraw we need to keep a list of names. A reference code on your evaluation sheet allows withdrawal of your replies. Other than that the sheets collected from you remain anonymous. No one else will ever know who wrote which sheet and I will only use that information should you wish your responses to be cut from the project records.

The software can run online, across a network, or be downloaded and run from CD or USB drive.

To run the web pages open the folder, for example ‘L04V4’ and click (or double click) on either of the files: index.html [or index_ad07bf10-83e9-4c27-a5ac-46e7743f15ac1]

This should open in whichever web browser is set as default. Often this will be Internet Explorer but any modern web browser: Chrome, Firefox, or Opera is fine.

You have options <Options> top left below the small graphic:

- Screen Preferences – to change the colour scheme and text sizes
- Clear Cookies – if you want to start afresh all notes of previous sessions are cleared.

Read through the text screens and follow any other instructions. Help files are included but please ask if you get lost or need assistance at any points. When navigating the screens the right side bar is slightly different from standard – but I’m sure you will soon Fig it out.

You need to answer the set questions in order to proceed. Wrong answers may allow three attempts, often this will also leave any partially correct answers in place, and then provide the answer needed.

The page numbers at the end of each screen allow you to go forwards (if all questions are complete) or backward if you wish to review a previous screen again.

Don’t worry if you don’t finish a set of pages. We are interested in your reactions and responses to what we have written rather than your onscreen answers. It is not a race to finish.

You may work in ‘small groups’; suggest in twos or threes.

Spend about 40 – 45 minutes going through the pages / screens – we call them a learning object.

Then individually write up your responses to the questionnaire / evaluation sheet.

7.2 Appendix C – Final Questionnaire

Evaluation Sheet: LO ____

Ref: [College] / ____

Please circle your preference marks using the scale of 0 – 9 where:

0 = did not like / lower / lowest & 9 = best / better / liked very much

No	Area	Scale	
	Design and layout on screen:		
1	Colour choice for background and / or text	0 1 2 3 4 5 6 7 8 9	
2	What level of knowledge in this area would you say you had prior to using this material?	0 1 2 3 4 5 6 7 8 9	
	Explanations and technical content – was it:		
3	Easy to read or follow?	0 1 2 3 4 5 6 7 8 9	
4	Understandable?	0 1 2 3 4 5 6 7 8 9	
5	Interesting?	0 1 2 3 4 5 6 7 8 9	
	Do you think that relating how a text message is sent to a friend helped you:		
6	Understand the technical content?	0 1 2 3 4 5 6 7 8 9	
7	Did this make it more interesting?	0 1 2 3 4 5 6 7 8 9	
	Did the questions help you to better or further understand the subject when they were:		
8	Used as progress checks?	0 1 2 3 4 5 6 7 8 9	
9	For further research?	0 1 2 3 4 5 6 7 8 9	

Which aspect did you like most about the material in the Learning Unit / Object?

Which aspect did you like least about the material in the Learning Unit / Object?

Please add any other comments you feel might be relevant:

Do you use a mobile phone?

Yes / No (delete as appropriate)

