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IMPLEMENTATION OF TECHNOLOGY ENHANCED LEARNING PEDAGOGY AND IMPACT ON EMPLOYABILITY AND LEARNING WITHIN ENGINEERING EDUCATION FRAMEWORKS

By

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A thesis submitted to Plymouth University in partial fulfilment for the degree of

DOCTORATE OF PHILOSOPHY

March 2015
Abstract

Implementation of Technology Enhanced Learning Pedagogy and Impact on Employability and Learning within Engineering Education Frameworks

Rebecca Eva Vickerstaff

Engineering Education experiences turbulent changes, both from government pressures and from industry demands on readdressing the requirements of graduate capability. Despite vast amounts of engineering literature discussing ‘change’ within the field, engineering curricula still maintains its predominant pedagogic model of dissemination to students as it did in previous decades.

Technology Enhanced Learning in education has created new and flexible options in the delivery and assessment of teaching and learning, but uptake is limited and approached with caution within Engineering Education.

This mixed methods research introduces an inclusive and innovative approach to Engineering Education assessment techniques utilising an integrated blended learning strategy to the implementation of Technology Enhanced Learning within engineering curriculums.

The research explores and assesses the effectiveness of Technology Enhanced Learning and educational pedagogies within Engineering Education frameworks to enhance and develop student learning, digital literacy and employability.
Abstract

Preliminary research positioned the research, utilising observation and interview techniques to baseline current pedagogic practices in undergraduate Engineering Education against current literature.

An alternative method of video assessment was implemented and embedded following a two year cycle of action research within a cohort of two undergraduate engineering modules. A prototype ‘toolkit’ was created using Xerte Online Toolkits (XOT) to facilitate student learning and support for the assessment. Additional techniques inside the cycles gained further qualitative and quantitative data via a survey and focus groups. Student learning and assessment results showed significant improvement following the introduction of this approach and validated the transferability of this technique into other educational disciplines.

An industry based survey validated chosen research methods and provided a comparison of viewpoints on key issues surrounding Engineering Education against existing stakeholders.

The research introduces a new innovative approach to Engineering Education utilising Technology Enhanced Learning, validated through positive industry feedback and student academic achievement and satisfaction. Significant improvements on student employability and engineering ‘soft skills’ are evidenced.
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<td>Building Information Modelling</td>
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<td>BYOD</td>
<td>Bring Your Own Device</td>
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<td>CAD</td>
<td>Computer Aided Design</td>
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<td>EE</td>
<td>Engineering Education</td>
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<td>HEFCE</td>
<td>Higher Education Funding Council for England</td>
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<td>HEI</td>
<td>Higher Education Institution</td>
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<td>JISC</td>
<td>Joint Information Systems Committee</td>
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<td>MMR</td>
<td>Mixed Method Research</td>
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<td>Problem Based Learning</td>
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<td>Project Based Learning</td>
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Author’s Signed Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award.

Presentation and Conferences Attended: 2

Word count of main body of thesis: 97,705
1 Introduction

This chapter introduces the issues and problems that face Engineering Education, defines innovations in Technology Enhanced Learning pedagogies that provide potential solutions in defining feature of Engineering Education as well as defining the research aims and objectives of the work. The structure of the thesis is discussed and introduces the reader to the methods and techniques used within this study during each phase.
1.1 Introduction and overview

Higher Education has, and still is, going through a period of change, both in terms of external factors, such as reductions in government funding and student fee restructuring, but also in terms of student engagement and demand (Rajasingham, 2011; Siemens & Matheos, 2012). In 2011 the Government released the Higher Education White Paper which signified major changes to the way the Higher Education system would be funded and regulated. In the paper students were placed at the heart of the education system with emphasis placed on delivering a good student experience and developing employability skills for graduates. Funding was also dramatically changed with public funding for teaching being routed through the student loan system (Department for Business, 2011).

Despite this period of change and adoption, the vast majority of educational institutions continue with the same ideology and methods of historic academic models (Daraio, Bonaccorsi, Geuna, Lepori, Bach, Bogetoft, F Cardoso, Castro-Martinez, Crespi & de Lucio, 2011; Siemens & Matheos, 2012).

Engineering Education (EE), is a discipline responsible for the training and development of graduate engineers and is a field that is particularly affected by changes from Higher Education. The field is experiencing turbulent changes both from government pressures on creating more spaces on Science, Technology, Engineering and Mathematics (STEM) courses (HEFCE, 2010) and
from industry demands on readdressing the requirements of graduate capability.

Concerns over the importance of Engineering Education in the academic field have led to an increase of engineering teaching staff questioning how engineering has previously been taught, however literature has shown that some engineering academic staff are unsure what alternatives are available and worry that pursuing them would result in staff loosing valuable teaching and researching time (Rugarcia, Felder, Woods & Stice, 2000).

Despite vast amounts of engineering literature and discussing ‘change’ within the field, engineering curricula is said to still maintain its predominant pedagogic model of dissemination to students as it did in previous decades (Daun, Salmon, Tenbergen, Weyer & Pohl, 2014; Felder & Silverman, 1988). Engineering educators are increasingly looking for pedagogies to enhance and innovate the delivery of Engineering Education to students. Engineering students themselves are aware of the importance of real work examples and see the relevance of their own Engineering Education being contextualised against real world industry problems (Pomales-García & Liu, 2007). Despite this awareness studies have shown that students feel Engineering Education is not in line with industry requirements, with teaching methods being traditional and outdated (Daun et al., 2014).
Teaching methods need to be stronger aligned with educational research and pedagogy (Olds, Moskal & Miller, 2005) and contextualised against working practices in engineering industry.

Research methodologies within Engineering Education have until recently, been traditionally based on quantitative research techniques with qualitative methods slowly emerging in the last decade (Kelly & Bowe, 2011). Literature calls for new and innovative research techniques within Engineering Education to help progress and develop the discipline using experimental and descriptive studies (Baillie & Douglas, 2014; Kelly & Bowe, 2011).

The introduction of Technology Enhanced Learning in education has created new and flexible options in the delivery and assessment of teaching and learning (Beetham & Sharpe, 2013). Despite some encouraging signs in the adoption from Engineering Education (Kapranos, 2013a), the discipline appears to be wary of changes in delivery methods (Mora, Sancho-Bru, Iserte & Sánchez, 2012). Whilst technology is more accessible for engineering educators, the integration of this within the field is approached with caution due to the complex nature of Engineering Education and it’s assessment of practical expertise.

Researchers studying Engineering Education such as Grimson and Kapranos, speculate that the use of Technology Enhanced Learning will become a strategy for helping to achieve the shift required to meet industry requirements and
demands within Engineering Education (Grimson, 2002; Kapranos, 2013a) and call for innovative and validated methods of assessing and developing Engineering Education.

The next section will introduce the aims and objectives of the research.

1.2 Aims and objectives of the research

As educational technologies are being widely discussed as a catalyst to driving change needed in Engineering Education (Galloway, 2007b; Graham, 2012a), a series of techniques and methodologies will be used.

Currently the majority of Engineering Education literature surrounding implementations of Technology Enhanced Learning are small scale and refer to the introduction of technology to replace or supplement a practical experience for engineering students, including remote laboratories and simulations (Balamuralithara & Woods, 2009b; Nickerson, Corter, Esche & Chassapis, 2007b).

Research studies by Nasr and Froyd concluded that a mixed approach to pedagogy is needed to refresh and develop Engineering Education to produce graduates that are industry ready and have digital skills and awareness to progress within the workplace (Froyd, Wankat & Smith, 2012; Nasr, 2014).
The research aims of the study will explore the implementation and effectiveness of an integrated blended learning approach utilising Technology Enhanced Learning within an Engineering Education curriculum to enhance and develop student learning and employability.

The aims of the work will investigate the following four areas:

1. explore and evaluate the appropriateness of the implementation of Technology Enhanced Learning pedagogies and methods within an Engineering Education curriculum
2. evaluate the appropriateness of action research studies within Engineering Education
3. assess and evaluate the appropriateness of a mixed methods research methodology approaches to Engineering Education
4. understand views and opinions of stakeholders involved in Engineering Education research including students, academic staff and industry based professionals and to compare against current Engineering Education research literature

By achieving the aims of the research study, the work will validate and recommend chosen methods and discuss and evaluate a number of key themes that have been underrepresented previously in Engineering Education including:

1. the impact of the Technology Enhanced Learning pedagogies and methods within Engineering Education curriculum by evidencing
improvements in students’ work and engagement motivation in students’
learning
2. the appropriateness of action research methods within Engineering
   Education and ability to transfer techniques into other disciplines
3. the appropriateness of a mixed methods research approach to
   evaluating work within Engineering Education
4. understand views and opinions of stakeholders involved in Engineering
   Education and form recommendations for changes in engineering
   curriculum

1.3 Contribution to knowledge
The research provides unique approaches to the implementation of Technology
Enhanced Learning within an engineering curriculum which is discussed in detail
in Chapter 7. Using action research, initial concepts and use of Technology
Enhanced Learning was successfully implemented into two large
interdisciplinary based engineering modules. Student training and support
material is provided fully online using Technology Enhanced Learning (TEL)
pedagogies to define and develop student skills and support them in their video
production.
Alternative assignment methods are specified using video assessment methods which are a unique approach to assessing students in their understanding and research in developing projects around the design concept process.

The research provides evidence on the appropriateness of action research methodologies within a mixed methods study in Engineering Education. In Engineering Education using a combination of these two methods is unique and provides recommendations of evaluating new practices and innovations in engineering curriculums.

In addition the research provides recommendations on the unique use of Technology Enhanced Learning within Engineering Education to develop, assess and evaluate engineering student’s soft skills and understanding of industry based practices by contextualising their learning. Soft skills within Engineering Education refer to the non-technical, interpersonal and communication skills that are required from a practising engineer in industry to be able to work effectively and efficiently in a constantly evolving world.

The structure of the thesis will be discussed in the next section.

1.4 Structure of the thesis

Chapter 2 provides an extensive overview of the main topics associated within this research domain. These include issues surrounding Engineering Education defined as; Engineering Education, learning methodologies, industry requirements and Technology Enhanced Learning. After examining existing
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literature within this field of research, gaps in the literature are identified and justification for the direction and methodology of the research are discussed.

Chapter 3 introduces and defines the methodologies for this research. It provides an overview to practices seen in Engineering Education both currently and historically. Literature supporting the methodological decisions in this research is discussed and justified, resulting in an overview of how each individual element of the research correlates to the overall vision of this work. A research road map outlines the three phases of work used within this study including; preliminary research, implementation of Technology Enhanced Learning using action research methods and an industry based survey.

Chapter 4 defines work carried out during the preliminary stage of the research. It discusses results from a series of observations from two different undergraduate engineering modules and an analysis of three semi structured interviews with engineering teaching staff. Data gathered from this stage of the research then formed the guidance and objectives of the following two year cycles of action research discussed in the subsequent chapter.

Based on data gathered during the preliminary stages, chapter 5 introduces the data results from the two action research cycles which implement and evaluate the application of Technology Enhanced Learning within an Engineering Education curriculum utilising a mixed methodological approach within a two year cycle. Additional data gathered from techniques using focus groups and
surveys are discussed and evaluated in terms of impact on student learning and employability.

Chapter 6 introduces results gathered during an industry based survey and presents and evaluated the data to validate chosen methods used during the previous action research cycles. Industry viewpoints obtained on key areas relating to this research then formed a comparison against student viewpoints gathered during the action research cycle stages to gain a full view of stakeholder’s opinions relating to the research domain.

Chapter 7 discusses and reflects on the main findings of the research in comparison to the original aims and objectives of the study. Results and key themes gathered during the study are discussed against current Engineering Education literature. The impact of the work in relation to engineering graduate employability and impact on student learning and teaching will also be discussed.

Chapter 8 concludes the research study and reviews the chosen research methods and techniques used within this study. The main achievements of the work is summarised and includes discussions around limitations of the research to date and recommends potential future directions for the work.
2 Literature Review

This chapter provides a brief overview of the main topics associated within this research domain. These include issues surrounding Engineering Education defined as; Engineering Education, learning methodologies, industry requirements and Technology Enhanced Learning.

After examining existing literature within this field of research, gaps in the literature are identified and justification for the direction and methodology of the research are discussed.

2.1 Issues Surrounding Engineering Education

The field of Engineering Education encapsulates a number of sub topics and areas. In order to perform a critical literature review, issues surrounding Engineering Education were brainstormed and using research search engines such as Google Scholar, a number of sub themes were identified as shown in Figure 1.
Figure 1 Engineering Education brainstorm diagram
In the next section, these sub themes are explored forming the research aims later on in this chapter.

2.2 Higher Education

Higher Education is an integrated component of our society, with research and teaching and learning in the sector driving the development of our country’s economy and innovations. The more traditional Higher Education Institutions have been in existence for over one millennium and the introduction of accessible education in the format of the ‘Open University’ in the 20th Century has seen these academic institutions play a permanent and accessible role on our society (Laurillard, 2013).

Degrees qualifications are now becoming the ‘norm’ and considered as an essential qualification to have in today’s generation (Hazelkorn, 2011; Marshall, 2010).

2.2.1 Current state of HE

In the last decade it has been widely discussed and documented by various researchers that Higher Education has, and still is, going through a period of change, both in terms of external factors, such as changes in funding and restructuring, but also in terms of student engagement and demand (Rajasingham, 2011; Siemens & Matheos, 2012) but despite this period of change and adaption, the vast majority of educational institutions continue with
the same ideology and methods of historic academic models (Daraio et al., 2011; Siemens & Matheos, 2012).

As a result of funding changes in Higher Education, Higher Education Institutions are starting to function and run like a business whilst being creative and enterprising in gathering additional external funding to supplement the increasing decline in public funding (Bolli & Somogyi, 2011; Brown, 2013). In order to compete with other Higher Education Institutions both nationally and globally for student places, they must revaluate their methods and practices to recruit potential new students and research investment (Jarvis, 2013).

2.2.2 Fee Change Influences

Financial uncertainties are a major contributing factor in the continual change culture in Higher Education. Historically funding into Higher Education was paid from public taxes but the introduction of up front tuition fees in 1998, and the further increase in 2006/2007 saw a dramatic shift in the financing behind conventional degrees (Dearden, Fitzsimons & Wyness, 2011).

The more recent fee increases have seen a perceived change in student attitude, forcing Higher Education Institutions to view students more as partners and consumers (Department for Business, 2011; Durkin, McKenna & Cummins, 2012; Molesworth, Nixon & Scullion, 2009) than simply the final graduate ‘deliverable’. More and more Higher Education Institutions are looking for ways to succeed financially and to be able to compete effectively against
other institutions for students, but also to rise to the expectations of a seemingly more demanding student (Woodall, Hiller & Resnick, 2012).

Higher Education Institutions with strong Science, Technology, Engineering and Mathematics (STEM) course presence have been fortunate to receive an increase in funding from the Higher Education Funding Council for England (HEFCE) to help support the growth of these subjects to facilitate the industrial government strategy (MP, 2013).

2.2.3 Widening Participation

Traditionally access to Higher Education Institutions (HEI) was only considered accessible to those from a higher middle-class background (Winterton & Irwin, 2012) but changes to funding and innovative teaching and learning delivery approaches have made university courses more attainable to those who were previously unable to (Hoare & Johnston, 2011), also referred to as widening participation (Subic & Maconachie, 2004).

Whilst widening participation in Higher Education has been increasing for nearly half a century (Chowdry, Crawford, Dearden, Goodman & Vignoles, 2013), there is still some work needed in order for the UK’s ‘top universities’ to fully embrace the notion of widening participation (Harrison, 2011).

In the same instance applications to Science, Technology, Engineering and Mathematics (STEM) courses from below socio-economic groups is not equal to those of higher social groups (Subic & Maconachie, 2004). Equally recruitment
from females in the STEM disciplines still remains underrepresented (Powell, Dainty & Bagilhole, 2012).

The stereotype of an undergraduate student has also changed over the last decade (Read, Hanson & Levesley, 2008a) with many students needing to juggle work commitments and study which goes against the traditional 9-5 mode of attendance. Increase in part time study has enabled more diverse cohorts to enter the educational systems but forced Higher Education Institutions to seek alternative delivery methods to support them.

The need for alternative delivery methods saw the development of distance learning, which has helped expand widening participation to students who may not be able to physically attend traditional campus based learning (Kirkwood, 2006).

2.3 Learning Methodology

Before considering the issues in Engineering Education, core learning theories need to be explored that underpin the developments in the field of Technology Enhanced Learning and engineering for the development of practical competencies.
2.3.1 Learning Styles

The subject of learning styles and theory has historically sparked great debate and controversy among teaching practitioners. The fundamental idea behind learning styles is that not one student learns the same way and that as educational providers we should take these styles into consideration when designing material as well as making learning material suitable for any learning style.

One of the main originators of learning styles was David Kolb who argued that effective learning encompasses four different learning preferences; Converger, Diverger, Assimilator and Accommodator, which is shown in Figure 2.
After his book was published in 1984 (Kolb, 1984), we have seen many educators embracing and expanding his theory. Numerous studies, (Cano-Garcia & Hughes, 2000; Demirbas & Demirkan, 2007; Song, Singleton, Hill & Koh, 2004) indicate that there is an element of usefulness to learning processes and individual development.

Valentina Sharlanova also agreed with the work of David Kolb. In 2004 she discussed that his theory has a number of benefits including helping students realise themselves as learners, helping teachers become reflective teachers, identifying learning styles of students and development of key teacher’s skills (Sharlanova, 2004).
Many people disagree with Kolb’s principles of learning styles and argue that there are limitations with his theory. Garner (Garner, 2000) argued that Kolb’s theories had weaknesses and lacked theoretical vigour whilst Webb (Webb, 2003) concluded on her doctoral thesis by saying that Kolb’s theory did not meet the standards of construct validity.

Likewise the Honey & Mumford learning style questionnaire faces the same critique. Again, this is another self-evaluating questionnaire which is meant to determine a person’s preferred learning style. The argument is that if somebody knows their own learning style, they can do activities that best reflect the type of learning they are i.e. activitist’s (doer) or reflectors (reviewer).

In engineering the issue of learning styles has also been discussed in literature and another learning style approach is suggested. In 1988 (Felder & Silverman, 1988), Felder and Silverman devised a new type of learning style model specifically designed for engineering students (Felder & Spurlin, 2005a).

The model suggests that students have a preference in one or the other of the following four dimensions:

- sensing (concrete thinker, practical, oriented toward facts and procedures) or intuitive (abstract thinker, innovative, oriented toward theories and underlying meanings);
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- visual (prefer visual representations of presented material, such as pictures, diagrams and flowcharts) or verbal (prefer written and spoken explanations);
- active (learn by trying things out, enjoy working in groups) or reflective (learn by thinking things through, prefer working alone or with a single familiar partner);
- sequential (linear thinking process, learn in small incremental steps) or global (holistic thinking process, learn in large leaps).

After testing their model it was seen that the students had a consistent style of learning preference as opposed to students from other disciplines. It is suggested that using this model enables teachers to achieve balanced courses and lets the students understand their strengths whilst identifying areas for improvement.

Researchers Leu, Kinzer, Coiro and Cammack (Leu, Kinzer, Coiro & Cammack, 2004) talk about possible new models of learning that could emerge due to the increasing amount of new technologies. People have access to more information literally at their fingertips via mobile phones and tablet devices. Traxler (Traxler, 2010) stated that this type of learning could allow Higher Education institutions to increase their capacity to deliver teaching and learning material in an inclusive and innovative way.
It’s this type of flexible learning that allows people to develop their own method of learning.