If 'Yes' please state Make: _____

Model: _____

7.3 Appendix D – References

- AQA, (2009), retrieved from: <http://www.aqa.org.uk/subjects/ict-and-computer-science/gcse/information-and-communication-technology-4520> last accessed 20/5/2013
- Atherton, J. S., (2011a), Learning and Teaching; Piaget's developmental theory [On-line: UK] retrieved 5 May 2013 from <http://www.learningandteaching.info/learning/piaget.htm>
- Atherton, J. S., (2011b), Learning and Teaching; Constructivism in learning [On-line: UK] retrieved 16 April 2013 from <http://www.learningandteaching.info/learning/constructivism.htm#Vygotsky>
- Australian Education, (2007), <http://australia.gov.au/about-australia/australian-story/school-of-the-air> retrieved 5/5/13
- Barnett, J., & Hodson, D. (2001), Pedagogical context knowledge: Toward a fuller understanding of what good science teachers know. *Science Education*, 85(4), 426-453.
- Bell, B. S., & Federman, J. E., (2013). E-learning in Postsecondary Education. *The Future of Children* 23(1), 165-185. Princeton University. Retrieved July 26, 2013, from Project MUSE database.
- BERA, (2011), Ethical Guidelines Retrieved from <http://www.bera.ac.uk/> Last Accessed 8/5/2013
- Bennett, J., Gräsel, C., Parchmann, I., & Waddington, D. (2005), Research Report. *International Journal of Science Education*, 27(13), 1521-1547.
- Bilash, O., (2011), retrieved from <http://www.educ.ualberta.ca/staff/olenka.bilash/Best%20of%20Bilash/inductivedeductive.html> last accessed 24/7/2013
- Bitzer, D.L., Johnson, R.L., (1971), "PLATO: A computer-based system used in the engineering of education," *Proceedings of the IEEE* , vol.59, no.6, pp.960,968, retrieved from ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1450224&isnumber=31145
- Blackboard, (2013), retrieved from www.blackboard.com last accessed 27/7/2013
- Boardman, D., (1993), 'Evaluating quality in research: Asking why? As well as how?' *International Research in Geographical and Environmental Education*, 2 (1), pp. 85-88.
- Bruner, J.S., (1961), 'The act of discovery', *Harvard Educational Review*, 21-32.
- Bruner, J. S., (1973), Organisation of early skilled action. *Child Development*, Vol 44:92-96
- Bruner, J. (1983), *Child's Talk: Learning to Use Language*. New York: Norton.
- Bruner, J.S., (1996), *The Culture of Education*. Cambridge, Mass.: Harvard University Press.
- Bruner, J. S., & Bruner, J. S. (2009), *Actual minds, possible worlds*. Harvard University Press.
- Bruner, J., Goodnow, J., & Austin, A. (1956), *A Study of Thinking*. New York: Wiley.

Bush, V., (1945), "As We May Think - A Celebration of Vannevar Bush's 1945 Vision", at Brown University Vannevar Bush and Memex – Living Internet

CDSM, (2013), Retrieved from: <http://www.cdsm.co.uk/company/casestudies.htm> last accessed 23/7/2013

Chadwick, K., (2013), retrieved from: <http://www.bizcommunity.com/Article/196/98/91640.html> last accessed: 23/7/2013

Clark, R. C., & Lyons, C., (2010), Graphics for learning: Proven guidelines for planning, designing, and evaluating visuals in training materials. John Wiley & Sons.

Cohen, L., Manion, L., & Morrison, K., (2007), Research Methods in Education, 6th Ed, Routledge Oxon.

Cole, M., (1978), Ed. and translation, Vygotskiĭ, L.S., (1938), Mind in Society: the development of higher psychological processes London : Harvard University Press

Creswell, J.W. (1994), Research Design: Qualitative and Quantitative Approaches London: SAGE.

Creswell, J.W. (1998), Qualitative Inquiry and Research Design Choosing Among Five Traditions. Thousand Oaks, CA: Sage Publications.

Creswell, John (2004), Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research. Columbus: Prentice Hall,

Department for Education, 2010, retrieved from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/175406/CPTF_-_External_Report.pdf last accessed: 23/7/2013

Dewey, J. (1938). Experience and Education, New York: Collier Books. [First published in 1938 – reprint 1963]

Dewey, J., Morris, D., & Shapiro, I. (1993). The political writings. Hackett Publishing Company.

Edexcel 2011 retrieved from: [http://www.edexcel.com/migrationdocuments/BTEC%20 - Nationals%20from%202010/BN029815-BTEC-90-credit-IT-L3-Issue2.pdf](http://www.edexcel.com/migrationdocuments/BTEC%20-Nationals%20from%202010/BN029815-BTEC-90-credit-IT-L3-Issue2.pdf) last accessed 20/5/2013

Education and Skills Act 2008, retrieved from: <http://www.legislation.gov.uk/ukpga/2008/25/section/2> 24/4/2013

E-Learning Centre, 2013, retrieved from: <http://www.e-learningcentre.co.uk/blog/2012/03/is-e-learning-becoming-more-popular-in-the-uk/> last accessed: 23/7/2013

Elliott, P., & Daniels, S., (2006), Pestalozzi, Fellenberg and British nineteenth-century geographical education. *Journal of Historical Geography*, 32(4), 752-774.

Equality Act 2010, Retrieved from <http://www.legislation.gov.uk/ukpga/2010/15/contents> last accessed 7/5/2013

Facebook, 2013, retrieved from <https://newsroom.fb.com/Key-Facts> last accessed 3/6/2013

- Gibson, I.W., (2001), At the intersection of technology and pedagogy: considering styles of learning and teaching, *Journal of Information Technology for Teacher Education*, 10:1-2, 37-61 DOI: 10.1080/14759390100200102
- Gilbuena, D., (2013) Sherrett, B., Gummer, E., & Koretsky, M. D. Appendix B– Understanding Feedback in an Authentic, Ill-Structured Project through Discourse Analysis: Interaction between Student and Instructor Objectives. *Industrially-Situated Project-Based Learning: A Study of Feedback and Diffusion*, 208.
- Grabinger, R. S., & Dunlap, J. C. (1995). Rich environments for active learning: a definition. *Research in Learning Technology*, 3(2).
- Grazzini, C., (1988), "The Four Planes of Development: A Constructive Rhythm of Life". *Montessori Today* 1 (1): 7–8.
- Gutek, G. L., (1988). *Philosophical and ideological perspectives on education*. Englewood Cliffs, NJ: Prentice Hall.
- HESA, (1997), retrieved from, http://www.hesa.ac.uk/dox/pubs_archive/ukvol_1997-98_table_0.pdf last accessed 3/6/2013
- HESA, (2007), retrieved from, <http://www.hesa.ac.uk/dox/dataTables/studentsAndQualifiers/download/subject1112.xls> last accessed 3/6/2013
- Hicks, M., Reid, I., and George, R., (1999), conference paper the Flexible Learning Centre, University of South Australia. Retrieved from: http://www.herdsa.org.au/?page_id=182#H Last accessed 27/7/2013
- Hummel, C., 1993, ARISTOTLE (384-322 B.C.) PROSPECTS: quarterly review of comparative education Paris, UNESCO: International Bureau of Education, vol. 23, no. 1/2, 1993, p. 39-51. Retrieved from: http://www.ibe.unesco.org/fileadmin/user_upload/archive/publications/ThinkersPdf/aristote.pdf last accessed: 2/5/2013
- IET Survey, (2012), retrieved from <http://www.theiet.org/factfiles/education/skill-survey-page.cfm> last accessed 3/6/2013
- Instructional Design 2011, retrieved from: <http://www.instructionaldesign.org/index.html> last accessed 4/5/13
- ITU, 2013, Retrieved from <http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx> accessed 7/5/2013
- Kelleher, C., & Pausch, R. (2007). Using storytelling to motivate programming. *Communications of the ACM*, 50(7), 58-64.
- Kerlinger, F. N., (1970), *Foundations of Research*, New York: Holt, Rinehart, & Winston
- Kolb D.A. (1984) 'Experiential Learning experience as a source of learning and development', New Jersey: Prentice Hall
- Laurillard, D., 1993, *Rethinking University Teaching: A Framework for the Effective Use of Educational Technology at chs 1 & 3*. London: Routledge