2.3.2 Problem based learning

Problem based learning (PBL) is heavily linked in with experiential learning. The theory behind PBL is that students learn by being given a problem to solve. In most cases this can come in the form of a research project, group work or a case study. PBL is meant to motivate students into self-directed learning and more importantly into looking for the knowledge that they need to learn in order to solve the problem at hand. Problem based learning in engineering prospective has been investigated and researched over the years.

In one evaluation Canavan, (Canavan, 2008) looked at how problem based learning had been introduced in three universities within BEng and MEng programmes and how it had been perceived by staff and students. The designs of the PBL modules were developed to ensure that the problems generated thinking to cover the learning outcomes. The results from this evaluation showed that when PBL was present the learning achieved was deep and reflective. Students gained valuable skills in problem solving, time management and group collaboration which, as reported by industry (Arlett, Lamb, Dales, Willis & Hurdle, 2010b; Lamb, 2010), is valuable to engineering. It is reported that PBL stimulated thinking in students as they had to figure out the problem at
hand and understand concepts and theories to solve them. Many reported that they learnt more in the PBL sessions than traditional lectures and that it felt like they were actually doing engineering.

However, there are those that questioned whether or not engineering is a suitable discipline for PBL to exist. In 2004 Yosof et al (Yusof, Aziz, Hamid, Hassan, Hassim, Hassan & NMA, 2004) carried out a qualitative evaluation of engineering course outcomes that embedded PBL. Their initial concern was large student groups associated with engineering and whether or not it could help students develop skills needed in the professional workplace. They state that although the world is changing, the method in which engineering is taught has remained the same. There is also an issue of lecturers feeling threatened by students self-learning. They are not sure what to do in a lecture where the students control their learning, there is also the concern that this relatively new method leaves the students feeling ‘failed’ by their tutors (Felder, Stice & Rugarcia, 2000b).

2.3.3 Experiential Learning

The importance of experiential learning is highlighted from various researchers. David Kolb developed the experiential learning theory learning cycle that was originally proposed by Kurt Lewin who got the idea from control engineering as show in Figure 3. Kolb stated that it was a continuous cycle of learning.
Kolb then went on to develop a learning style inventory (Kolb, 2005) which was a test that the user could do themselves based on Kolb’s experiential learning theory. The idea behind it was for the learning to measure themselves on their strengths and weaknesses when it came to the learning process. However, the biggest critique of this was Kolb himself (Kelly, 1997), when he said that the results are limited as it is only the learner evaluating their own type of learning and does not seem to reference learning style preferences through standards or by their behaviour.

Learning styles could be considered a highly controversial subject but there is no hiding the fact that no one student does learn the same and that we should be taking this into consideration to enhance our teaching methods to reach new audiences. When looking more specifically at the issues of virtual learning many researchers agree that the design of virtual (and remote) laboratory classes must ensure that learning styles are accounted for to ensure that students’ opportunities are maximized (Lindsay & Good, 2007).
2.4 Engineering Education

Engineering Education is an area where problem based learning is particularly significant due to the problem solving nature of engineering as a whole. The requirement for practical competencies such as construction understanding, material knowledge and awareness of industry standards, places the need for problem based learning at the heart of Engineering Education (Augusti, 2007).

Whilst engineering as a disciple has origins dating back to ancient civilisation, standards and regulations for Engineering Education were only demanded by individual institutions such as the Institution of Marine Engineers, in the 1950’s, which later resulted in the formation of the Joint Council of Engineering Institutions in 1964.

As criticisms of the Joint Council of Engineering Institutions grew, a national review took place looking at the provision and standards of the engineering profession. As a result of this the greatly debated Finniston Report ‘Engineering our Future’, provided recommendations to promote and develop Engineering Education (Jordan & Richardson, 1984).

In 1982, shortly after the Finniston Report, the Engineering Council was formed the members of which were by majority, qualified engineers and industry related personnel. In 1985 the Engineering Council published the Standards and Routes to Registration (SARTOR) which aimed to provide a process to assess
professional engineering institutions to ensure educational standards were being met (Baillie & Fitzgerald, 2000). This was later revised in 1997 (Brown, 1998), increasing length of study in engineering courses to answer industry demand on the employability skills of an engineering graduate. The Engineering Council then went through further reviews in 2001 and 2002, and published the first version of the 'UK Standard for Professional Engineering in 2003 (Bull & Gardner, 2010).

Engineering Education further developed in 1990’s with the development of the Conceive Design Implement and Operate (CDIO) framework which aimed to provide students with engineering fundamentals contextualised in a real world domain (Crawley, 2002). It was formed due to mounting concerns of Engineering Education providing students with the skills and knowledge needed of a graduate engineer and revolutionised the direction of Engineering Education.

Engineering Education is radically evolving due to the increase of distance education, industry needs and restrictions on both University funding and space (Galloway, 2007b). However, we are still seeing similarities between teaching now to teaching back in 1970 (Rugarcia et al., 2000). Concerns over the importance of education in the academic field have led to many university staff to question how engineering has previously been taught, however some staff are unsure what alternatives are available and worry that pursuing them would
result in staff loosing valuable teaching and researching time (Rugarcia et al., 2000). Concerns are also raised that the more radical a change in educational reform in engineering then the harder it will be to engage staff with the change (Arlett, Lamb, Dales, Willis & Hurdle, 2010a).

According to an article in the Guardian by Anthea Lipsett in February 2008, Engineering courses in the country are in trouble (Lipsett, 2008a). Based on a report commissioned by the Engineering and Technology Board (ETB) and the Engineering Professors' Council (EPC) the article reported that Universities are struggling to maintain their expensive equipment and also have less physical space to teach students. The main concern is the out of date equipment will mean a loss in hands on experience and as industry states, practical experience is essential.

In 2002 Shuman et al (Shuman, Atman, Eschenbach, Evans, Felder, Imbrie, McGourty, Miller, Richards & Smith, 2002) discussed the future of Engineering Education and the need for change. They said that emerging technologies in engineering held both good and bad opportunities for engineering. They believed that advancements meant that students wouldn’t necessarily need to physically be in classrooms to learn, why couldn’t they learn via the internet or by simulations? In the paper Felder gave credit to rich multimedia instruction and how this has the potential to increase deep learning better than any traditional method could. However, although there is an increase in Technology
Enhanced Learning in engineering, there still remains a lack of good evaluation of their effectiveness. However, some developers of these technology creations have failed to include those involved in traditional methods meaning that they did not get the opportunity to show the traditional lecturers the value of embedding or trialling such things (Beder, 1999).

Institutions that embed distance learning tend to use technology based learning more effectively and when looking to the future it is hard to predict if students would prefer distance learning rather than attending physical lectures and practical’s.

When given a more self-directed learning task, students felt a bit unnerved by the experience, they were unfamiliar to the concept of taking control of their own learning (Felder, Stice & Rugarcia, 2000a). To combat these issues various researchers have suggested ideas for academics to try out that might ease the students into this method of learning:

- Embed new methods early and small to ease them into it
- Communicate with your students on what you are doing and why
- Be flexible

When looking at a history of Engineering Education changes have occurred. The acknowledgment of technology such as distance learning in engineering teaching has begun to emerge (Evans, 2013; Olds, Moskal & Miller, 2005). Students currently entering Higher Education are more accepting of technology
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(Cole, 2009; Jones, Ramanau, Cross & Healing, 2010b). However, within engineering a considerable amount of time and resource still needs to be directed at developing methods and approaches utilising technology to support the teaching.

As discussed by Froyd, Wankat et al (Froyd, Wankat & Smith, 2012), there have been five major shifts in Engineering Education over the past one hundred years including:

1. “a shift from hands-on and practical emphasis to engineering sites and analytical emphasis
2. a shift outcomes-based education accreditation
3. a shift emphasising engineering design
4. a shift applying education, learning, and social behavioural sciences research
5. a shift integrating information, computational, and communications technology in education”

The first of the five shifts focused on the gradual move from hands-on practice based courses to a more mathematical and theory based approach to engineering to give engineers the theoretical tools to solve technical problems (Wedelin, Adawi, Jahan & Andersson, 2015).

The second of the shifts impacted heavily on Engineering Education, where accreditation became an integrated part of engineering curriculum design. To
gain accreditation in an engineering program, engineering educators incorporated graduate attributes outlined by the accrediting professional bodies such as the Engineering Council (Byrne, Desha, Fitzpatrick & “Charlie” Hargroves, 2013). This has resulted in engineering programs having to demonstrate and show that their graduates encompass the learning outcomes specified by the accreditation process (Mills & Treagust, 2003).

The last three shifts are still in progress and will continue to have an impact on the future direction of Engineering Education, particularly the impact of technology.

### 2.4.1 Current climate of Engineering Education

### 2.4.2 Need for change

Industry is starting to demand more engineering graduates who encompass strong technical skills, good interpersonal skills, self-directed learning and good commercial awareness (Rugarcia et al., 2000; Spinks, Silburn & Birchall, 2007; Tong, 2003). Over the last decade industry has been more vocal with communicating with Higher Education institutions on the direction of Engineering Education and so it is wise to pay attention to their needs (Korhonen-Yrjänheikki, Tukiainen & Takala, 2007). A report by the Royal Academy of Engineering (Engineering, 2007) collated observations, feedback ideas from industry and academia on what needs to be done to ensure that engineering graduates are equipped to apply their knowledge in real life
engineering situations and work globally and collaboratively. In the report the need for graduates who possessed good technical understanding and communication skills was strongly emphasised. Engineering graduates are seen as an integral part of supporting the infrastructure of our national economy by applying skills learnt during their undergraduate education (Engineering, 2007). However, the report also stressed that we are in danger of facing a shortage in the next 10 years of ‘high calibre engineering graduates’ which the country needs if we are to obtain investment into UK businesses. Other literature mirrors this call for change in graduates and to shift the emphasis of Engineering Education from teaching to actual ‘learning’ (Grimson, 2002).

Despite the amount of literature available on Engineering Education reform (Galloway, 2007b; Kirschenman, 2011), the actual teaching element and graduate output remains unchanged and the curriculum can no longer remain as it has been for the last 40 years (Galloway & PE, 2007).

However, any changes to Engineering Education, in particular changes to courses, need to formally meet requirements set out by accreditations bodies such as the Quality Assurance Agency but the accreditation process itself can be seen as a hindrance to innovation rather than helping to meet change (Arlett et al., 2010a). One of the recommendations from the Educating Engineering for the 21st Century Working Group (Engineering, 2007) is that the accreditation process should be more proactive in driving the change in course content and
structure rather than being a purely ‘passive auditing exercise’ and be Bologna compliant. The Bologna process is an inter-governmental process and agreement currently involving 47 nations across Europe. It originated to ensure that standards in Higher Education were comparable between European countries (Heitmann, 2005).

Funding is a large factor in governing the change in Engineering Education, whilst accreditation bodies still place a large emphasis on practical skills (Chandrasekaran, Stojcevski, Littlefair & Joordens, 2013; Crawley, Malmqvist, Östlund, Brodeur & Edström, 2014), funding to engineering courses has dropped down to a ratio of 1.7 (courses were previously funded by HEFCE at twice the basic rate of resource) yet the overall consensus is that university engineering courses need to be funded at least 2.5 the basic rate but ideally 3 (Engineering, 2007). However, this is unlikely to take place especially considering the changes in government over the last decade. Even though the government recognised the importance of Higher Education in rebuilding the economy, the economic climate hit HEFCE funding in 2010 with the government introducing a £200 million contribution towards reducing public spending and a further £82 million efficiency saving in teaching grant allocation and £30 million in teaching capital (HEFCE, 2010). The drop in funding was the first reduction since the late 1990’s (Universities face cuts as Hefce deals with first funding drop in years 2010). In 2011 HEFCE announced their strategy for 2011 – 2015 with funding of £150 million per annum allocation. This also
included the changes of tuition fees in Higher Education which saw increases of up to £9,000 per year being charged by over a third of Universities by 2012.

In 2012 the new tuition fee funding system was fully implemented, meaning students in England, once graduated, had to pay tuition fees of between £6,000 and £9,000 a year dependant of institution course fees.

To ensure the future economy rebuild, institutions in 2010 were asked by government to shift their teaching provisions and resources to subjects that are seen as ‘strategically important and vulnerable subjects (SIVS) such as Science, Technology, Engineering and Mathematics (HEFCE, 2010) and to also increase the number of student places on these subject courses.

Despite recent encouraging signs of increased provision in the allocation of £1 Million HEFCE funding to engineering subjects (HEFCE, 2015), previous literature suggests engineering courses are still strained due to an already evident lack of funding.

### 2.4.3 Future of Engineering

The literature would suggest we are heading for a change in the teaching of engineering. We need to provide graduates with social skills, assessment skills and self-evaluation that industry demand (Jennings, 1998b). New innovative approaches and methods to Engineering Education are starting to be looked at
more seriously. Introducing pedagogically sound technical innovations is vital to the future of engineering graduates (Chisholm, 2003). To apply these technologies effectively we also need to look at the attitudes of lecturers and encourage them to use new technologies. New technologies in Engineering Education such as eLearning is seen to be an important strategy for achieving the shift from traditional taught engineering curricula to one that supports active learning (Grimson, 2002).

Felder (Felder, Woods, Stice & Rugarcia, 2000), discussed the need for change in the traditional lecture style teaching in Engineering Education, and along with Galloway and Kirschenman (Galloway, 2007a; Kirschenman, 2011), stated that the traditional teaching methods won’t give students the skills needed to be successful in the work place.

New innovations in Engineering Education have been tested and published in growing numbers over the last decade (Felder, Stice & Rugarcia, 2000b). Distance learning, simulations and new methods of teaching pedagogy are beginning to be integrated into the curriculum (Fabregas, Farias, Dormido-Canto, Dormido & Esquembre, 2011; Stefanovic, 2013b).
2.4.4 Accreditation issues

When it comes to the practical element of engineering, accreditation bodies strongly emphasise the importance of engineering graduates being able to demonstrate their ability to conduct experimentation (Balamuralithara & Woods, 2009a). This issue is compounded when considering practical access in engineering courses being delivered. When looking at the requirements from accrediting bodies such as the Institute of Mechanical Engineers (IMECHE) and The Institution of Engineering and Technology (IET) we see that they have a strong emphasis on the need for practical learning outcomes using laboratories ((UK-SPEC); IET). The US accreditation body ABET (Smaill, Rowe, Godfrey & Paton, 2012) criteria includes engineers having the ability to solve engineering problems, analyse and interpret the data that arise from laboratories (Nickerson, Corter, Esche & Chassapis, 2007a). As well as the US, the UK engineering accreditation bodies see laboratory training as ‘mandatory’ (Chan & Fok, 2010).

In 2011 the Open University has recently gained accreditation on two online courses; Bachelor of Engineering (Honors) and Master of Engineering (University). The course is delivered using study guides and materials, audio and video material, home activity kits, and relevant software.
2.4.5 Laboratories

In order to provide students with a practical experience, many Higher Education Institutions use laboratories to develop practical skills and competencies. However, these are expensive to maintain and run and their continued use in education is constantly being evaluated within literature.

2.4.5.1 An Introduction

As a result of the changes to Engineering Education such as the increase of distance education, industry needs and restrictions on both University funding and space, Engineering Education is struggling to provide a practical experience to students. Regardless of these issues industry and accreditation bodies require engineering graduates to be practically competent.

Practical laboratory work is a widely discussed area in both engineering and other disciplines such as science, medicine. Engineering graduates are required by accreditation bodies such as IMECHE and IET to have strong practical engineering skills gained through learning perhaps carried out in laboratories ((UK-SPEC); Hicks, Cunningham, Dagless, McCormick, Ridgman & Young, 2006). IMECHE and IET state that students must possess the following practical attributes:

“practical engineering skills acquired through, for example, work carried out in laboratories and workshops; in industry through supervised work experience; in individual and group project work; in design work; and in the development and use of computer software in design, analysis and control. Evidence of group working and of participation in a major project
is expected. However, individual professional bodies may require particular approaches to this requirement”.

Accreditation bodies such as IMECE and IET confirm whether or not an engineering programme or course provides the graduate with the skills and knowledge needed for professional competence once in industry.

Students themselves feel that a practical hands on experience helps them to reinforce and apply the theories and concepts taught in their lectures via experimentation (Esche, 2002). Laboratory work in engineering in the UK can take up to 50% with additional time being spent by the students to write up their practical report (Davies, 2008).

2.4.5.2 Sustainability issues effecting practical engineering laboratories

Research (Abdel-Salam, Kauffmann & Crossman, 2007; Stefanovic, 2013b) shows that practical laboratories are beginning to be over utilised and under resourced due to the problems of maintaining expensive laboratories and accommodating large students groups. Furthermore, the changing focus of Higher Education provision means institutions have to cope with the demand of distance education and widening participation. Changes in Higher Education, discussed in Chapter 2.2, are introducing problems around management and delivery outside of the “traditional” timetable. However, the demands of
professional bodies for accreditation are very clear regarding the need for practical experience. These conflicting factors are putting laboratory provision under a great deal of pressure.

2.4.5.3 Cost of maintaining and running labs

One of the main issues of the sustainability of engineering laboratories is the cost implications. Engineering laboratories are in some cases decreasing due to lack of funding resources (Gustavsson, Nilsson, Lag\ & \\#246, 2009). This is mainly due to laboratories being resource intensive both in terms of equipment cost, laboratory space and human resource (technicians and demonstrators) (Page, 2010; Poole, 2008; Read, Hanson & Levesley, 2008b). As discussed in the first chapter, the recent change in government and current economic climate has meant that further cuts to Higher Education funding will be seen and an increase in student numbers (HEFCE, 2010) which will only accentuate the problem.

2.4.5.4 Large student groups (lab session before theory)

Hands on experiments in engineering courses are notoriously problematic in terms of resource as previously discussed, the increase of student numbers was linked with the decline in practical engineering laboratories even back in 1992 (Wliams & Gani, 1992) and with predicted increases in students enrolling in
engineering programs, the problem will only escalate. In traditional laboratories actual student access to the equipment is limited and often students do not get enough one on one contact with the equipment (Forinash & Wisman, 2005). It is unfeasible due to space and health and safety issues to take large numbers of students within the laboratories and so several smaller groups are taken at different times and dates but this uses time and therefore minimises the equipment ‘contact time per student’ (Esche, 2002).

To try and address the issue of large student groups, some institutions have been piloting alternative to traditional engineering taught methods such as distance education. The case of online delivery costs have been seen to be comparable to traditional campus taught courses, however the online delivery is more scalable to large groups than the traditional ones (Bourne, Harris & Mayadas, 2005).

2.4.5.5 Importance of the practical laboratory element to produce a good engineering graduate

Engineering is very much seen as a hands on practical discipline (Abdel-Salam, Kauffmann & Crossman, 2007). Most researchers and educators agree on the importance of the role of laboratories and how vital they are within engineering (Auer, Pester, Ursutiu & Samoila, 2003; Bourne, Harris & Mayadas, 2005). Laboratories provide students with the ability to understand the theories and
concepts learned in the classroom and put them into practice in a safe and supervised environment.

Auer, Ursutiu, Pester and Samoila (Auer et al., 2003) discussed that in an ideal laboratory learning environment there are several different learning elements and strategies:

1. Repetition of theoretical knowledge
2. Application of theoretical models and concepts in a practical situation
3. Training of practical skills using the required elements and instruments for the experiment
4. Training of practical, social and communication skills
5. Critical reflection of the results of the experiment
6. Learning processes involved, such as technical writing and documentation

Students themselves feel that laboratory work enables them to relate theory to practice (Balamuralithara & Woods, 2009a; Colwell, Scanlon & Cooper, 2002; Edward, 2002).