- Laurillard, D., 2004 *E-Learning_in_Higher_Education.doc 2* also published in 'Changing Higher Education', Edited by Ashwin, P., London, Routledge, 2005
- Leeds, (2013), Retrieved from http://www.ldu.leeds.ac.uk/ldu/sddu_multimedia/kolb/static_version.php. Davies, C., and Lowe, T., last accessed 30/6/2013
- LeGard, W.T., (2004), retrieved from: www.scribd.com/doc/13401568/Piaget-Versus-Vygotsky last accessed 6/5/2013
- Leonard D. C., (2002), *Learning theories, A to Z*, Oryx Press, Westport, Conn.
- Lombardi, S.M., (2011), *Internet Activities for a Preschool Technology Education Program Guided by Caregivers*. Doctoral dissertation, North Carolina State University. pp. 139–40.
- Maddux, C.D., (1997), *The Newest Technology Crisis*, *Computers in the Schools*, 13:3-4, 5-12
- McManus, (c. 2007), retrieved from www.csap.bham.ac.uk/ALAC/text/Active%20Learning.doc last accessed 25/6/2013
- Montessori, M., (1969), "The Four Planes of Development". *AMI Communications* (2/3): 4–10.
- Montessori Movement, (2011), retrieved from: <http://www.montessori-ami.org/montessori/movement.htm> last accessed: 23/7/2013
- Montessori, (2013), retrieved from <http://michaelolaf.net/FAQMontessori.html> last accessed 26/6/2013
- Moodle, (2013), retrieved from <https://moodle.org> last accessed 27/7/2013
- National Academy of Engineering, US, (2012), retrieved from http://www.nap.edu/openbook.php?record_id=13165&page=4 last accessed 27/7/2013
- Nehme, M., (2010), *E-Learning and Students' Motivation*. *Legal Educ. Rev.*, 20, 223.
- Ofcom, (2007), retrieved from <http://media.ofcom.org.uk/facts/> last accessed 21/5/2013
- Ofcom, (2008), retrieved from <http://media.ofcom.org.uk/facts/> last accessed 21/5/2013
- Ofcom, (2011a), *CMR, Q4* retrieved from <http://media.ofcom.org.uk/facts/> last accessed 21/5/2013
- Ofcom, (2011b), retrieved from <http://media.ofcom.org.uk/2011/08/04/a-nation-addicted-to-smartphones/> last accessed 3/6/2013
- Ofcom, (2012), *précis of Communications Market Report* retrieved from <http://media.ofcom.org.uk/2012/07/18/uk-is-now-texting-more-than-talking/> last accessed 21/5/2013
- Ofqual, (2013a), retrieved from <http://ofqual.gov.uk/qualifications-and-assessments/national-curriculum-and-early-years>, last accessed 15/6/2013
- Ofqual, (2013b), <http://ofqual.gov.uk/files/2013-02-07-qualification-levels-diagram.pdf>, last accessed 22/7/2013

- Ofqual Register, (2013), The Register of Regulated Qualifications, retrieved from: <http://register.ofqual.gov.uk/> last accessed 23/7/2013
- Ofsted, (2007), retrieved from <http://www.ofsted.gov.uk/inspection-reports/find-inspection-report/provider/ELS/130624> last accessed 8/5/2013
- Ofsted, (2010), <http://www.ofsted.gov.uk/inspection-reports/find-inspection-report/provider/ELS/130622> last accessed 8/5/2013
- Oliver, R., 2001. Developing e-learning environments that support knowledge construction in higher education. In: Electronic Document from Second Web Conference 2001, pp. 407–416. Last accessed 25/7/2013
- Oxford Brookes, (2000), retrieved from <http://www.brookes.ac.uk/services/ocslid/archive/theories.html>. Last accessed 3/7/2013
- Oxford Index, (2011), BTEC retrieved from: <http://oxfordindex.oup.com/view/10.1093/oi/authority.20110803095538106> 24/4/2013
- Paulsen, M. F., (2002), Online Education Systems: Discussion and definition of terms. NKI Distance Education, 1-8. Retrieved from: <http://www.porto.ucp.pt/open/curso/modulos/doc/Definition%20of%20Terms.pdf> last accessed 26/6/2013
- Pestalozzi, J. H., (2010), Leonard and Gertrude (from the 1885 edition published by D. C. Heath). Memphis: General Books.
- PlatoHistory, (2011), retrieved from: <http://www.platohistory.org/blog//timeline/> on 5/5/2013
- Prince, M. J., & Felder, R. M., (2006), Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education*, 95(2), 123-138.
- Reichelt, L., (2006), retrieved from <http://www.disambiguity.com/when-to-use-drag-drop-some-informal-research-results/> last accessed: 26/7/2013
- Rousseau, J. J., (1762), *Émile*, eBook translated by Barbara Foxley retrieved from: <http://www.gutenberg.org/cache/epub/5427/pg5427.txt> last accessed 5/5/2013
- Rowland, S., (2006), *The Enquiring University*. Milton Keynes: Open University Press/Society for Research in Higher Education. McGraw-Hill International.
- Sawyer, R. K., & Greeno, J. G., (2009), Situativity and learning. In P. Robbins & M. Aydede (Eds.), *The Cambridge Handbook of Situated Cognition* (pp. 347-367). Cambridge: Cambridge University Press
- Shlechter, T.M. (1988). The effects of small group and individual computer-base instruction on retention and on training lower ability soldiers. E-Book retrieved from: <http://hdl.handle.net/2027/uiug.30112101574959> last accessed: 6/5/2013
- Simpson, 2005 Internet Encyclopedia of Philosophy retrieved from <http://www.iep.utm.edu/bacon/#SH2b> last accessed 16/6/2013

Stanney, K.M., Mollaghasemi, M., Reeves, L., Breaux, R., & Graeber, D.A., (2003), Usability engineering of virtual environments (VEs): identifying multiple criteria that drive effective VE system design, *International Journal of Human-Computer Studies*, Volume 58, Issue 4, April 2003, Pages 447-481, ISSN 1071-5819, 10.1016/S1071-5819(03)00015-6. (<http://www.sciencedirect.com/science/article/pii/S1071581903000156>)

Strauss, A., & Corbin, J., (1990), *Basics of qualitative research: Grounded theory procedures and techniques*. Newbury Park, CA: Sage Publications, Inc.

Taasoobshirazi, G., & Carr, M., (2008), A review and critique of context-based physics instruction and assessment. *Educational Research Review*, 3(2), 155-167.

Training Teachers Globally, (2011), Retrieved from (<http://trainingteachersglobally.wordpress.com/tag/zone-of-proximal-development/> 6/5/2013

UCAS, (2008), retrieved from http://www.ucas.ac.uk/about_us/stat_services/stats_online/data_tables/hesubject, last accessed 20/5/2013

UNICEF, (1999), retrieved from: <http://www.unicef.org/teachers/> Last accessed 8/5/2013

USASK, (c. 2000), retrieved from <http://www.USASK.ca/education/coursework/802papers/Skaalid/definition.html> last accessed 25/6/2013

University of Salford, (2013), Retrieved from <http://www.pg.salford.ac.uk/ethics> Last accessed: 23/7/2013

Vygotskiĭ, L. L. S., (1978), *Mind in society: The development of higher psychological processes*. Harvard University Press. Ed. Cole et al.

Vygotsky Group Online P540, (1996), <http://itls.usu.edu/~mimi/courses/6260/theorists/Vygotsky/vygobio.html> Last Updated on May 3, 1996 last accessed 4/3/2013

W3schools, 2013, Retrieved from <http://w3schools.com/> last accessed 7/5/2013

Westbrook, R. B., (1991), *John Dewey and American Democracy*, Cornell Univ. Press.

Whitelegg, E., & Parry, M., (1999), Real-life contexts for learning physics: meanings, issues and practice. *Physics Education*, 34(2), 68-72.

Wikipedia, (2013), <https://en.wikipedia.org/> Plato V green screen image

Wikipedia, (2013a), Online Internet traffic retrieved from http://en.wikipedia.org/wiki/Internet_traffic quoting figures from Cisco last accessed 7/5/2013

Wikipedia, (2013b), retrieved from https://en.wikipedia.org/wiki/Distance_education last accessed 27/6/2013

Lord Willis, (2013), retrieved from <http://www.theyworkforyou.com/lords/?id=2013-03-21a.759.1> last accessed 3/6/2013

Wood, P. B., (2012), *Developing An Active Learning Approach For The Geography Pilot GCSE – An Action Research Investigation* Unpublished Thesis University of Birmingham Retrieved from University of Birmingham Research Archive e-theses repository 10/3/2013

Zweben, S. (2007). 2005-2006 Taulbee Survey Record Ph.D. Production Continues: Undergraduate Enrollments Turning the Corner. *Computing Research News*, 7-22.

7.4 Appendix E Inside of or Facing Back Cover

CD ROM includes:

Web page versions of all Learning Object's 1 – 6

To run the electronic version open the appropriate directory under root, /TextTez and click on either of the 'index.html' or 'index*.html' files. [* = wildcard]

.pdf versions: containing the main text, images, and outline of the questions used in the Learning Object's

.pdf version of this thesis