Despite the general consensus from the literature on the importance of practical work to engineering disciplines, many Higher Education institutions are not addressing the issue of student access to practical laboratory facilities (Cooper, 2005).
2.4.5.6 Alternative methods to traditional laboratories

The issue of providing a practical laboratory experience for students is one that has been debated and researched in great detail in Engineering Education. Various reports, literature and case studies discuss alternative methods to a traditional laboratory (Balamuralithara & Woods, 2009b; Fabregas et al., 2011; Lindsay, Liu, Murray & Lowe, 2007).

As previously discussed in Chapter 2.2, methods of tackling the practical access issues particularly through courses being delivered online have been in the form of “intensive residential schools” or “summer schools” and home bench kits (Cooper, 2005). However, home kits are limited what types of experimentation can be achieved.

One approach to giving students access to a practical experience is by conducting appropriate laboratories online. There are currently two types of methods to carrying out labs online; remote labs and simulation in the form of virtual laboratories (Balamuralithara & Woods, 2009a).

2.4.5.7 Remote Laboratories

A remote laboratory gives students the ability to access real equipment over the Internet (Balamuralithara & Woods, 2009a). This provides real data to the student and allows them to explore the experimental environment in a “live” setting. The Internet has allowed for developments and increase in the use of
remote laboratories. Remote laboratories are one method seen to have the potential solution for addressing the issues of access to laboratories for students as well as cost implications and maintenance (Gravier, 2009). The presence of remote laboratories is predicted to increase and also gain in popularity (Esche, 2002; Gravier, 2009; Wu, Chan, Jong & Lin, 2003).

Whilst remote laboratories do not require the student to be present they do however use real equipment. Lindsay (Lindsay et al., 2007) analysed students perceptions in using a remote laboratory and found that although they found the flexibility of the lab access to be convenient, they also reported that it gave them a different learning experience that were seen to be absent during a more traditional laboratory such as more time and ease of record keeping.

Henry (Henry, 2002) discussed using remote labs in undergraduate engineering and explained how labs could be run remotely which allows students to control the parameters of the lab remotely. Over 50,000 experiments have been run using his remote lab with users from all around the world. He believes such labs have huge potential to give schools that don’t have labs access to the experiments. Roesch, Roth and Yahoui (Roesch, Roth & Yahoui, 2005) also talked about how remote labs were beneficial to allowing international students to access labs and share their studies between universities. It can therefore be surmised from this report and other reports on remote laboratory labs it is assumed that remote labs support the need and possibility of widening
participation in engineering. One area is that of disabled students and issues associated with physically getting to a laboratory session, remote experimentation gives disabled students access to a practical experience (Colwell, Scanlon & Cooper, 2002).

Evaluations of the implementation and effect on alternative laboratory provision have been varied but mostly positive. One study evaluated a laboratory where one half of the class accessed the lab via the internet whilst the other performed the experiments in the actual laboratory (Lang, Mengelkamp, Jaeger, Geoffroy, Billaud & Zimmer, 2007). The conclusion from this study was that the remote access results were just as effective as the traditional method.

One of the favoured aspects of remote labs for students was that they were able to do practical work in their own time around their work commitments (Cooper, 2005). Interestingly, when students were asked in a report to prioritise certain elements of a practical laboratory they rated the ‘physical presence of being in lab’ as least important (Nickerson et al., 2007a).

Traditional laboratory methods give the student a short time in the laboratory to gather the data they need and after they are expected to produce a written report on their findings. In the case of remote laboratories pedagogic research by Esche would suggest that it would be more advantageous if students had access to a ‘online laboratory’ where they could come back at their own time
and convenience and refine their experiments and data (Esche, 2002). Remote experimentation also promotes self-directed learning in students where they have control of their continued learning. A summary of the benefits of remote experimentation for students can be summarised in Figure 4 (Esche, 2002).

<table>
<thead>
<tr>
<th>Students</th>
<th>Instructors</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• students can be exposed to a more comprehensive experimental experience</td>
<td>• are enabled and encouraged to include demonstrations of laboratory experiments into their lectures</td>
<td>• distance learning offerings become more attractive through an experimental component</td>
</tr>
<tr>
<td>• asynchronous learning is encouraged, which is especially suited for non-traditional, commuting part-time students</td>
<td>• are provided with a tool to monitor the remote usage of the experimental setups and to track student performance</td>
<td>• strains on laboratory class schedules, equipment budgets and personnel are alleviated</td>
</tr>
<tr>
<td>• student self-learning is promoted</td>
<td>• gain additional flexibility for tailoring experiments (e.g., challenge problems)</td>
<td>• through appropriate input screening, an inherently safe experimental environment can be created thus avoiding student accidents and equipment damage</td>
</tr>
<tr>
<td>• student self-assessment and feedback can be integrated</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4 Benefits of remotely accessible experiments to stakeholders in laboratory education (Esche 2002)

2.4.5.8 Virtual Laboratories

A virtual laboratory is “an interactive environment for creating and conducting simulated experiments: a playground for experimentation” (Albu, Holbert, Heydt, Grigorescu & Trusca, 2004). Virtual laboratories are similar in nature to remote experimentation but rather than accessing equipment in the lab
remotely students are accessing a virtual representation or simulation of an experiment. A simulation can be defined as a set of techniques for re-creating aspects of the real world, typically to replace or amplify actual experiences (Dutta, Gaba & Krummel, 2006).

These types of laboratories are being seen by some to ‘revolutionise’ Engineering Education (Chan & Fok, 2010).

There is a lot of literature existing about the use of virtual laboratories, especially in the fields on science, medicine and engineering (Balamuralithara & Woods, 2009a; Dalgarno, Bishop & Bedgood Jr, 2012; Jara, Candelas, Torres, Dormido, Esquembre & Reinoso, 2009; Stefanovic, 2013a; Toth, Morrow & Ludvico, 2009). Students have been left unable to complete their degrees if they don’t have access to a physical laboratory. Whilst some educators assume a virtual laboratory can achieve different results, the learning outcomes in virtual laboratories’ are in some reports seen to be no different from traditional approaches (Poole, 2008).

Virtual labs that can be used as a preparation tool for a real laboratory. Hashemi and Majkowski (Hashemi, Majkowski & Anderson, 2003) researched a laboratory that was used to give students an induction to the practical before going in the lab itself. The idea was to expose students to the equipment, lab objectives, learning outcomes and methods before going in to their scheduled session as to not waste precious and expensive laboratory time. He also argued
that some traditional laboratories simply let students follow instructions and they don’t really understand what they are doing. Hashemi and Majkowski believe that if a tool was developed that shows the students the objectives, procedures and outcome of the lab then they will get more from the lab and learn more.

Some argue however that despite attempts to create pedagogically sound virtual labs the student who has solely been exposed to virtual labs will be incompetent at repeating the experiment in a real laboratory - they believe the student will be more of a spectator than a learner. However, students particularly like the time efficiency saving in a virtual lab and instant feedback (where applicable) (Poole, 2008). In a case study at the University of Hong Kong (Chan & Fok, 2010) students found the virtual laboratory effective but suggested perhaps it should be used as an addition to traditional laboratories rather than a substitute. The main disadvantages of virtual labs mirror those of remote experimentation in that students will be unable to get to grips with the actual physical instruments in the laboratory (Chan & Fok, 2010).

In this light, perhaps virtual laboratories could make a significant contribution in preparing students for the actual physical laboratory experience. To make the learning process more effective, the software has to be as close to the real experiment as possible. If more virtual laboratories are created with sound pedagogic thought then educators why these online labs could become more
popular and provide a real alternative to traditional laboratory methods (Balamuralithara & Woods, 2009a).

2.4.5.9 Simulations (as well as Use of Simulation in Medicine and Science)

A simulation can be defined as a set of techniques for re-creating aspects of the real world, typically to replace or amplify actual experiences (Dutta, Gaba & Krummel, 2006). There are many different types of simulations or simulators both attempting to provide the user with an alternative to carrying out the specific task in real time.

The advancement of simulators in engineering has meant engineers are able to analyse and evaluate in the ‘virtual domain’ allowing them to practice different what if scenarios which is vital in engineering (Chaturvedi & Akan, 2008). They also allow students to experience experiments that might otherwise be too expensive or dangerous to participate with in real life (Andersen, Squires & Reklaitis, 1992).

According to Aldrich there are four traditional genres of simulation (Aldrich, 2005):

- branching stories
- interactive spreadsheets
• game-based models
• virtual products and labs.

This section will concentrate on the use of simulations as a practical laboratory tool.

Like engineering, teaching medical students practical knowledge is a problem that arises in many undergraduate courses. Students are given theoretical knowledge but how can they test out their theory without having a real situation?

Simulations are being seen as a technology that can attempt to address these issues and an area that is rapidly expanding within medical education (Bond, Lammers, Spillane, Smith-Coggins, Fernandez, Reznek, Vozenilek & Gordon, 2007).

High fidelity simulators are being seen as an effective teaching tool in undergraduate medical education (Weller, 2004). They allow students to test theoretical knowledge in safe environment rather than using real-life patients, other advantages are summarised in Figure 5 (Maran & Glavin, 2003). In 2004 158 simulation centres were identified in a worldwide survey of which some were involved in medical undergraduate teaching alone (Morgan & Cleave-Hogg, 2002).
However, little evaluation has been carried out on the use and effectiveness of simulation technology in medical education, any research that has been done has been inconsistent and unjustified (Barry Issenberg, Mcgaghie, Petrusa, Lee Gordon & Scalese, 2005).

Various studies have been carried out on how simulated engineering laboratories and how they have been perceived by students. One such study was one carried out at Australian National University where they used simulations on final year engineering students (McCarragher, 1999). The aim of the practical was to give students a better understanding of the design of robot control algorithms. They were given two activities, one using traditional methods using an actual robot that had to be pre-constructed due to time constraint and one using a computer based lab using MATLAB and SIMULINK. Before the students did the activities they were given a pre lab session where they were asked to discuss their understanding of three different areas associated with their module/subject area; Controller Design, Implementation and Applications. The controller design subject was based on their lecture material; the implementation section was based on the practical method of
getting the controller to work on the robot and the applications section discussed which control method would be suitable in which situation.

The learning outcomes of the simulated activity were to let the students explore the different settings of the software in order to affect the robot based on some data given to the students beforehand. The aim of the practical activity was to get the students to understand how the wiring and communication had been set up and to program the robot using the control laws and how the different laws affected the robot.

After the lab write ups the students were invited to discuss their understanding of the control techniques after the practical session and after their pre lab discussion.

When looking at student feedback from students the results from simulated laboratories we see possible areas for concern. Some students perceived the simulation as ‘just another computer simulation that had to get done’ or ‘they weren’t very interesting’ and didn’t think they had much relevance to what they were doing. The simulation seemed to help most in terms of understanding the design issues whereas the results from the physical activity showed students gained little in terms of design knowledge. In terms of the implementation issue, the students didn’t feel that they had much insight into this via the simulation and interestingly even the practical session was not as successful as previously anticipated. Mainly because the students were unable to physically
construct the robot, they didn’t bother to look into the implementation issues themselves. Students enjoyed the physical laboratory as they could explore and receive a hands-on experience with the robot and some even attended additional sessions just to understand things further.

One of the important elements of this investigation was to see how students engaged with the self-directed learning to show that students should take responsibility for their learning rather than to just be dictated to. Interestingly, the results from the simulation was seen to be negative as the students couldn’t see a physical result in their actions, whereas in the physical laboratory the robot moved as a result of what they did. Although the simulation had an animated robot, the students didn’t fully engage with it and see past the simulation. However, as with most of these studies, the group of students tested was small and not large enough to make decent qualitative research.

A concern with this study is that the physical laboratory was seen to be more beneficial, but with the Engineering Education changing due to costs, larger groups and geographical placement of students, the simulated laboratories need to be looked at into making them more effective.

In a study (Davidovitch, Parush & Shtub, 2006), took the technology of simulations and embedded the learning theory of David Kolb’s Experiential Learning Theory into their Project Management Trainer (PMT) simulator to
support the learning approach. They believed that the simulator supported aspects of experiential learning theory by:

- Learning and interacting with the simulator can provide the concrete experience which can evoke feelings.
- Working with a simulator provides the opportunity for reflective observation. In particular, a history keeping and inquiry mechanism was evaluated as part of the study here and how it affected learning.
- The different scenarios and data items in the simulator enable the abstract conceptualization and integration of concepts acquired throughout the learning process.
- The simulator provides a continuous and dynamic environment for active experimentation.

Davidovitch, Parush and Shtub (Davidovitch, Parush & Shtub, 2006) concluded that simulations were beneficial because they helped bridge the gap between the learning environment and a real environment. The simulator simulated critical thinking and promoted active learning in a complex subject area.

Many other educators have discussed the use of simulations to explain complex theories and support the move to encourage and motivate students to learn in a more active manner (Tubaileh, Hammad & Kafafi) (Chung, Harmon & Baker, 2001; Morgan & Jones, 2001). If designed effectively we may see an increase in
the use of simulations in engineering to help solve the issue of accessibility and cost (Campbell, Bourne, Mosterman & Brodersen, 2002).

2.4.5.10 *Immersive Environments in Higher Education*

Virtual/Immersive Worlds, also referred to as multi-user virtual environments (MUVEs), have increased in popularity over the past decade (UC Davis researchers build virtual world for bioterrorism training 2008; Inman, Wright & Hartman, 2010). A virtual world can be defined as a ‘computer-based, simulated multi-media environment, usually running over the web and designed so that users can inhabit and interact via their own graphical representation know as avatars’ (Boulos, Hetherington & Wheeler, 2007a). Many real world companies have established a strong presence in Second Life such as Cisco (CISCO in Second Life, 2006), Dell(DELL), Autodesk (‘Autodesk in Second Life,’ 2006), Toyota, Adidas (Au, 2006), Nissan (Pendragon, 2006), Intel and Vodafone (Bearne, 2007). Figures 6 – 8 show the company’s presence in Second Life.
Figure 6 DELL Island in Second Life

Figure 7 Autodesk in Second Life
This type of technology has been of interest to educational disciplines such as science and engineering as it gives users the ability to perform tasks or manipulations that are impossible to carry out in the real world (Loomis, Blascovich & Beall, 1999). This type of experiential learning as discussed in Chapter 2.3.3 is fundamental to allow students to further develop their understanding and experience of practical problems within engineering. Immersive environments potentially could give students an area where they can collaboratively work together to solve and understand a practical problem or understand an upcoming laboratory whilst immersed in a virtual domain. This would allow students to safely interact with a simulation, experiment or demonstration in their own time without the need for a demonstrator to be present or for concern over health and safety issues or damage to expensive
equipment. Students would be able to return to the environment when they wanted to further reinforce intended learning outcomes on what they are expected to do.

The most popular and largest immersive environment is Second Life (Bolli & Somogyi, 2011) which was launched by Linden Labs in 2003 and has a growing user base of over 14 million around the world (Skerratt, 2009). In Second Life users or ‘residents’ as referred to in Second Life, are able to purchase land within the environment and develop it either via open spaces or private areas, there is also the option to rent areas too (Lab, 2010). Screenshots of Second Life are shown in Figures 9 – 11.

Figure 9 Examples of two undeveloped private islands for sale in Second Life in August 2010
Figure 10 Example of developed house for sale in Second Life in August 2010

Figure 11 Author in land for auction August 2010
In education the use of virtual worlds is in its early stages of development but is an area that it is predicted to have huge potential (Cobb, Heaney, Corcoran & Henderson-Begg, 2009). Whilst some educators are excited by the potential and believe it will influence education, others believe that it is still building its foundations (Moore, 1995). In terms of virtual environments Second Life is the primary choice for education use (Kirriemuir, 2009; Warburton, 2009), however, it is important to recognise that there are other virtual environments available such as Active Worlds, Olive (Active Worlds, 1997), Twinity (Perdigones, Benedicto, Sánchez-Espinosa, Gallego & García, 2013) and OpenSim (Graham, 2012b). One of the most distinguishable features of Second Life over any other virtual world is the ability for any user to build and manipulate objects using the Linden Scripting Language (LSL) (Gerald & Antonacci, 2009).

However, more recently the use of Second Life in Education has seen a gradual decline within Higher Education Institutions (Wang & Burton, 2013). One factor which has been reported to have impacted on this decline was Linden Lab’s decision to discontinue a discount on land-maintenance fees previously available to educational institutions.

OpenSimulator (OpenSim), has become more popular with Higher Education Institutions, seeing many of them moving from Second Life to OpenSim (Christopoulos & Conrad, 2012).
2.5 Technology Enhanced Learning

Technology Enhanced Learning (TEL) is becoming an essential part of learning and teaching within educational institutions. As defined by JISC (Joint Information Systems Committee), Technology Enhanced Learning is:

"a culture where a broad range of learners are provided with a robust technology environment that provides effective learning opportunities, wherever the learner chooses to learn" (Committee, 2009)

Distance Learning is a way of delivering education and instruction to students who are not physically present in a University setting.

However, not all educational institutions are ready for distance learning and instead choose a variety of techniques that utilise Technology Enhanced Learning to support and engage students.

The next section will provide an introduction to Technology Enhanced Learning shortly followed by a brief overview of different technologies and methodologies that encapsulate the term ‘Technology Enhanced Learning’.
2.5.1 An introduction

Technology Enhanced Learning (TEL) describes the application of information and communication to teaching and learning, and is frequently used in Higher Education both in the UK and globally (Kirkwood & Price, 2014).

According to a report by the Open University (Wild, Lefrere & Scott, 2013), learning in the 21st century is required to be personal, flexible and accessible to students anywhere and at any time. Technology is reported to be an integral part of achieving this (Walker, Voce & Ahmed, 2012).

The introduction of Technology Enhanced Learning in education has created new and flexible options in the delivery and assessment of teaching and learning (Beetham & Sharpe, 2013).

One of the common discussions around Technology Enhanced Learning is the question itself, does technology enhance learning? Literature and good practice suggests that the correct question should be how can educators utilise and design technology that enhances the learning process?

In the next section, tools and methods of technology enhanced learning are briefly defined.

2.5.2 Video in Teaching and Learning

The use of videos within teaching and learning provides an effective medium for enhancing and communicating complex information to students.
Video is increasingly being used within teaching and learning to enhance and supplement teaching and learning practices. Video within education is being used in multiple ways including:

- use of video to provide feedback for students (Crook, Mauchline, Maw, Lawson, Drinkwater, Lundqvist, Orsmond, Gomez & Park, 2012)
- use of video to enhance and contextualise learning (Mitra, Lewin-Jones, Barrett & Williamson, 2010)
- use of videos as casestudies (Malon, Cortes & Greisen, 2014)
- use of video for assessment (Gama & Barroso, 2013)

Open access systems such as YouTube has provided users with a repository for sharing and viewing home-made videos. Whilst these platforms have enhanced social media, they are also increasingly being used to enhance teaching and learning within education.

In a recent undergraduate student nursing course (Clifton & Mann, 2011), YouTube was used as a mechanism for enhancing learning by embedding videos into the students virtual learning environment. Student’s engagement levels were increased and practitioners found that the use of YouTube videos within their teaching and learning facilitated deep learning and allowed the students to develop critical awareness. The flexibility of YouTube meant that students were able to access the videos any time of day or night and fitted in with clinical sessions.
The production of videos for teaching and learning purposes have increased in Higher Education with educators using it to enhance and supplement teaching and learning material. In a project at the University of Huddersfield (McDowell, 2011), educators are using video to promote learner engagement in the assessment and feedback process.

The use of video assessment within education is steadily on the increase as access to technology grows to both students and teaching staff. Educators continue to look for more innovative and engaging ways of assessing students, video assessment has been identified as an effective way of understanding students learning process within a certain topic.

In a recent case study, video was used as a formative assessment for high school physics teachers to gain information on where learning is successful or failing (Gama & Barroso, 2013). In this study students were asked to produce short videos of themes and topics they had learned during the term which would later be presented to their peers. Academics involved in this study found that the videos identified elements of student difficulties such as accessing their cognitive resources and methods to their learning, that were traditionally not picked up in the former form of assessment such as tests and questionnaires.

2.5.3 Social Media and ePortfolios

The use of social media has grown considerably in recent years particularly with the introduction of tools such as Facebook, Twitter and Instagram. In a recent
study the use of Facebook was used to enhance teaching and learning in a team based project (V. Rasiah, 2014). Students found the tool to be an ‘innovative and effective’ tool in promoting student centred learning.

In another study, the use of social media was explored and proven to be an effective way of promoting informal learning that could be integrated into educational curriculums (Chen & Bryer, 2012).

Junco, Heiberger el al (Junco, Heiberger & Loken, 2011), measured the impact of social media within student learning and engagement. They implemented the use of twitter within the course and found that it could be used as an educational tool if the background pedagogy is in place.

However, some educational studies (DeAndrea, Ellison, LaRose, Steinfield & Fiore, 2012; Grajales III, Sheps, Ho, Novak-Lausher & Eysenbach, 2014), particularly from the medical field, raise concerns over the privacy settings in the use of social media such as Facebook and Twitter on a student’s professional career.

2.5.4 Mobile technologies

According to a recent report, mobile technologies are becoming more prevalent with Universities making more demands on their TEL support teams (Walker, Voce & Ahmed, 2012).
Mobile learning refers to learning using standards and capabilities of mobile devices such as smart phones or tablets (Cheon, Lee, Crooks & Song, 2012). According to the 2013 NMC Horizon Report (Johnson, Adams, Cummins, Estrada, Freeman & Ludgate, 2013), mobile technologies have advanced in the last two years and are increasingly being used within educational frameworks. They are predicted to play an important part in the future delivery and development of educational pedagogies.

2.5.5 Virtual Learning Environment

Virtual learning environments (VLEs) such as Moodle, Blackboard, WebCT support and facilitate Technology Enhanced Learning. They provide a platform in which educators can deliver course materials online and engage students using inbuilt collaborative tools such as wikis or online quizzes.

VLE’s also allow online collaboration and interaction amongst peers and provide academics with statistical analysis on student’s engagement and participation within the course.

Future direction of VLE’s in education remains debatable. Innovations in alternative technologies are growing. Some researchers have argued that virtual learning environment have become structured and reliant on traditional educational pedagogies and projects predict that emerging web-based tools could create new opportunities in teaching and learning, redefining the need of the VLE (Stiles, 2007).
2.5.6 Computer Based Assessment/Alternative Assessment

Assessment is critical to Higher Education with both formative and submissive assessments being delivered in a blended or traditional approach (Gikandi, Morrow & Davis, 2011). Computer-aided assessment refers to the methods in which assessments are delivered and assessed on a computer. This can be online or off-line and with advancements in software such as QuestionMark Perception, Hot Potatoes and inbuilt VLE assessment tools, is becoming more prevalent in education pedagogies.

2.5.7 Massively Open Online Courses (MOOCs) and Flipped classrooms

Massive open online courses (MOOCs) are a recent innovation (2012) in Technology Enhanced Learning and create free online learning possibilities. Within education, MOOC’s open up the potential of new pedagogies and techniques including the ‘flipped’ classroom which will be discussed in the next section and promotes widening participation access for Higher Education Institutions.

The main concept behind a MOOC is a course or programme that is delivered fully online, normally with little or no cost. It passes the ownership of the learning to the end-user and allows them to manage their own participation within the course (Hoxby, 2014).
In education, MOOCs have been predicted to impact heavily within teaching and learning, with many Higher Education Institutions exploring the potential and appropriateness of the tools (Russell, Klemmer, Fox, Latulipe, Duneier & Losh, 2013).

Another pedagogy to have recently resurfaced in education is the flipped classroom, which allows educators to set their learners a series of tasks or activities to complete prior to their attendance in the classroom. Flipped classroom methodologies are incorporated into a blended pedagogic approach within education, where initial learning is facilitated via technology outside of the classroom and then brought back in to further deepen and develop critical thinking. Flipping the classroom is not a new pedagogy and has been in use for decades (Berrett, 2012), however, the innovations in Technology Enhanced Learning have given educators more flexibility and ability to give students access to the material before the session.

This technique has grown in popularity in the last few years (Herreid & Schiller, 2013) due to the ability to combine a series of learning theories including problem-based and active learning (Bishop & Verleger, 2013). Flipped classroom is by nature facilitating active learning by giving the students ownership of their learning around a series of student-centred tasks.

In a recent case study by James, Chin et al (James, Chin & Williams, 2014), flipped classroom pedagogy was used to facilitate maritime industry education.
Similarly to engineering, maritime education has historically been taught in a traditional classroom interface but due to industry demands of graduates being 'work ready', educators looked at implementing technology methods to help prepare their students professionally. The students involved in this study were asked to work through a series of mathematical problems presented them via workbooks prior to the lecture within groups. When back in the classroom, the students would then present their methods of solving the problems to their peers and receive critique on their work. Evaluation found that the students were taught critical thinking by creating a more active learning experience between the student and lecturer. The educators found that these techniques had further potential of transitioning students from university education to the industry workplace by developing independence in this students and allowing them to take ownership of their learning.

In another case study by Warter-Perez and Dong (Warter-Perez & Dong), flipped classroom pedagogy was used in a digital engineering course to promote active learning and reduce and engaging lecture-based activities. They found that by reducing time spent by the academic talking to the students, students were able to apply their learning in context and ask further questions of the lecturer as time was freed up to allow them to do this (Warter-Perez & Dong).
2.5.8 Bring your own device (BYOD)

The increase of investment in Higher Education Institutions Wi-Fi connections and technology, has promoted and encouraged the concept of students using their own devices within their teaching and learning. The devices can be smartphones, tablet devices or laptops but literature states that students are increasingly using their own devices in their learning inside the lecture room as well as in their own time (Thomson, 2012).

Students expect their learning to incorporate their own devices. The 2014 NMC Horizon Report (Johnson, Adams Becker, Estrada & Freeman, 2014), discussed how personal devices have become the gateway to personal learning and allowed students to explore new subjects using tools that are unique to each learner.

2.5.9 Digital Literacy

There are many variations of the definition of digital literacy (Eshet, 2004; Goodfellow & Lea, 2013; Greene, Yu & Copeland, 2014). It be summarised as the technique and ability to analyse, use and locate appropriate digital technology for the particular task.

In educational research, the concept of digital natives is debated frequently (Ng, 2012) and in industry employers request students that are digitally literate and
able to use different technologies appropriately (Santos, Azevedo & Pedro, 2013).

Digital literacy is vital within education with students having their own methods of learning and facilitating their studies using technology.

Literature argues over the concept of a ‘digital student’ or ‘native’ (Helsper & Eynon, 2010; Jones et al., 2010b; Margaryan, Littlejohn & Vojt, 2011; Thompson, 2013), and has found that stereotyping is dangerous within education and assumptions should not be made. In 2011 White and Le Cornu (White & Le Cornu, 2011), proposed an alternative ideology to Prensky’s Natives and Immigrants referred to as ‘Visitors and Residents. This concept moved away from the stereotyping of individuals and instead concentrated on the way in which people behaved and used technology. White believed that people behaved differently with technology regardless of age of background and that motivation and context drives the relationship with people and technology.

Literature (Helsper & Eynon, 2010) suggests that educators should concentrate on using appropriate pedagogically validated technologies and look to embed these as a way to engage students.

2.5.10 Approaches in Technology Enhanced Learning

A technique that is becoming more common in Higher Education is blended learning.
Blended learning as defined by Garrison and Kanuka (Garrison & Kanuka, 2004) as:

“The thoughtful integration of classroom face-to-face learning experiences with online learning experiences”

This approach mixes Technology Enhanced Learning pedagogy with traditional methods. Virtual learning environments facilitate blended learning by providing educators with the platform in which to enhance and supplement traditional face-to-face lectures or classroom activities.

Blended learning is most powerful when used to contextualise or enhance activities carried out in the classroom. In an example, Yigit, Koyun et al (Yigit, Koyun, Yuksel & Cankaya, 2014), used a blended learning model to teach programming in computer Engineering Education. Tools such as surveys, quizzes and simulations were embedded in a blended model and compared against traditional learning methods. They found the average of marks were similar for the blended and traditional approach, however the blended approach was more flexible and supported different learning styles in comparison to the additional mode of delivery.

In another study (Owston, York & Murtha, 2013), students perceptions of blended learning courses were evaluated. The majority of students preferred a blended approach to their learning and felt they were able to learn concepts
better using this method in comparison to traditional face-to-face lecture room scenarios.

2.5.11 Challenges to Technology Enhanced Learning Adoption

In summary to the Technology Enhanced Learning section, challenges in the adoption of these methods are discussed.

Despite literature reporting positive benefits in adopting Technology Enhanced Learning in education, there remains a group of ‘educators’ that do not engage.

Barriers to the implementation of Technology Enhanced Learning include:

- lack of knowledge and skills (Park & Ertmer, 2008)
- unclear digital strategies within faculties (Elzawi & Wade, 2012)
- inadequate infrastructure (Childs, Blenkinsopp, Hall & Walton, 2005)
- Student engagement and expectations (Beetham & White, 2013)

Technology is now more accessible for engineering educators; but the integration of this is approached with caution due to the complex nature of Engineering Education.

The next section outlines industry requirements within Engineering Education.

2.6 Industry requirements within Engineering Education

Industry impact on Engineering Education has evolved over the last two decades with more recent demands from industry shaping the way in which educators
deliver engineering skills. Student numbers in engineering have grown considerably in the last decade due to industry demands (Smaill et al., 2012).

Engineering Education requirements have been increasing over the last two decades, with two important reports, Finniston (Jordan & Richardson, 1984) and SARTOR (Levy, 2000) impacting on the development and expansion of the prevision of engineering in Higher Education. The 1980 Finniston report was commissioned by the government and led by Sir Monty Finniston. It provided a summary of Engineering Education in response to complaints from industry regarding the shortage of qualified engineers. The SARTOR (Standards and Routes towards Registration) was published by the Engineering Council shortly after its formation, and was a result of its review of the professional regulation in engineering.

Strong industrial links are defined as being critical to the success and development of Engineering Education research. Despite numerous literature and outlaying the benefits of industrial relationships, many institutions feel that they are insufficient opportunities to close online industry practices with teaching engineering (Alpay & Jones, 2012).

The lack of progression and change in this field has sparked great debate from industry professionals and has found that new methods in industry practices are often delayed to reflect into academia and educational methodology (Solnosky,
Parfitt & Holland, 2014). When the government implemented the move to standardise all government based building frameworks using the Building Information Modelling (BIM) by 2016 (HM Government - Department for Business, 2012). Industry practices have had to adapt and train their staff to meet this goal but the reflection in the education curriculum has been slow to introduce teaching concepts to support this (Pikas, Sacks & Hazzan, 2013).

Literature suggests that the classroom activity should represent tasks and activities carried out by an engineer in the workplace (Allie, Armien, Burgoyne, Case, Collier-Reed, Craig, Deacon, Fraser, Geyer & Jacobs, 2009). As a result of this, case studies discussing implementations of institutions attempting to simulate a ‘real world’ exposure to engineering students have been steadily increasing over the last decade (Galloway, 2007a; Jonassen, Strobel & Lee, 2006; Köhler, Bakker & Peck, 2013).

2.7 Research aims and objectives
The literature review demonstrated that there is an abundance of literature surrounding Engineering Education that demonstrates the need for reform in the delivery and structure of engineering curriculum.

Technology is widely discussed as a catalyst to driving this change but the majority of literature is of small scale and concentrates on the introduction of technology to replace or supplement a practical experience for engineering students including remote laboratories and simulations.
Technology Enhanced Learning is becoming increasingly important to educators outside of this discipline and has created new and flexible options in the delivery and assessment of teaching and learning in Higher Education. Within Engineering Education the adoption of Technology Enhanced Learning is still relatively limited and teaching staff appear wary of changes in delivery methods and assessment due to concerns over accreditation and the loss of fundamental engineering skills.

Many Engineering Education institutions are continuing with passive traditional styles of lecturing where students are being talked at rather than engaging in the learning process. In comparison to other subject areas, Engineering Education is lagging behind in progress in embedding technology practices within its curriculum.

Research papers have concluded that a mixed approach to pedagogy is needed to refresh and innovate Engineering Education to produce graduates that are industry ready and have digital skills and awareness to progress within the workplace.

The research aims of the study will explore the implementation and effectiveness of an integrated blended learning approach utilising Technology Enhanced Learning within an Engineering Education curriculum.

In particular, the aims of the work will investigate the following four areas:
1. explore and evaluate the appropriateness of the implementation of Technology Enhanced Learning pedagogies and methods within an Engineering Education curriculum

2. evaluate the appropriateness of action research studies within Engineering Education

3. assess and evaluate the appropriateness of a mixed methods research methodology approaches to Engineering Education

4. understand views and opinions of stakeholders involved in Engineering Education research including students, academic staff and industry based professionals and to compare against current Engineering Education research literature

The next chapter will introduce the methodologies and techniques used within the research study and justified chosen pedagogies and approaches.
3 Methodology

This chapter explains the methodologies for this research. It provides an overview to practices seen in Engineering Education both currently and historically. Literature supporting and informing the methodological decisions in this research will be discussed and justified resulting in an overview of how each individual element of the research correlates to the overall vision of this work.
3.1 Literature around Engineering Education Methods

The literature review in Chapter 2 outlined a number of areas that require further investigation and evaluation in Engineering Education including:

1. explore and evaluate the appropriateness of the implementation of Technology Enhanced Learning pedagogies and methods within an Engineering Education curriculum

2. evaluate the appropriateness of action research studies within Engineering Education

3. assess and evaluate the appropriateness of a mixed methods research methodology approaches to Engineering Education

4. understand views and opinions of stakeholders involved in Engineering Education research including students, academic staff and industry based professionals and to compare against current Engineering Education research literature

A small proportion of research identified successful implementation of mixed method research approaches, in particular embedding a pedagogical approach of Technology Enhanced Learning in both assessment practices and teaching and learning in the engineering curriculum.

This next section will summarise key areas of Engineering Education literature methodologies and identify missing approaches before outlining the methodology for this research.
Engineering as a subject or terminology has been around for decades; however the discipline of Engineering Education according to Clarke (Clarke, 2012) has only been a recognised topic since 2011 and grown as a distinct field of research in social sciences in the last decade (Beddoes, 2014; Johri & Olds, 2011).

Ghaffari and Talebbeydokhti (Ghaffari & Talebbeydokhti, 2013) defined the goal of Engineering Education;

‘The goal of Engineering Education is to train engineers who can make changes to their environment, based on their learning to make life more comfortable for people’.

Literature around Engineering Education methodologies are vast and varied with the majority of studies focusing on a specific element in engineering curricula such as laboratories, industry requirements and design engineering. As the literature review in Chapter 2 discussed, engineering curricula is said to still maintain its predominant pedagogic model of dissemination to students as it did in previous decades (Daun et al., 2014; Felder & Silverman, 1988) which contradicts Baruh’s (Baruh, 2012) suggestion that “the only permanent thing in Engineering Education is change.” The ‘change’ in Engineering Education refers to changing requirements in accreditation from accrediting bodies, the changing student expectation and attitude and the ever increasing expansion of internet and computational techniques (Baruh, 2012).

Historically engineering literature has continuously discussed the call for reform and change. In 1980 Tomkins asked the question “Is there something missing in the education of engineers” (Tomkins, 1980). He also referred to academia as
being in an ‘ivory tower’, somewhat disconnected from the reality and needs of industry. These views have repeated through the last thirty years in literature and research but as literature suggest, we still see little change in methods (Beckman, Coulter, Khajenoori & Mead, 1997; Gattie, Kellam, Schramski & Walther, 2011; Matusovich, Paretti, McNair & Hixson, 2014).

Engineering Education research papers concentrate on reviewing existing literature (Borrego, Foster & Froyd, 2014) and implementing small scale pedagogical driven changes to teaching methods (Gattie et al., 2011). Research has called for dramatic reform and technological innovations to Engineering Education (Felder, 2012; Fuchs, 2012; Hall, Scott & Paterson, 2013), but practitioners are struggling to implement educational pedagogies that have the ability for widespread implementation due to restrictions on funding and staff engagement (Heitmann, 2005; Kelly, Smith & Ford, 2012; Matusovich et al., 2014).

Before discussing methodologies used in this research, a brief overview of research practices and trends in Engineering Education will be discussed, forming a picture of the current educational state as well as identifying missing literature relevant to this piece of work.

As seen in the literature review, Engineering Education encompasses many different areas that relate and contribute to the discipline, such as project based
learning, design engineering, Technology Enhanced Learning, industry led research and laboratories.

In this next section these five areas are outlined and a brief summary of methodologies used within these subjects will be evaluated and discussed.

3.1.1 Design and Creative Engineering

Design is considered to be an integral and distinguishing feature of engineering in particular ‘the design process’, but innovations, particularly in the teaching of design, has only recently started to be published under the field of Engineering Education.

The term ‘design thinking’ within engineering has become more prominent in education in the last decade. Razzouk and Shute (Razzouk & Shute, 2012) defined design thinking as;

‘Design thinking is generally defined as an analytic and creative process that engages a person opportunities to experiment, create and prototype models, gather feedback and redesign’.

They also believed that by incorporating effective ‘design thinking’ into the curriculum, students would become more proficient in problem-solving both inside their educational setting and in the real world. Educational work has started to emerge on embedding design thinking into the curriculum (Breslin, Nicol, Grierson, Wodehouse, Juster & Ion, 2007; McAlpine, Reidsema & Allen, 2006; Morozov, Kilgore & Atman, 2007).
Some educational institutions have introduced student design competitions as a way of promoting and developing design thinking in engineering undergraduates (Buchal, 2011). As discussed in the literature review in Chapter 2, the use of Computer Aided Design has been argued to be crucial in helping students develop the skills.

Alongside the notion of design thinking comes creativity. Traditionally, engineering is referred to as a science, a complex set of problems that needs solving, but recent literature and industry requirements are seeking for engineering graduates who are also creative (Chandrasekaran et al., 2013; Stephens, 2013). The notion of engineers being ‘creative’ comes under contradiction with the more traditional educators who argue that engineers must be accurate and not creative and that engineers are unable to take risks due to safety (Zhou, 2012).

Literature suggests that there are small steps being taken to embed creativity and design thinking within Engineering Education curriculum. One of the ways in which design and creativity function within an engineering environment is through the use of project based learning (Dym, Agogino, Eris, Frey & Leifer, 2005), which is discussed in this next section.

3.1.2 Project Based Learning methodologies in Engineering Education

Due to its increased relevance in Engineering Education over the last five years, much research has been done around the topic of learning through project
based pedagogies in engineering (Chandrasekaran, Stojcevski, Littlefair & Joordens, 2012; Graham & Crawley, 2010; Mills & Treagust, 2003).

Project based learning is defined as students working in groups to solve problems that are linked to the curriculum and more often than not by nature, interdisciplinary (Chandrasekaran et al., 2012).

The pedagogical benefits of project based learning has been reported to have a powerful and positive impact on student knowledge and development of the soft skills that industry are demanding of 21st century engineering graduates. Literature suggests that this approach closely mirrors the professional behaviour of engineers practising industry (Holland, Walsh & Bennett, 2013).

The effective implementation of project based learning in engineering at a University in Portugal was discussed by Fernandes, Flores et al (Fernandes, Flores & Lima, 2012). Students worked in teams and were given open-ended projects to solve collaboratively in their groups. The aim of the work was to develop and enhance skills that were pivotal to engineering practices such as project management, communication and teamwork. They found that students experienced deep level learning and were able to contextualise their work to practices seen in industry outside of the University environment. In their results they discussed the importance of interdisciplinary work and how the students engaged with the process and found it beneficial to their learning.

Recommendations as a result of this work centred on the workload that this
methodology created for the academics involved. They found that the students expected high results due to the amount of time and effort they spent working within this project, the assessment marking for the academics were more manual particularly when taking into consideration group effort and contribution.

They stated that future work should concentrate on using methods that would make the assessment criteria easier to follow, implement and evaluate from both the student’s perspectives and the academics.

Project based learning is slowly increasing within Engineering Education curriculum, however as literature previously discussed suggests, in order for project based learning to be effective it must have strong links with industry.

### 3.1.3 Industry Lead Research

As discussed in Chapter 2.6, industry lead research is vital to the future and success of Engineering Education. Pressures from industries are forcing educational institutions to define and justify the calibre of students coming out of current UK courses. Employability skills of graduates are coming into heavy debate (Stephen & Christine, 2000), reinforcing the need for educators to rethink the platform and methodology in which students are taught.

The engineering undergraduates of today will be tomorrow’s engineers and for this reason, industry is calling on educational institutions to help shape the graduate skillset for engineers and change their teaching to be research led and
industry informed (Clarke, 2012). Literature increasingly discuss the concern and complaints over the deficiencies in engineering graduates that are being produced both UK and world-wide (Felder, 2012).

The wariness of change in this field has sparked great debate from industry professionals and has found that changes in industry practices often take a while to reflect into academia and educational methodology (Solnosky, Parfitt & Holland, 2014). A more recent example of this can be seen by the government move to standardise all government based building frameworks using the Building Information Modelling (BIM) by 2016 (HM Government - Department for Business, 2012). Industry practices have had to adapt and train their staff to meet this goal but the reflection in the education curriculum has been slow to introduce teaching concepts to support this (Pikas, Sacks & Hazzan, 2013).

Literature argues that the classroom activity should represent the tasks and practices carried out by an engineer in the workplace (Allie et al., 2009). As a result of this, case studies discussing implementations of institutions attempting to simulate a ‘real world’ exposure to engineering students have been steadily increasing over the last decade (Galloway, 2007a; Jonassen, Strobel & Lee, 2006; Köhler, Bakker & Peck, 2013). These case studies have been mostly on a modular level where faculties have created a new module that they believe encompass learning outcomes needed to produce the non-technical ‘soft skills’ such as communication and project management, frequently referred to in the
literature (Grimson, 2002; Rao, 2014). In addition to the required soft skills, the paradigm’s surrounding interdisciplinary based curricula in engineering is increasing with its pedagogic benefits proving to be an effective way of stimulating the way in which engineers work in industry.

When attempting to provide engineering undergraduates with the skills needed to become a proficient engineer, practical knowledge is seen as essential to reinforce fundamental skills in engineering. Engineering educators are looking for alternative ways to provide a practical experience to students due to the expense and scalability of traditional engineering laboratories. One of the alternative methods is utilising remote and online laboratories which are discussed in this next section.

3.1.4 Remote and Online Laboratories

Due to its practical nature engineering educators must assess their students’ practical competences in order to meet engineering accreditation standards (Gelegenisis & Harris, 2014). However, with increasingly large groups in laboratories (de-la-Fuente-Valentín, Pardo & Delgado Kloos, 2013) and limited access to equipment due to financial cutbacks (May, Terkowsky, Haertel & Pleul, 2012), educators are looking towards alternative innovative methods of assessment and delivery such as remote laboratories and simulations (Balakrishnan & Woods, 2013).
Higher Education Institutions constantly have to budget and adapt to funding changes so achieving more exposure to practical skills that have traditionally been taught in laboratories is not easily achievable (Bochicchio & Longo, 2009). One of the growing areas of investment is in technology, and many Higher Education Institutions turn to technological alternatives to give students experiential exposure (Balamuralithara & Woods, 2009b).

Whilst literature in this area is fairly extensive (Fabregas et al., 2011; Nickerson et al., 2007b), the majority of institutions have continued in traditional exposure to practical experimentation (Stefanovic, 2013a).

Research surrounding Engineering Education have focused on the calls of change from industry to provide them with graduates who are able to work and thrive in modern technological climates (Arlett et al., 2010b).

There is much literature surrounding the evaluation and implementation of alternative methods to delivering a practical experience in engineering. These include remote laboratories, online laboratories, home kits and simulations. Despite the apparent availability of new technologies to facilitate practical experience, many argue that existing laboratories, particular in engineering, are far behind with new developments (Şeker, 2013).

Educators are investigating the potential of how to effectively implement a non-traditional laboratory into a curriculum that is said to still maintain its predominant synchronous teaching methods. One area within Engineering
Education research that is being increasingly looked at to find a solution is Technology Enhanced Learning.

### 3.1.5 Engineering Education and Technology Enhanced Learning

The introduction of Technology Enhanced Learning in education has created new and flexible options in the delivery and assessment of teaching and learning (Beetham & Sharpe, 2013). Despite some encouraging signs in the adoption from Engineering Education (Kapranos, 2013a), the discipline appears to be wary of changes in delivery methods (Mora et al., 2012).

Many institutions have yet to embrace the new opportunities that Technology Enhanced Learning opens up to learners and continue with the ‘chalk and talk’ methods of passive lectures that was discussed by Mills and Tregust over a decade ago (Mills & Treagust, 2003). A number of research papers conclude that a mixed approach to pedagogy is needed (Auer, Dobrovska & Edwards, 2011).

Progression has been made, mostly in the last five years, but Engineering Education is an area that is lacking behind in comparison to other disciplines. Arguably, this has been discussed that this lack of progression it is due to the practical and mathematical nature of engineering and the difficulties of teaching complex material (Bourne, Harris & Mayadas, 2005), but innovations in remote laboratories, simulations and internet technologies and Technology Enhanced Learning have opened up new opportunities to learning (Fabregas et al., 2011). Technology Enhanced Learning is steadily on the increase within educational
fields (Kalz & Specht, 2014; Wood & Ashfield, 2008) and some speculate that this will become a strategy for helping to achieve the shift required to meet industry requirements and demands within Engineering Education (Grimson, 2002).

Whilst technology is more accessible for engineering educators, the integration of this is approached with caution due to the complex nature of Engineering Education. In a case study of nine institutions that undertake postgraduate and undergraduate engineering programs, Banday, Ahmed et al (Banday, Ahmed & Jan, 2014), concluded that e-learning developments within engineering must be designed to facilitate learning at different levels to suit a range of student capabilities. In another paper, Banday identified five areas of deficiencies in traditional Engineering Education teaching methods (Banday, 2012):

- Poor student teacher communication
- complex teaching methodologies
- loss of synchronisation in the curriculum
- poor collaboration
- difficulties managing students

In both of Banday’s case studies, the implementation of Technology Enhanced Learning methodologies and technology significantly improved the performance and learning of students by facilitating a deeper level of learning than conventional teaching methods in engineering.
Evans (Evans, 2013), discussed the problems associated with large groups in Engineering Education and identified the use of technology to help promote and establish communication between the academic and the students. In this case study over five hundred and fifty students were used on a trial to evaluate the use of social media in establishing an online community for distribution of many lectures and collaboration. The academic also used screen capturing to record videos to further enhance student learning and promoted these via their online community due to the difficulties faced in obtaining a physical space large enough for the amount of students. Their results found that the use of videos not only improved the students to lecture interaction but also promoted communication amongst the students themselves and allowed peers to support each other in their studies.

Technology embedded into teaching practices opens up more opportunity for student driven learning (Laurillard, 2013). However, when given a more self-directed learning task, literature reviews reveal that some students felt a bit unnerved by the experience, they were unfamiliar to the concept of taking control of their own learning (Felder, Stice & Rugarcia, 2000a). To combat these issues some researchers have suggested ideas for educators to implement, that might ease the students into this method of learning:

• Embed new methods early and small to ease them into it
• Communicate with your students on what you are doing and why
Methodology

• Be flexible

An educational pedagogy with the potential to support educators in embedding new methodologies is blended learning, which was explained in Chapter 2.5.10. Literature has repeatedly called for Engineering Education to adopt a blended approach for training and education (Ku, Goh & Ahfock, 2011) however this field is still less engaged in comparison to other educational disciplines with incorporating Technology Enhanced Learning into the curriculum. Suggestions towards a blended approach could have pedagogical advantages in the first instance. Blended learning as described by Garrison and Kanuka (Garrison & Kanuka, 2004) is:

“The thoughtful integration of classroom face-to-face learning experiences with online learning experiences”

Blended approaches in teaching and learning are diverse in their implementations but can facilitate different fields of inquiry utilising alternative methods of communication depending on learning requirements and outcomes. The use of blended learning in Engineering Education could create opportunities for improving the quality and teaching experience for students. According to Bourne (Bourne, Harris & Mayadas, 2005), these improvements could occur in the form of industry based partnerships, cross institutional instruction and knowledge sharing. The motivational factors in the engagement of Technology Enhanced Learning in Engineering Education will only occur when new learning
experiences, that were unattainable in traditional methods, are achieved in a pedagogical appropriate educational environment.

Ebner and Holzinger (Ebner & Holzinger, 2002), successfully implemented a blended pedagogic approach to an engineering course in structural concrete. They highlighted that computers themselves cannot improve the way in which students learn but create new possibilities of learning through motivation and improved didactics. In their case study, one hundred students attended lectures to understand concepts of structural concrete buildings. Traditionally, it was difficult to deliver the learning topics due to the limitations of the subject. By developing an e-learning suite consisting of discussion boards, simulations and multimedia content within the course, students and teachers were able to improve communication and collaboration to compliment the traditional teaching delivery. The pedagogical appropriateness proved advantageous by creating an enhancement to the course rather than a replacement in a blended learning format. In their evaluations they found the implementation of this approach improved the motivation of the students in a lecture room scenario. While not all students took part in the discussion forums, many referred back to them as a revision tool and a way in which to identify problems they may be experiencing.

In another study, Yigit, Koyun et al (Yigit et al., 2014), used a blended learning model to teach an algorithm programming course in computer Engineering
Education. By using distance education technologies such as surveys, quizzes and simulations in a blended learning model they found that this module increases student retention and provides many benefits in comparison to traditional mode of education. They compared fifty students who undertook the blended learning model and fifty students who used traditional learning methods to assess final module marks. They found the average of marks were similar for the blended and traditional approach, however the blended approach was more flexible and supported different learning styles in comparison to the additional mode of delivery.

Despite literature recommendations on new pedagogies that are available as a result of innovations in technology, the adoption and delivery of these methods are still small scale and approached with extreme caution within Engineering Education. The next section will discuss the limitations in existing research within Engineering Education.

3.1.6 Limitations of existing research defined within Engineering Education methodologies

Limitations in Engineering Education research within the context of implementing technological appropriate pedagogy were identified during the literature review in Chapter 2 and Chapter 3.1. Whilst recent research suggests that change is slowly emerging in the field, this is slow and not always in
connection with educational methodologies that have the potential to underpin knowledge and understanding.

In order to understand methodologies used within the context of Engineering Education research, literature around current and historic methods in engineering were evaluated to assess any common themes. Favourable methods were recognised to evaluate practices as well as identify methodologies that are seen to be effective. As previously discussed, the field of Engineering Education research is proportionally new compared to other scientific areas, with only four known research journals dedicated to this discipline; Journal of Engineering Education (JEE), European Journal of Engineering Education, International Journal of Engineering Education and Advances in Engineering Education (Beddoes, 2014).

In a review of engineering papers from research journals and Google Scholar searches, seventy four papers were evaluated and their content categorised in a table under the following headings: case studies, action research, literature review, survey, report, focus groups, interviews and assessment and feedback.

The review of these papers is shown in Table 1.
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<tr>
<th>Methodology</th>
<th>Case Study</th>
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### Methodology

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## Methodology

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### Methodology

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| (Baillie & Douglas, 2014) | X | 0 |

| (Banday, Ahmed & Jan, 2014) | X | Action Research Lit review | Survey Report Focus Groups Interviews Assessment and feedback Cited by (Aug) |
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By reviewing research methodologies in engineering literature, a common theme of evaluation and methodology was found within the field. The predominant methods consisted of case studies and literature reviews which supports statements of limitations within current trends of Engineering Education research (Case & Light, 2011).

Using a combination of the literature review and evaluation of the seventy-four papers, gaps in methodologies were identified with predominant methods consisting of evaluating and reviewing existing literature and small scale case studies of practices. Focus group methodology was underrepresented as well as interviews which only made up a small proportion of results. The speculation behind this apparent lack of specific methodologies could potentially reconfirm suggestions from literature that qualitative methods are only just emerging in Engineering Education (Baillie & Douglas, 2014), which will be discussed further in Section 3.2.2.

Whilst research methodologies in Engineering Education research could be listed under three categories; quantitative, qualitative and mixed methods research, references towards techniques such as action research were underrepresented within this discipline.
The next section will introduce potential methodological choices appropriate for use within this study including; quantitative, qualitative and mixed methods research techniques.

### 3.2 Literature to Support Methodological Choices

Before introducing the choice of research practices used in this work, it is necessary to review potential research methodologies in order to identify the best pedagogic approach for this work. Discussions around methodologies will be compared against literature in Engineering Education and in educational theory in general, in order to later support the justification for this work.

According to Bryman, Johnson, Onwuegbuzie and Turner, there are three categories of research methodology; quantitative, qualitative and multi or mixed methods (Bryman, 2006; Johnson, Onwuegbuzie & Turner, 2007). In the next section quantitative, qualitative and mixed methods research will be discussed and defined both generally. Similar approaches use in other research projects are evaluated against literature in Engineering Education before later defining the appropriateness of this approach.

The first methodology to be discussed is quantitative research.

#### 3.2.1 Quantitative research methodology within Engineering Education research

Quantitative research methodology is a data led approach which concentrates on gaining statistical and numerical data and is suited to large sample numbers.
As Aliaga and Gunderson (Aliaga & Gunderson, 1999) described quantitative research is;

‘Explaining phenomena by collecting numerical data that are analysed using mathematically based methods (in particular statistics)’.

This type of research is suited to methodologies such as structured survey questions with closed questions which can later be explored further with qualitative methods if appropriate. Alternatively, question design if used effectively in methodology such as surveys, can gather further quantitative data using techniques and question types such as Likert scales and ratings.

In Engineering Education the use of quantitative research is seen to be the traditional predominant method (Kelly & Bowe, 2011). Quantitative techniques are predominately used for experimental designs in the field of Engineering Education (Olds, Moskal & Miller, 2005).

Fowler, McGill et al (Fowler, McGill, Armarego & Allen, 2002), utilised quantitative data when assessing students on their learning styles. They were able to statistically evaluate results based on Kolb’s learning style infantry (Kolb, 2005) tests to form percentage results in categorisations.

In another study (Holloway, Alpay & Bull, 2010), quantitative research methodologies were used within a survey for engineering undergraduate students. Within the same study, handheld clickers were used to gain further
quantitative data in an engaging and motivational approach (Holloway, Alpay & Bull, 2010).

In 1997 Ibbs (Ibbs, 1997), used quantitative measures within a survey to develop data for analysis on impacts of project change within construction projects. The quantitative methods produced numerical and statistical data to allow the researcher to draw conclusions and present general trends contributing to the change within construction projects. This data collection approach allowed the results to be presented visually using histograms and charts. Whilst using qualitative data collections would have given the researcher a deeper understanding of the reasons behind change, they would not have been able to gather large numbers of respondents as easily categorised their data into key themes and findings.

Whilst quantitative methodologies traditionally lend themselves to the STEM disciplines such as engineering and mathematics, they do not allow the researcher to identify the reasoning behind the data which is primarily gathered using research techniques in qualitative methodology.

The next section defines qualitative research within Engineering Education.

3.2.2 Defining qualitative research within Engineering Education context

Qualitative research is a more unstructured type of methodology which lends itself to exploratory and investigative work. It allows the researcher to develop
a deeper understanding around a topic by using methods such as focus groups and unstructured interviews to help generate hypothesis for further work.

As defined by Bryman (Bryman, 2012):

“Qualitative research is a research strategy that usually emphasises words rather than quantification in the collection and analysis of data. As a research strategy it is broadly inductivist, constructionist, and interpretivist, but qualitative researchers do not always subscribe to all three of these features”.

Qualitative research has become more prevalent in the latter part of twentieth century (Flick, 2014) and is now considered as equal as quantitative research when used the appropriate context (Avison, Lau, Myers & Nielsen, 1999).

By nature, qualitative research is difficult to plan, gather and analyse particularly with large sample sizes (Kelly & Bowe, 2011).

It has been argued that the majority of engineering educators have a background in quantitative research backgrounds rather than qualitative (Leydens, Moskal & Pavelich, 2004) which has primarily driven previous research literature to use quantitative methods of data collection and evaluation.

More recently, Engineering Education journals have been pushing for more research papers with qualitative methodological approaches embedded within educational theory to discuss impact on the feature of the discipline (Baillie & Bernhard, 2009).
As a result the use of qualitative research methods are increasing. Educators within the field are looking to methodologies such as surveys, interviews and focus groups to gather information rich data to further progress Engineering Education as a discipline.

Jose and Paretti used qualitative techniques via surveys to gain data on students’ views on motivational factors that affect achievement and persistence in Engineering Education (Jones, Paretti, Hein & Knott, 2010a). Likert scale questions and open ended questions allowed the researcher to gain some quantitative data but then supplement the reasoning behind their choices with qualitative data.

In another study qualitative methods were used within a series of case study reviews to evaluate students reasoning for choosing engineering programs (Matusovich, Streveler & Miller, 2010). This method allowed key themes and ideas to emerge from the data to give the researcher a clearer understanding of why students decide on engineering courses.

Both qualitative and quantitative methodologies have been outlined, but an increasingly popular method of research among educators is mixed methods research which is defined in the next section.

3.2.3 Defining mixed methods research within Engineering Education

Mixed method research (MMR) utilises the common approaches to both qualitative and quantitative research and integrates the viewpoints and
perspectives of both methods to give the researcher flexibility and tools to gain a thorough understanding of their data. This method has proven to be a popular technique within the disciplines of medicine and science (Sale, Lohfeld & Brazil, 2002) but the majority of users of this methodology is within social science research. Bryman (Bryman, 2012) discussed the increasing use of mixed method approaches in conducting social research.

Historically, mixed methods research began in the field of sociologists and cultural anthropologists (Johnson, Onwuegbuzie & Turner, 2007) and was seen to be more relevant to the social sciences. The beginning of the twenty first century saw an increase in practices in mixed methods research in subject areas that traditionally had utilised either quantitative or qualitative techniques. Within Engineering Education the use of mixed method research is limited with few literature publications reaching the wider public. Creamer and Ghoston (Creamer & Ghoston, 2013) used a mixed methods approach to analyse content from mission statements of engineering colleges. They believed that this approach enabled the detection of ideas and themes through qualitative data collection as well as validating results via quantitative approaches. It opened the door to new ideas that would have not been possible had they followed a singular quantitative approach.

In another mixed methods study, Crede and Borrego (Crede & Borrego, 2013) created a survey based on exploratory data collected via a mixed methodology
to gather information on engineering student retention. They reported that the approach gave them a deeper understanding from the results as a combined method rather than from the individual qualitative and quantitative data.

Matusovich, Paretti et al used mixed methods data to understand motivation within research practice cycles in Engineering Education (Matusovich et al., 2014). Whilst they found the majority of their qualitative data provided them with key themes and viewpoints, the quantitative data collected via a survey allowed them to collect statistics to compliment the qualitative data.

Sheriff (Sheriff, 2012), used a mixed methods approach combining survey data and interview methodologies to evaluate the use of technologies for engineering students and lecturers. By combining these methods the researcher was able to draw conclusions and validate quantitative data gained during the survey process to form recommendations and ideologies around the use of technology within engineering educational stakeholders.

Whilst some literature exists on utilising mixed methods in engineering, the majority of literature concentrated on issues such as gender equalities and student retention. Literature is limited on the use of mixed methods approach in validating new approaches and tools in Engineering Education. No literature could be found on implementing this approach when embedding new technologies into Engineering Education pedagogy. One hypothesis is due to the newness of all these paradigms, particularly when further implemented with a
mixed methodology approach. As discussed in the literature review in Chapter 2.4, not only is Engineering Education is still a new field, when combining engineering with a new phenomenon of Technology Enhanced Learning, further limitations in access to information are apparent. Arguably, publications and reports could be in draft formats and not yet released, however, this research is based on the currently available literature and work at the time of write up.

This next section will further explore individual research strategies and identify predominant methods used in current Engineering Education research.

3.3 Methodology Strategies in Engineering Education

This section explores methodology strategies in Engineering Education research identified in various research papers during the literature review in Chapter 2. Whilst this is not an exhaustive list of potential research strategies, it baselines these against publications and case studies discovered and discussed during the preliminary research stage and literature review.

The use of qualitative research in technical subject areas such as engineering, science and mathematics is limited. Emerging qualitative research within Engineering Education struggles to be accepted within research journals and publications (Baillie & Douglas, 2014). The predominant method of research evaluation tends to be mainly quantitative with a small amount of qualitative evaluations (Amaratunga, Baldry, Sarshar & Newton, 2002).
Engineering Education research methodologies are predominantly categorised into two themes (Olds, Moskal & Miller, 2005):

- descriptive studies detailing current Engineering Education paradigms
- studies that evaluate and examine and implementation of the phenomena

This next section will outline methods and practices in qualitative and quantitative research and discuss their suitability to Engineering Education.

### 3.3.1 Action Research practices and methodologies

Action research was, according to literature (Adelman, 1993), first defined by Kurt Lewin in the 1940’s. Over the years the term ‘action research’ has been interpreted and adapted by different researchers; however it’s fundamental terminology remains the same. Its definition is experimental by nature where a problem is identified, something is implemented or carried out to solve it and a series of evaluations then take place to measure the effectiveness of what has been done. The process is then repeated until a solution is found, or other methods are implemented within the process. Each cycle within the process has the basic steps of plan, act, observe/evaluate and reflect as illustrated in Figure 12.
Within education, action research is seen to be a vital methodology for instigating an improvement of practice within a teaching and learning context. Action research in this setting involves instructors, teachers and practitioners creating and implementing pedagogic educational changes in a curriculum within a community of practice. The term community of practice as defined by Wenger (Wenger, 1998) is a group of people who share a concern for something they do and learning how to do it more effectively as they communicate.

In the last decade traditional quantitative researchers have moved towards action research methodologies (Newman, 2000). Action research is interpreted and implemented across the educational research area in varying formats, with different researchers creating their own ways in which they reflect on the practices.
Some researchers have built on Lewin’s model of action research to create a more flexible methodology suited to an educational framework. John Elliott extends the cycle approach of Lewin’s model to allow greater flexibility within the action research by incorporating more analysis and fact-finding within a series of activities throughout the cycle, and not just at the beginning (Elliot, 1991). Figure 13 visualises a revised version of Lewin’s model of action research created by John Elliott.
This method allows multiple activities within the cycle to be continually assessed to contribute to the reflection and recommendations on future work which is suited to a yearly academic and educational scenario.

In another example of action research within education, (Kaneene, Ssajjakambwe, Kisaka, Miller & Kabasa, 2013), the methodology is used within the training of graduate students for teaching in community practice.
Preliminary studies carried out firstly identified a problem and using traditional research techniques such as focus groups and observations, formed recommendations for a solution utilising Technology Enhanced Learning. Data collected during this initial phase formed the recommendations for a series of learning of online teaching materials to be implemented and evaluated. As a result of this continuing cycle of action research, a series of open educational resources (OER) modules were created and embedded into a teaching course at University. The continuing development of the resources were informed by results carried out during the action research cycles and evaluations on this method were proven to be successful and contributed to knowledge retention within the field of work.

According to Case and Light (Case & Light, 2011), action research is an emerging yet underrepresented methodology in Engineering Education. Its definition varies by interpretation from different researchers but in essence action research aims to improve, enhance and realise practice through actions performed by research and theory. One of the most accurate descriptions of action research is summarised by Reason and Bradbury (Reason & Bradbury, 2001, p.1):

“Action research is a participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human purposes, grounded in a participatory worldview which we believe is emerging at this historical moment. It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit
of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities’.

Cycles of action research in Engineering Education although limited, have been proven to be effective when integrated into in engineering curriculum. As Daniels, Cajander et al discussed (Daniels, Cajander, Pears & Clear, 2010), this approach allows the educator to apply and evaluate several educational theories appropriate for the discipline in order to facilitate a changing and developing curriculum within Engineering Education.

Action research is particularly effective when implementing a new practice or methodology which needs to be rigorously evaluated for further implementation at a later stage. This methodology lends itself well to evaluating new technologies within an educational context to further facilitate learning. However, due to the emerging nature of the combination of both of these fields combined, there has been limited to literature available at the time of the study.

Table 1 in Chapter 3.1.6 illustrated a small number of action research practices were identified in literature.

Benjamin and Keenan (Benjamin & Keenan, 2006) utilised action research to implement problem-based learning within a ten credit final year engineering course. Over the course of three years they implemented, evaluated and improved on the use of problem based learning within an undergraduate course and compared results against the traditional mode of delivery. By using this
method the researchers were able to reflect on marks received each year and follow up on feedback from the students which took place with weekly feedback sessions with students.

In another study, a single cycle of action research was implemented to evaluate the implementation of computer technology within a mechanical engineering undergraduates course (Deliktas, 2011). A pilot course was implemented to evaluate initial concepts and elements of developed learning material enhanced using computer technology. This pilot course was then evaluated using an online quiz and web-based questionnaire. Results from this data were put forward as recommendations for future developments. Following a successful pilot course, the concept was implemented across further engineering modules within the faculty.

Another paper discussed the use of action research for implementing and evaluating an online course that was designed collaboratively between the University of Virginia and TU Dortmund University (Moore & May, 2012). An online course was created containing interactive teaching and learning material aimed to develop cultural competencies with students from both universities. Following the implementation of the course, student’s experiences and opinions were evaluated using virtual techniques such as online questionnaires and email feedback. Based on the results from the feedback, a further cycle of implementation and development were recommended to include student
revisions. Action research enabled an element of reflection on educational practices to further enhance and improve on pedagogies associated with Engineering Education.

Within action research other techniques and approaches can be used to further complement the research process including focus groups, surveys, observations and interviews. The next section will describe these approaches and identify practices seen using these techniques within Engineering Education.
3.3.2 Focus Groups

In addition to surveys, focus group methodology (also referred to as group interviews) is another popular choice in qualitative research and is a quick and effective way of collecting rich data from participants around a specific topic. This method of research mainly lends itself to qualitative research as it allows the researcher to gain opinions and thoughts around subject areas and expand where necessary. Traditionally focus groups are carried out in a physical location with a moderator and group of between six and twelve participants as recommended by Morgan (Morgan, 1998). This allows for enough variation in opinions and views but not enough that the comments are broad and not explored further.

Innovations in technologies and developments in broadband capability have also allowed focus groups to be facilitated online using closed discussion forums or chat rooms (Evans & Mathur, 2005).

Focus groups are advantageous for exploring participant’s knowledge and experiences and also allowing the justification of why they feel a given way towards a topic or question. Responses to questions or opinions can be further probed by the moderator to create deep rich dialogue between participants.

Following focus groups, researchers are able to draw out common themes and ideas based on the data gathered. Discussions can be focused around an area of interest and responses explored further by the moderator. Literature suggests...
that the most effective data gathered is via the discussion that is triggered among the participants themselves (Stewart & Shamdasani, 2014).

Within Engineering Education the use of focus group methodology is limited with many researchers preferring surveys to evaluate an experience or view which was referred to in Section 3.1.6.

When focus groups have been used within Engineering Education as part of the evaluation process, rich data was extracted and contributed to further developments within the studies. A good example of effective focus group valuation was found in the DIDET project (Breslin et al., 2007). This study was a collaboration of four UK – USA collaborations within the Joint Information Systems Committee (JISC) and the National Science Foundation’s (NSF) Digital Libraries in the Classroom Program which utilises Technology Enhanced Learning to facilitate teaching and learning within the project environment. The evaluation data gathered from the focus groups allowed the academic staff to continually evolve and develop the project to refine and improve the content in preparation for the subsequent years. This evaluation process was stated to have played an important part in the success of the project.

In another example Garcia and Liu (Pomales-García & Liu, 2007), used focus group methodologies to research views from undergraduate engineering students on perceived excellence in Engineering Education. During the focus groups the researchers used a combination of brainstorming icebreaking...
activities to promote discussion on the students. A further ten questions relating to perceived views of excellence in engineering were discussed. The study provided the researcher with evidence on what students felt Engineering Education should encompass and were able to make recommendations based on student data. The promotion of discussion that focus groups facilitate, allows participants complete freedom of their opinion and to also debate different viewpoints and justify reasoning. Other methodologies were in qualitative research don’t allow the synchronous flow of communication and information.

3.3.3 Surveys/Questionnaires

The most common methodology in Engineering Education research papers as discussed in previous sections is the use of surveys (Klotz et al., 2014; Sunthonkanokpong, 2011), also referred to as questionnaires. The increase of online technologies has made surveys an easy and accessible form of data collection for research (Evans & Mathur, 2005).

Surveys for both qualitative and quantitative research, are a popular choice of gaining data (Evans & Mathur, 2005). Question types in surveys allow variation and scope for a gathering unique or statistical data based on multiple choice responses. Whilst surveys are predominately used to gain quantitative data due to the ease of managing large responses, the use of surveys in qualitative
research is on the increase and is a powerful tool to gain rich data (Jansen, 2010).

Open ended questions in surveys create an opportunity for the exploration of the participant’s views on a particular topic or experience in a qualitative data collection. By limiting the response to a simple free text box, any bias towards an answer is avoided by the research allowing complete freedom and spontaneity (Reja, Manfreda, Hlebec & Vehovar, 2003).

The use of surveys within Engineering Education is said to be commonplace amongst researchers (Olds, Moskal & Miller, 2005) where educators predominately use surveys as a method of evaluating student satisfaction (Bourne, Harris & Mayadas, 2005; Crawley, 2002).

Sageev and Romanowski (Sageev & Romanowski, 2001), used surveys with their graduates to assess which current course had impacted on their industry based experiences. The survey used a combination of question types to gain a variety of key data and allowed the respondents to comment in allocated spaces.

A survey was used to gather data on the motivations of engineering students within Higher Education (Savage, Birch & Noussi, 2011). The survey used Likert scale questions to allow quantitative data to be collected and free text fields to allow the option of qualitative data to further complement the ratings on the Likert scale questions. The survey was used due to its scalability where they
were able to send the survey to over one thousand nine hundred students in Higher Education.

Close ended questions allow the research the ability to integrate quantitative data collection into the survey by limiting responses to a particular question. This can be helpful for gathering quick data on demographics or rating experiences and competencies within a chosen topic.

In another case study, surveys were used on an international level to assess engineering students knowledge about sustainable development (Azapagic, Perdan & Shallcross, 2005). The questions were multiple choice based and asked the students to evaluate their own knowledge of different topics. The question design allowed the researchers to gather quantitative data quickly and effectively on an international level. However, limitations in this question methodology did not allow the gathering of qualitative data to support choices and limited the responses the participant could make around a topic.

3.3.4 Observations Techniques

Participant observation is another popular method in qualitative research studies and allows the researcher to collect data from people and processes (Gill, Stewart, Treasure & Chadwick, 2008b). This type of data gathering can be effective for evidencing and describing how an existing situation is in a particular study.
In a case study discussed by Ebner and Holzinger (Ebner & Holzinger, 2007), used a combination of observation techniques and testing to understand the appropriateness and impact of the implementation of a series of learning objects created to support students in instructional design. Their observations allowed them to notice similarities between different student groups using their learning objects and how they interacted and use them within their learning. This data would not have been evaluated effectively by methodologies such as surveys or interviews. The observation approach allowed them to experience hands-on the impact of their work.

Despite their appropriateness to an experimental situation, observation research techniques are rarely utilised within Engineering Education research however, Olds, Moskal et al (Olds, Moskal & Miller, 2005), have identified observations as an effective way of measuring impacts of experimentation.

In another use of observation within Engineering Education, Laeser, Moskal et al (Laeser, Moskal, Knecht & Lasich, 2003), used this technique to observe team working interactions to further develop their graduate students. Results from the observations allowed them to understand areas in which student’s struggled to comprehend and were able to adapt training accordingly.

Leydens, Moskal et al discussed qualitative observation methods in assessing Engineering Education where educators are able to determine how students behave in a particular scenario and evaluate the impact of an implemented
activity (Leydens, Moskal & Pavelich, 2004). By using observations the researchers are able to gather first-hand information on how students interact with them a particular scenario.

Within Engineering Education observations were also used to compare engagement levels and learning retention between traditional lecture delivery and interactive lectures. Observers were placed in each lecture scenario and notes made on the student engagement and retention experience during the sessions (Van Dijk, Van Der Berg & Van Keulen, 2001).

As literature begins to increase in qualitative Engineering Education domains, recommendations on combining observational techniques other methodologies are beginning to emerge. In a paper by Carvalho and Williams (Carvalho & Williams, 2009), observation techniques were used in conjunction with a series of active learning activities to facilitate learning within the lecture classroom. They aimed to investigate whether observations could be used to measure learning activity within a traditional lecture scenario. Results from the study indicated that the approach proved successful particularly when embedded within an active learning methodology.

Another frequently used methodology within qualitative research techniques in engineering is interviews, which are discussed in the next segment.
3.3.5 Interviews

Interviews, along with focus groups are the most common methods on data gathering in qualitative research (Gill et al., 2008b). Along with surveys, interviews are a popular research technique within educational research (Olds, Moskal & Miller, 2005). Interviews tend to fall under the following three categories; structured, semi-structured and unstructured. Each of the categories has their place in qualitative research. Structured interviews consist of a series of predetermined questions with limited need to follow up.

Unstructured interviews have no preconceived ideas and concepts and tend to start with an open question such as defining an experience or opinion with further questions based on the participant’s response to the opening question.

Semi-structured interviews are a more popular choice of interview technique, several predefined key questions are asked to explore particular thoughts but also allow further probing in certain areas. These type of method is considered more flexible and a good method of gathering qualitative data for research (Gill et al., 2008b).

In Engineering Education research, interviews are used to gain qualitative data around experiences or opinions around an implementation of new methods in the curriculum. In 1997 Hadgraft used interview techniques to question his students on their experiences within the course and to gain feedback on what they felt was missing (Hadgraft, 1997).
More recently, Demian and Morrice (Demian & Morrice, 2012), used interviews on a small scale to question students on the use of virtual learning environment to further supplement quantitative data gathered using analytics within the virtual learning environment system. Even on a small scale of just two students, they were able to start building key themes and ideas around how students used the system and what further improvements could be made.

In another study Borrego used interview techniques to supplement literature reviews around Engineering Education research as a discipline. He interviewed leaders and authors to help determined and recommend key factors that should be taken into consideration for authors when attempting to submit literature to help shape the development of expertise of Engineering Education (Borrego, 2007). Interviews when combined with other techniques have been proven to be a very effective way of forming a good research picture.

3.3.6 Summary of methodology strategies in Engineering Education

This section explored different methodology techniques used within Engineering Education including focus groups, surveys, observations, interviews and action research methodologies.

The next area of work will justify and introduce the research tools used within this study.
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3.4 Research Tools Used and Why

In order to explore the implementation and effectiveness of an integrated blended learning approach utilising Technology Enhanced Learning in Engineering Education, a number of critical issues and factors need to be addressed and implications for change discussed. Engineering Education methods must be stronger aligned with educational research and pedagogy, a vision which Olds and Moskal (Olds, Moskal & Miller, 2005) discussed as being critical to future innovations in Engineering Education research.

As the field of Engineering Education research is still a relatively new and emerging field, exploration was needed to investigate the current perceived state of Engineering Education from the perspective of stakeholders who contribute to and are affected by engineering curriculum. Stakeholders such as students, industrial based professionals and engineering educators were included within the research to ensure representation of all fields of Engineering Education is considered to validate the data. Each stakeholder will be introduced during each phase of the research and its relationship within this study explored.

The next segment will describe the mixed methods approach used in this research before outlining the research roadmap containing the individual phases of the research and relationships among them.
3.4.1 Description of Mixed Methods in Relation to This Research

A combination of mixed research methods was used in this study, including observations, interviews, focus groups and surveys. Mixed research methods as defined in Section 3.2.3, is work using a combination of quantitative and qualitative research techniques and methods into a single study (Johnson & Onwuegbuzie, 2004). The mixed methods research was used within two cycles of action research to further complement and gather data that is rich in detail and knowledge.

Using this method encompasses the benefits of both qualitative and quantitative research to provide an informative and complete set of results. It follows guidance and recommendations from various researchers to conclude that by using this method, the data provided is more useful and relative in its content and the data outcomes are more suited to the work rather than following either qualitative or quantitative techniques individually (Johnson, Onwuegbuzie & Turner, 2007).

It has been argued that the choice of methodology should be driven by the research question rather than the subject, and that the use of mixed methodology research in Engineering Education should be further investigated over the next ten year to explore its potential (Borrego, Douglas & Amelink, 2009).
As discussed in Section 3.1, Engineering Education research discusses the use of various individual methodologies in either an experimental or descriptive study. However these techniques have limitations and various researchers conclude that one individual method would not have generated a complete picture of the research area or question. This rationale and process is recommended by Bryman and other social researchers (Bryman, Becker & Sempik, 2008; Teddlie & Tashakkori, 2003).

One hypothesis states (Case & Light, 2011),

‘by expanding our methodological range we might be able to expand the kinds of research questions that can be addressed in engineering education research’.

Mixed methods techniques are gaining in popularity among educational research (Creamer & Ghoston, 2013; Johnson & Onwuegbuzie, 2004), however within Engineering Education the literature available around mixed methodologies is limited (Matusovich et al., 2014).

A mixed methods approach will also provide guidance on its potential relevance and use in future Engineering Education work. Following on from the categorisation of engineering research methodology is discussed by Olds, Moskal et al (Olds, Moskal & Miller, 2005), this study utilises the effect of methodologies in both descriptive and experimental studies with an action research methodology framework.
The main body of this research is of a qualitative nature to fully explore views surrounding Engineering Education and to obtain thoughts and opinions from students, education practitioners and industry based professionals in architecture, design, construction and engineering.

Qualitative studies are open, exploratory and rich in data and description and most powerful when used in conjunction with quantitative analysis (Kelly & Bowe, 2011).

The lack of qualitative research in Engineering Education is noted in literature and some have speculated that this is due to the training of ‘traditional engineering educators’ being primarily in quantitative methods and would not have experience or understanding of qualitative research (Case & Light, 2011).

This research also however, used statistical quantitative data from the survey and the focus groups to compliment and expand and understanding of data gathered during the qualitative analysis.

This gives a clearer picture on the current state of Engineering Education from those directing involved in the field by being able to explore comments and statistical data gathered from multiple methods.

The next section outlines the individual tools and techniques used in the research.
3.5 Research Road Map

The three stages of the research are explained on how they contribute to the overall vision and context of the work. Figure 14 provides an overview of the three stages of the research and their relation to each other within the context of this work.

1. Preliminary Research Stage

2. Action Research Cycles

3. Industry Based Survey

1. Preliminary research – preliminary research took place in the form of observations and semi structured interviews to position the research in context to current Engineering Education literature. Observations of two undergraduate engineering modules were used to gather data on teaching and assessment practices. Semi structured interviews with teaching staff associated with engineering modules were interviewed to
compare findings against the observations and to reinforce findings discussed during the literature review.

2. **Action Research Cycles** - A two year cycle of action research within two cohorts of undergraduate engineering modules were implemented and embedded into the engineering curriculum. Additional research methodologies were used within the cycles to gain further qualitative and quantitative data using focus groups and student satisfaction and skills audit surveys. These methodologies will evaluate the implementation of new assessment techniques utilising Technology Enhanced Learning and form recommendations for subsequent years in the action research cycle. Cycle one included the introduction of alternative inclusive assessment using the creation and production of video assignments. Implementation and experiences were evaluated inside the cycles using focus groups and skills audit surveys. Cycle two refers to the implementation of the online resource toolkit prototype to support the video assignment used during cycle one. Further evaluation and experiences were discussed in the focus groups and summarising conjunction with the student satisfaction data.

3. **Industry based survey** – A web based survey reinforced viewpoints from industry based professionals and educators on issues and teaching limitations in Engineering Education. Relevant questions mirrored those
asked to the students during the focus groups carried out during the action research cycles to validate chosen techniques. Industry viewpoints obtained on key areas relating to this research will then form a comparison against student viewpoints gathered during the action research cycle stages.

Each individual stage of the research is explained in detail in the subsequent sections and relationship to the overall vision of the work is discussed.

### 3.5.1 Preliminary research

Preliminary research was undertaken to position the research and explore opportunities for case studies to use during the action research cycle of the study.

Observations were used in conjunction with semi structured interviews to baseline current pedagogic practices seen in undergraduate Engineering Education against reflections and studies in literature.

Data gathered from the preliminary research stages will form the aims and objectives of the following two research cycles.

The next section will introduce the use of observations within this study for the preliminary research stage.
3.5.1.1 Observations

The first methodology to be used within this research study is observation techniques. According to Leyden (Leydens, Moskal & Pavelich, 2004) observations give direct real time information on the behaviours of individuals or groups carrying out an activity. It allows the researcher to draw out information on key aspects relating to the research.

In this stage of the research the aim of observations was to examine specific instances in Engineering Education in context and test against the literature. This analysis was executed on four individual undergraduate modules.

The observations of these traditional engineering modules were used to baseline the research topic and identify the appropriate module(s) to use in the action research. As Kawulich described (Kawulich, 2005), many qualitative researchers recommend the use participant observation in conjunction with additional methodologies such as surveys, interviews etc.

Preliminary observations of traditional taught engineering methods were carried out to first form the baseline of the research. Two individual modules were observed and traditional methods of teaching and assessment were identified.

Both modules chosen for initial investigation had the following characteristics:

- large module cohorts
• contain practical elements and assessment
• contain timetabling concerns
• taught by more than one academic or technician

The next section will introduce the two modules used within the observations, MFMT101 and DSGN143.

3.5.1.1.1 Manufacture and Materials 1 (MFMT101)

Manufacture and Materials 1 (MFMT101) is a 20-credit module undertaken by first year engineering undergraduates. Assessment was made up of a 3-hour exam in the summer, which counts for 50% of the total mark and coursework which makes up the other 50% of assessment mark in the form of a laboratory report during the autumn term and a written assignment in the spring term.

The evaluation consisted of a series of observations including four independent laboratory observations carried out over a four-week period and observations of three lectures over a three-week period. A further analysis of the teaching and learning material, assessment practices and module information was carried out using the area of the module on the virtual learning environment system.

Lecture material and interaction on the virtual learning environment (Microsoft SharePoint) was also monitored to observe traditional teaching methods. Observations were carried out during the first semester running from September 2009 until February 2010.
This module had experienced an increase in class size for the teaching year 2009/2010 resulting in the scheduling of three additional laboratory classes in comparison to previous years with student numbers of nine or ten per group. Similar to the literature discussed in previous sections, the module has experienced large groups in laboratory classes due to timetabling and resource implications. This module was observed and followed over the first term to identify any potential problems and review how the module functioned with large class sizes in a practical engineering laboratory and lecture setting, and whether or not the experience mirrored the experience of students that was found in literature discussed in Chapter 2.4.

3.5.1.1.2 DSGN143

Integrated System Design (DSGN143) is a large first-year undergraduate engineering module which in its largest capacity has over 300+ students. At the time of the study the module cohort was approximately 220 students enrolled on the module. The module contains a strong element of interdisciplinary work and is predominantly based and assessed in groups. Similarly to MFMT101, this module experiences issues in delivering a learning experience to students due to timetabling, resources and physical space limitations.

Initial observations were carried out by attending the introductory lectures and reading lecture notes and presentations found on the virtual learning environment for the modules. Material and support resources were evaluated
and used to gather information on the way in which the module is delivered to students and identify concerns from academic staff.

Observations were carried out over two individual lectures and an observation of the students presenting their group work. Current assessment methods were observed to later form recommendations on the appropriateness of modules for the action research cycles.

The next section will outline the methods in the final element in the preliminary research stage consisting of a series of semi-structured interviews.
3.5.1.2 Interviews

To reinforce observations and validate existing Engineering Education research literature, interviews were carried out with teaching staff associated with engineering modules, particularly those with large groups in engineering. The observations discussed earlier in this section, will be complemented by targeting personnel who are directly involved with the module and similar engineering disciplines within the faculty. Where interview techniques have been used on Engineering Education as an singular method, results were limited in numbers and generalisations were difficult to make (Lindahl, 2006). Therefore, by using interviews as part of a series of methodologies, a greater spectrum of data was gathered in the appropriate environment.

Three individual interviews were carried out in relation to this study. Two interviews with academic members of staff within the engineering faculty were carried out using a set of semi-structured questions.

The third interview consisted of a semi-structured interview with an engineering technician who was involved with, and the lead, on the running of the practical engineering laboratory for one of the observed modules (Manufacture and Materials 1-MFMT101).

The interviews are specified further in this next section.
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3.5.1.2.1 Interview One - Engineering Academic

The first academic chosen had over thirty years’ experience practising Engineering Education and had frequent exposure to practical laboratories of students. This academic worked with engineering students, both undergraduate and postgraduate, however the nature of the questions were based around their experience with undergraduate engineering students. This chosen participant did not have any experience teaching distance learning in engineering but had vast experience of simulations and had shown an interest in exploring the use of technology to support and enhance their teaching.

3.5.1.2.2 Interview Two- Engineering Academic

The second academic interviewed had seventeen years’ experience working within Engineering Education both as a lecturer and as a demonstrator for engineering laboratories. Similar to the first academic they also had experience working with both undergraduate and postgraduate engineering students. The responses for this survey were based on their experience with undergraduate engineering students. They also had experience teaching in engineering courses online.

3.5.1.2.3 Interview Three - Engineering Technician

Interview three was carried out with a technician who had over thirty-five years’ experience working within practical laboratories, including twenty years inside the institution used in this research study.
They had been actively working in the laboratories at Plymouth University for twenty years and were present, and leading, laboratory sessions in each of the observations carried out for this module.

All interviews consisted of a series of semi-structured interview questions to allow the possibility for exploration.

When consent was given, the interviews were recorded and transcribed anonymously in line with University ethical clearance and procedure.

Questions used and the format of the interview are defined and justified in this next section.

**Background Introductory Questions**

1. How many years have you been involved in engineering laboratories?

2. Please give a brief introduction to your role within the engineering laboratories

Introductory questions we used as icebreakers to the interviews to allow participants time to relax and begin discussing their roles in engineering laboratories within the context of Engineering Education.

**Observations from Last Few Years**

3. What have been the changes in the last few years in providing practical engineering laboratories within the university?
4. In your opinion how do larger student group numbers affect the way laboratories are structured, for example the tensile test?

5. Have you ever had any distance learning students involved in engineering laboratories, if so how did the university facilitate this?

One of the key themes highlighted and discussed in previous Chapters 2.4.5, were issues surrounding practical engineering laboratories within Engineering Education. Literature reported concerns and difficulties from educators are providing the students a practical experience due to restrictions on time, space and funding limitations (Fabregas et al., 2011). Interview questions asked the participants to comment on their observations and views on providing a practical experience to students to compare to literature. Issues relating to large groups were also asked during this stage of the interview in order to investigate if participants viewed large groups as a problem in delivering laboratories.

One of the main laboratories used within the faculty for engineering is the tensile test. As this is a predominant laboratory within the majority of courses at the University, questions on its use were included in the interview along with views on virtual laboratories to later compare against views raised in literature.

Tensile Test Laboratory

6. How important is the use of this equipment/test in engineering laboratories?
7. If time could be freed up in the laboratory using the tensile test as an example (specific reference to the test used in MFMT101) how would you best use this time?

Virtual Laboratories

8. What are your views on the use of virtual laboratories in engineering?

9. Have you seen any simulations used in any engineering laboratories? If so how effective were they?

Interviewees were asked their opinions on the future delivery of the practical experience within engineering. Many literature reports speculate on the popularity and increase of technological alternatives such as remote laboratories. The respondents were asked questions around the future of engineering laboratories to gain qualitative data on their views and concerns.

Future of Engineering Laboratories

10. What role do you see new technology playing in the future of engineering laboratories?

11. Do you think we will see any changes in the way engineering laboratories are taught in the next five years?

3.5.1.2.4 Summary of proposed interview methodology

A series of three individual interviews were outlined and defined within the context of the research study. Justifications behind questions were described
and together with the observations discussed in Section 3.5.1.1 will form the recommendations that the choice of modules used within the action research cycles. Key themes and viewpoints will also be compared against literature and quantify during the discussions section in Chapter 7.

3.5.1.3 Summary of proposed preliminary research methodology

In this section the preliminary research methodologies were detailed contextualised within this research study. This stage of the research will gather baseline data using interview and observation techniques. Data gathered during this will be combined together with information identified during the literature review to position the research against current engineering literature and form recommendations and guidelines for the action research cycles discussed in the next section.
3.5.2 Action Research - Implementation of Technology Enhanced Learning In Engineering Education

A two year cycle of action research within a cohort of two undergraduate engineering modules was implemented and embedded into the module curriculum. Additional techniques were used inside the action research cycles to gain further qualitative and quantitative data via a survey and five individual focus groups.
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Figure 15: Action research cycles
Action research, whilst underrepresented in Engineering Education, has the potential to be an effective methodology for the discipline (Case & Light, 2011). Its use within this study will be to evaluate the implementation of new assessment techniques utilising Technology Enhanced Learning within two undergraduate engineering modules and two individual cohort years.

Following on from observations carried out in the preliminary stages of this research study the following two modules were chosen to take forward and implement a two year cycle of action research. A visual representation of the approach is shown in Figure 15.

The first cohort contained approximately two hundred and twenty first year engineering students enrolled in a module entitled ‘Integrated System Design’. The module document report can be found in Appendix 9.1.

The second cohort consisted of approximately one hundred and ten masters level undergraduate engineering students enrolled on a project module titled ‘Interdisciplinary Design Project’. The module document report can be found in Appendix 9.2.

The modules were chosen due to their interdisciplinary approach inside the module curriculum. Both the first year and the master level modules contained strong elements of project interdisciplinary work.
The first year module had been observed during the preliminary stages of the research and the Masters level interdisciplinary design project (IDDP) consisted of two modules joined together which for the remainder of this thesis will be referred to as IDDP.

The students inside both these modules were split into groups of approximately five to six participants and given a real world design solution/case study to work through collectively as a group in a project-based scenario. This encompasses the key principles of project based learning as outlined by Chandrasekaran, Stojcevski et al (Chandrasekaran et al., 2012) in the beginning of this chapter.

Each of the principles recommended by Chandrasekaran, Stojcevski et al are highlighted in bold below and the appropriateness of the chosen modules identified for each principle:

‘Students work together in groups and collaborate on project activities’ - The students are split into interdisciplinary (students from across different courses such as mechanical and civil engineering) groups by the lecturer and amongst the groups roles were allocated such as project lead.

‘A real world problem that affects the life of the students is presented for investigation’ – Once the groups were allocated the students chose a design case study to work on and produce a set of assessable learning outcomes defined against the minimum content set by the Lecturer.
‘Students discuss findings and consult their teacher for guidance input and feedback’ - Students had various milestones in terms of assessment and had regular meetings with their lecturers to discuss their work for continual feedback.

‘The maturity level of student skills determines the degree of guidance provided by the teacher’ – The level of assessment and direction from the lecturer was dependent on the stage of the student. The first year students had more guidance and input from their academics in comparison to the final year students. The final year students were expected to engage with industry professionals to validate their concept design and results.

‘Final products resulting from project based learning can be shared with the community at large, thus fostering ownership and responsible citizenship in addressing real-world problems’ - Both modules were chosen not only for the interdisciplinary project design approach, but also due to the open day that was carried out each year where the students could present their work and findings to invited members of the public and from industry professionals.
3.5.2.1 Action Research Cycle One - Implementation of video assessment

Traditionally both of the modules required the students to present their interim research findings and work on their chosen case study towards the end of term one (December time). This consisted of the students mirroring traditional assessment criteria reviewed during the observation period in Chapter 3.5.1.1, by presenting to their peers and their lecturers inside a large lecture classroom.

Reflecting what has been consistently referenced in literature, this traditional method has become problematic due to finding a physical teaching space large enough to cater for two hundred plus students and allowing for timetabling issues.

As suggested by Olds, Moskal et al (Olds, Moskal & Miller, 2005), and Engineering Education will only progress if the assessment is pedagogically appropriate and of high quality. If assessments are ineffective, student motivation and staff attitude will suffer and hinder progression of Engineering Education.

An illustrative diagram of the first cycle of action research implemented in this study is shown in Figure 16 and individually broken down and explained in the following section.
Figure 16: Action research cycle one
3.5.2.1.1 Planning activities – observation of traditional assessment

Planning activities in the action research phase used a combination of the observations carried out in the preliminary stage of the research discussed in Section 3.5.1 and the specification of alternative assessment methods to enhance practices within the module.

It was identified during the initial research that a combination of both large student groups and traditional assessment methods hinder creative process and understanding. Limitations of physical group presentations took valuable time and resource from an already highly structured module timetable.

Further investigations observed that traditional presentation delivery methods using Microsoft PowerPoint, hindered creativity and students found it was difficult to portray their design concepts ideology and work due to using a limited linear technology.

By observing how students traditionally delivered their presentations, key observations and recommendations were formed to specify an alternative assessment mode that would encompass some of the soft skills that engineers must have when they enter the workplace (Rao, 2014).

The specification of the alternative assessment is discussed in the next section.
3.5.2.1.2 Planning activities – specify alternative assessment methods

Based on preliminary observation results, an alternative method of assessment was created to replace the physical presentation model by means of a video assessment that the students have to create and produce themselves.

A consultation took place with the module leader of both DSGN143 and IDDP on the appropriateness of specifying an alternative method of assessment. The module leader had strong industry links and was open and keen to pilot a new form of assessment. Following the consultation, video assessment was specified and the introduction of support purely online using Technology Enhanced Learning was embedded into the curriculums to support students in the creation of the video.

The criterion for the video for both the first and the final year students was as follows;

“The purpose of the Marketing Video is to sell your Business Plan to potential investors to convince them that:

- you have a project that they should invest in so that they will recognise that you have an innovative and deliverable proposal to receive a suitable return on their investment
- Fund you to move forward with the build phase of your proposal.

Your company has:

- The detailed understanding of the project
- A capability to act as a consultant during the implementation of the project.”

Within this assessment students had complete creative freedom of software and formatting options. Students were also made aware that the assessment is
predominantly based on the content of the video and not the professional standard of the video. This mode of inclusive assessment allows students flexibility in their delivery of content for the project.

Video is increasingly being used within teaching and learning to enhance and supplement teaching and learning practices. Within the literature identified in Section 2.5.2, video is being used in multiple ways including:

- use of video to provide feedback for students (Crook et al., 2012)
- use of video to enhance and contextualise learning (Mitra et al., 2010)
- use of videos as case study’s (Malon, Cortes & Greisen, 2014)
- use of video for assessment (Gama & Barroso, 2013)

The use of video assessment within education is becoming more prevalent as access to technology grows to both students and teaching staff. As educators look for more innovative and engaging ways of assessing students, video assessment has been identified as an effective way of understanding students learning process within a certain topic.

Gama and Barroso recently used video as a formative assessment for high school physics teachers to gain information on where learning is successful or failing (Gama & Barroso, 2013). In this study students were asked to produce short videos of themes and topics they had learned during the term which would later be presented to their peers. Academics involved in this study found that the videos identified elements of student difficulties that were traditionally
not picked up in the former form of assessment such as tests and questionnaires. They also found that students took considerable care and attention in the production of the videos which resulted in high quality video production and understanding of the learning process.

In a medical study, this technique was used to investigate the appropriateness of using video assessment in evaluating ENT surgical procedures in trainee surgeons (Bowles, Harries, Young, Das, Saunders & Fleming, 2014). In a trial study, educators investigated whether or not the technical skills of ENT surgeons could be assessed using a video method rather than traditional observation methods. In total thirty procedures were evaluated using this method and results found that this method would benefit the technical education assessment methods used within surgical procedures.

Another medical case study discussed the effectiveness of using video assessment for self-reflection and evaluation in clinical skill performance with medical students (Maloney, Storr, Morgan & Ilic, 2013). Half of the control group used within this study were taught using traditional methods and half carried out a video assessment task to aid reflection in their performance. Students who carried out the video self-reflection task scored higher than students who followed the traditional assessment route. The researchers found that students’ confidence was increased as a result of the assessment and were able to reflect more critically on their skills and learning abilities. Students felt
that the use of video assessment promoted effective educational values, particularly when combined with traditional methods as an enhancement to their practice.

In Engineering Education literature, there is little evidence of videos being used in an assessment despite its proven effectiveness in other disciplines such as medicine and science (Bowles et al., 2014; Gama & Barroso, 2013; Maloney et al., 2013).

The implementation of the video assessment will evaluate its effectiveness within Engineering Education discipline and compare results from the traditional assessment methods.

The next section will introduce how the video assessment was implemented to the students.

3.5.2.1.3 Acting methods – implementation of video assessment

To implement the video assessment, various techniques and methods of delivery were used to support and inform the students of the assessment.

A lecture was given by the module leader outlining the pedagogic reasoning behind the choice of assessment and how this will impact on the students learning.
The virtual learning environment system at the time of this stage of the research was based on Microsoft SharePoint technology. The assessment criterion was uploaded to the virtual learning environment and an announcement placed on the front of the module page. Additional emails were sent to the students along with a reminder during the group meetings with the module leader.

To support the students initially, a support site was set up specifically dedicated to assisting students with the tasks within the module including the video assessment.

The site was directly linked to the student’s module page on their virtual learning environment and contained a series of pages related to activities on the module. The video assessment had a section containing a series of links to existing material relating to software such as Windows live movie maker and iMovie as well as embedding video tutorials specifically created for this module.

A skills audit which is described in Section 3.5.2.1.5, evaluated the students experience with video creation and production in order to further support and assist the students. The support materials were adapted based on the results from this audit.

An additional workshop was set up for the students with one of the technicians in the library who work within the video editing suite. At the time of implementation, their video suite consisted of a series of four computers equipped with Adobe Premiere Pro software.
The workshop was available to students who would be responsible for the video assessment. The aim of the workshop was to support students in the production and editing of their film and advice on exporting their video into a format in which it could be submitted.

A series of guides were also put together to advise students on how they would be uploading their final video to the University’s video repository.

3.5.2.1.4 Acting methods – adapting support material

Existing support materials were adapted and expanded upon based on results gathered from the skills audit which was given to the students at the beginning of the term.

Deficiencies in skills were identified as well as equipment access. Support resources and guides were created to supplement gaps in knowledge identified as a result of the skills audit. Limited access to equipment was identified and access to video equipment made available to students.

The next section will expand on the skills audit used to gather this information.

3.5.2.1.5 Evaluation activities – skills audit

The assessment will be evaluated during the action research cycle, discussed later in this chapter, to interpret the data and work from the students to baseline this method of assessment against traditional methods discussed in the preliminary research stage in Chapter 4.
A non-compulsory audit by means of a survey was carried out to first evaluate and assess the student’s digital literacy skills relating to video creation and production. A simple online survey embedded into the students virtual learning environment was created asking them a series of questions relating to their experience of using and creating videos, access to equipment and general confidence in creating media for videos. The audit was emailed to the students after the groups had been selected in order to pre-empt any support issues that would be needed to allow the students to create their videos.

As discussed in previous Chapter 2.5.9, there is an abundance of literature around the topic of digital literacy (Ibrahim, Shariman & Woods, 2013; Santos, Azevedo & Pedro, 2013). The aim of this simple survey was not only to support the students, but to compare speculated digital literacy and capability among students to that of literature and reflect on the assumptions made on digital literacy (Bennett, Maton & Kervin, 2008; Jones et al., 2010b; Santos, Azevedo & Pedro, 2013).
3.5.2.1.6 Evaluation activities - Focus Group Techniques

A series of five focus groups was carried out during the period of the two year action research cycle. Students were approached by email to volunteer to take part in the focus groups and participation was agreed on a first-come first-served basis. All focus groups were carried out and planned with full University ethical clearance seen in Appendix 9.3, and students were informed that responses to any questions were non-compulsory and they could contribute as much or as little as they wanted.

All five of the focus groups were fully transcribed and analysed using manual and electronic coding methods. Initially the transcriptions were printed and handwritten notes and key points were highlighted. The transcripts were then entered and again manually coded using Qualitative Research Data Analysis Software (QDAS) NVivo 10. In this research study the use of NVivo will predominantly act as a data management tool for handling the evaluation of the focus groups. Nodes were created within NVivo to identify common themes, terminologies, topics and questions.

During the first cycle of action research, two focus groups were initially carried out to obtain the students views and opinions on a variety of areas relevant to the research including;

- views on the topic of engineering design concept skills including what the student thought that that entailed
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- reflections and thoughts on their work on the interdisciplinary project
- opinions on the use of computer aided design (CAD) and virtual reality (VR) within the context of engineering
- views and comments on their experience of Engineering Education and how they see this changing in the future
- their thoughts on how technology may impact on working practices in Engineering Education in the next ten years
- feedback and evaluation on the video project and what, if anything, the students felt would have helped them in the process
- feedback and comments into a proposed ‘Toolkit’ prototype to support the students in both the module and the video assessment activity

Students were also given the option to follow up the focus group with any additional comments by email of which one or two participants made use of.

Focus group one was carried out in April 2013 and consisted of nine first-year undergraduate engineering students who had just completed the module DSGN143 with video assessment.

Questions for both focus groups for cycle one of the action research were developed and designed and based around recommendation from researchers in qualitative research for gathering data from focus groups (Gill et al., 2008b; Stewart & Shamdasani, 2014). The question design incorporated different question types recommended for using in focus groups as stated by Krueger and
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Casey (Krueger & Casey, 2002) including; opening questions, introductory questions, transition questions, key questions and ending questions

Questions used for both focus group one and focus group two were defined as follows:

1. Please read the quote in front of you and begin discussions of your opinions on this quote.

   The following quote was given to students to act as an opening question and an icebreaker to engage discussion.

   “Today’s engineering students are proficient in detailed design tools but lacking in conceptual design and ideation” (Taborda, Chandrasegaran, Kisselburgh, Reid & Ramani, 2012).

   Giving the students a quote at the beginning of the focus group provides a baseline of discussion to lead up to the key areas of conversation. The quote was deliberately open-ended to avoid a simple yes or no answer.

   The quote was chosen as its controversial statement is one that is reflected in several pieces of literature (Buchal, 2011) and one that’s exploration would be beneficial in evidencing and comparing views from the students themselves. Students’ ability to conceptualise their learning has come into discussion frequently in both engineering and architecture literature in recent years. It has been argued that the evolvement of technology in computer aided design (CAD) software has produced a group of students who are proficient in using software but have limited
skills on the logic behind the design concept (Daud, Taib & Shariffudin, 2012; Ye, Peng, Chen & Cai, 2004) and this question would reflect the students stance on this.

2. What is your understanding of the term engineering design concept skills?

As discussed earlier in this chapter, discussions around the appropriateness and relevance of design skills in engineering has become a hot topic in recent years. Students’ interpretation of this terminology was sought after to allow comparison between the definitions used in many literatures and to explore students understanding of the design concept process and skills.

3. I’d like you to think about your work on the interdisciplinary design project from the initial concept through to what you have accomplished in the last week i.e. the final design concept video.

a. Which parts have you particularly enjoyed?

b. Which did you perhaps find more challenging?

Interdisciplinary design work within Engineering Education is argued to be an effective way of representing activities and tasks carried out by engineers in the workplace (Allie et al., 2009). By asking the students to reflect on their experiences during their interdisciplinary work and
project, evaluated the effectiveness and challenges faced with this method in Engineering Education.

4. **How useful are VR walkthroughs in assisting with the design concept process for engineering designs i.e. building projects and plans?**
The use of virtual reality (VR) in Engineering Education, particularly in relation to design, has been steadily increasing over the last few years. This question aimed to explore student’s perceptions on the relevance of VR walk-throughs within the context of the design concept. During the initial observations of this module in Section 3.5.1.1.2, students had to create a computer model and VR walk-through of their design.

5. **What do you feel gives a proper understanding of the design of a building/project... a physical model, a VR walkthrough or a combination of both? And discuss your answers.**
This question followed on from the usefulness of VR walk-throughs in assisting with the design concept process. The same question was asked to professionals in the industry based survey in order to compare both the student and industry views.
6. If you could have had anything to assist you with understanding the concepts and processes behind the ‘Design concept’ what may have been helpful to you?

To assist in the process of evaluation during the action research cycle the students were asked if they felt anything was missing that could have helped them understand concepts and processes behind the work carried out under the design concept brief.

7. What elements of the teaching of engineering that you have experienced have you preferred?

The students were asked to reflect on their experiences of teaching as a whole including modules outside of the modules used inside of this study. There is much literature on student’s preferring certain modes of course delivery (Fernandes, Flores & Lima, 2012) and this question was designed to compare and contrast the responses from the students to views found in literature.

8. How do you see the teaching of engineering changing in the future?

This key question aimed to obtain the students view of how they saw the teaching of Engineering Education changing in the future, if at all. The
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future of Engineering Education has been quoted as needing change and a shift in practices to be able to meet professional expectations (Arlett et al., 2010b; Kirschenman, 2011). Whilst there is much literature on the perceived views of the direction of Engineering Education by both educators and industry based professionals, little research exists on the views from the students themselves. By asking this question the data was then compared to the same question used in the industry based survey to look for any similarities or differing opinions. When appropriate, the question was further probed and asked the students how they would like to see it change in order to compare against the same question that was asked to professionals in the industry based survey.

9. If an online toolkit was developed to help you understand the processes behind design concepts, what would be useful to have included?

As the use of Technology Enhanced Learning is seen as a beneficial way of enhancing teaching practices (Beetham & Sharpe, 2013; Johnson et al., 2013) students were asked to give their views on what would be helpful to supplement the learning and support required under the design concept video assessment. This question helped form the justification behind the design and content of the toolkits described in cycle two in
10. Would you look to use this toolkit via mobile access?
   
a. Do you think you would use it much that way?

   b. What benefits would you see from mobile access?

This question was asked in order to understand how important it is to students that a learning resource should work seamlessly on a mobile device as well as a PC/Mac. As literature suggests the behaviour of students, particularly in reference to the learning methods of students now entering Higher Education is changing this question sought to explore these speculations and understand the students use their own devices in this manner.

11. How do you think technology will impact on working practices in engineering over the next 10 years?

The impact of technology in engineering practice has been well documented over the last few years (Breslin et al., 2007). Many researchers have formed different views on how technology could impact on working practices in engineering over the next ten years (Froyd, Wankat & Smith, 2012) and various hypotheses have been debated. This question was asked to both the focus groups and the industry based survey in order to compare views of the students and
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those working within engineering and education. This question aims to
gather exploratory data and opinions around a prevalent topic in
Engineering Education.

12. Is there anything else you feel is relevant to add in, any further
questions to ask?

This question acted as a closing question and gave the students the
ability to add in additional comments or questions that they felt were
relevant to the research as recommended by various qualitative
researchers (Bryman, 2012; Krueger & Casey, 2002; Silverman, 2013).

Focus group two was carried out again in April 2013 and consisted of ten final
year undergraduate engineering students who had just undertaken the
interdisciplinary design project module with video assessment. The questions
mirrored those used in focus group one, however slight variation occurred as a
result of some of the students responses to allow further exploration of points
and comments.

To gain additional quantitative data, a small student satisfaction evaluation
survey was carried out prior to the focus groups which are discussed in the next
section.
3.5.2.2 Action Research Cycle Two - Implementation of Online Toolkit Prototype

Cycle two of the action research was carried out in the following academic year of 2013/2014. Figure 17 illustrates the cycle of activities carried out during this stage.

The skills audit survey was once again introduced before the students carried out the video assessment exercise. The platform of delivery did however change and the survey was linked to from the new toolkit as a way of getting students to engage with the toolkit.

The next section will specify the planning activity which specifies the toolkit prototypes.

![Figure 17: Action research cycle two](image-url)
3.5.2.2.1 Planning activities - Specify Prototype Resource Toolkit

Following on from the evaluation and feedback from cycle one, two prototype ‘toolkits’ of resources were created using Xerte Online Toolkits (XOT) to support the students on the interdisciplinary work on the module and the video assessment work.

Xerte Online Toolkits (XOT) is an open source application that is used to build and publish web-based interactive e-learning objects. Learning objects can consist of a variety of interactive pages created from pre-defined templates. Learning objects can be exported into stand-alone applications or embedded into webpages. More recent versions of Xerte Online Toolkits allow the finished work to be published in an HTML 5 format allowing the content to be readable and viewable on mobile platforms and devices, including Android, iPads and BlackBerry devices. An additional and vital benefit of using this platform is the accessibility features inbuilt which allow the end-user to specify their own font, letter size, contrast and also provide narrations and screen reading capabilities.

Xerte Online Toolkits (XOT) are already in use in many institutions and organisations all over the world and successful implementation of these are beginning to emerge in literature (Awad, Venkatesan, Roberts, Keating & Myles, 2013; Dickinson, Kane-Iturrioz & Idea).
Structure and content of the toolkits was developed as a result of the direct feedback from focus groups carried out in cycle one of the action research and also from discussions from the module leader on both the first and final year module cohorts.

Two toolkits were created to simplify the process for the students and to ensure the information is an overloaded and confusing to the end-user. Both the toolkits aimed to provide the latest and most comprehensive set of support materials containing materials, construction, advice and examples to benefit the production of the student videos.

The first toolkit shown in Figure 18, was referred to as the ‘Video Production Resource’ and contained a set of eight interactive support pages.

![Video Production Resource](image)

**Figure 18: Video production resource toolkit**
1. **Introduction to the Resource** - introduced the concept and reasoning behind the toolkits and provided initial guidance on the students on how to use the resource.

2. **Design Concept Video** - a twelve minute video was created and embedded as part of the toolkit. The video provided background to the pedagogy behind the use of videos within the student’s studies and provided them with key information to enable them to produce their own video with appropriate content. It also discussed the framework behind the design project, the importance of the design concept video and what the students need to include in it content wise in order for them to achieve the key learning outcomes. Resources included inside of the toolkits were discussed along with the relevant to the assessment. A full transcript of the video was made available on request.

3. **Project Concept Diagram** - an interactive hotspot chart showing the pathway and module timeline was created. Students could click on any of the module milestones such as ‘project selection’ and find further information and guidance on what the student should be both working on and understanding at this point. This was based on feedback from the students during cycle one that they often felt lost and unsure of what they should be doing at certain points during the module due to the amount of assessment that took place. Creating a resource that allowed
them to refer back and familiarise themselves with assessment criteria and milestones was a popular request from the students.

4. **Skills Audit** – the online skill survey (traditionally held inside the virtual learning environment) was embedded inside the toolkit in order to engage learners with the toolkit. The skills audit survey helped to gauge what support was required from the video concept project and allowed support materials to be adapted if necessary.

5. **Help in Using the Toolkit** - no prior knowledge was assumed in relation to the ease of use and navigation of the toolkits. A series of help files, including a tree navigation view of the toolkit, was created to show students how to navigate the toolkits and more importantly what the toolkits contained in terms of help resources.

6. **Structure Your Video Project** - contains advice and guidance on structuring the video project including; recommendations on storyboarding to allow students to properly plan their video work and for understanding the requirements in creating clear definitions in the work needed in the design brief and referred back to recommendations documented in The Royal Academy of Engineering’s ‘Creating Systems That Work’. Industry based standards were introduced as a recommendation due to feedback from students in cycle one that there was little contextualisation to working based practices in their learning.
7. **Previous Video Examples** - six video examples of students work from 2012/2013 were included and a brief summary included by the module leader on why design concept videos scored highly in the assessment. The inclusion of these videos came from feedback during focus groups carried out during cycle one as students felt they had nothing to go on and would have liked to have seen some previous examples.

8. **Video Support Materials Resource** - this last page introduced the second toolkit titled ‘Video Support Materials Resource’ and explained what was in the content of the toolkit and its relevance to the students.

The second toolkit shown in Figure 19 was referred to as the ‘Video Support Materials Resource’ and contained a set of fifteen support pages.
1. **AutoCAD Support** - contained a list of support resources and materials on how to use AutoCAD. This piece of software is used extensively within both these modules and student feedback from the focus group during cycle one demonstrated that students were not aware on how to obtain the software, who to go to for support and how to do some simple exercises. This page including information on how the students could contact and find the AutoCAD technician in the university that is dedicated to supporting students. It also provided some basic information on what the software does and linked to a dedicated module on the virtual learning environment containing a series of self-directed learning tutorials and videos.

2. **Solidworks Support** - students within both of these modules are exposed to Solidworks from the first year. It is a series of 3-D software tools that allow students to create, simulate, publish and manage their data and is used in conjunction with a variety of other engineering based tools to help students achieve a concept design. Similarly to the AutoCAD page, this provided students with a list of resources, self-directed tutorials, how to access the software and most importantly who the dedicated to a technician is in supporting them. The majority of students from cycle ones focus groups were not aware that there was access to a dedicated person. In addition, module feedback presented from the 2012/2013
cohort demonstrated that students would have liked to have had the option of attending a drop-in workshop session or having access to a person rather than just an email address.

3. **Revit Support** – Autodesk® Revit® is a piece of software that is relatively new in terms of its implementation into the engineering curriculum. This software was specifically built for Building Information Modelling (BIM) which is becoming more prevalent in the engineering and construction industry. As discussed earlier in Section 3.1.3 the move to standardise all government based building frameworks using the Building Information Modelling (BIM) by 2016 (HM Government - Department for Business, 2012) has been met cautiously by industry practices but is yet to be fully embedded and introduced in the majority of Engineering Education curriculum (Pikas, Sacks & Hazzan, 2013). As a result of this, an optional workshop was offered to the students by the dedicated technician and a comprehensive set of online resources was embedded into the toolkit for the students.

4. **Windows Live Movie Maker** - this freely available software was introduced to the toolkit due to its accessibility and ease-of-use. A series of guides and video tutorials were created for the students to enable them to create a multimedia video in which they could embed and utilise other forms of media such as audio clips, images and virtual reality (VR) walk-throughs. Feedback from the focus groups during cycle one
indicated a preference from the students that they would like recommendation on one piece of software from both a PC and Mac perspective that they could use to create their project without previous knowledge or experience. The simplicity and free access of this software was an appropriate choice for the PC-based recommendation. In addition, this software was installed on all of their university fleet machines on campus in both laboratories and open teaching computer spaces and did not rely or speculate on students using their own machines.

5. **Final Cut Pro** - this software, along with iMovie, were the video editing software recommendation for students that used Macs and Apple-based products. As mentioned earlier, students from cycle one of the action research discussed the need for a recommendation for a single video editing software package. Due to software licensing in the University, a combination of Final Cut Pro and iMovie were both recommended based on the accessibility of this software in the Apple MAC open access computing areas. Students who used Macs at home would have access to either iMovie or Final Cut Pro. Recommendations and tutorials were linked to from this resource page.

6. **iMovie** - similar to Final Cut Pro, this page outlined tutorials and links to how students can use this software to produce their video project.
7. **Adobe Premiere Support** – for students who had experience using video editing software before, a more sophisticated and involved piece of software was recommended. Adobe Premiere Pro is available on both PC and MAC platforms and links to resources and a link to a free thirty day trial was included on the results page in the toolkit. In addition to this, students were made aware of a video editing room on campus that they could book out and used to create their videos. This facility also came with a dedicated technician on hand at all times of which several students utilised.

8. **Where to Book Equipment** – literature suggests (Miller, Voas & Hurlburt, 2012) that students may have access to their own equipment and many are part of the phenomena of ‘bring your own device (BYOD)’ (Thomson, 2012), however arguments have also shown that we should not speculate on technology if it could impact on the students assessment or learning outcome. In order to pre-empt any disadvantage that a student might not have access to any video or audio equipment, a list of available places on campus that students could book out equipment was listed.

9. **Specialist Software Location and PC Access** – due to feedback from the students involved in the focus groups in cycle one, a page in the toolkit was dedicated to listing all of the available software that the students could potentially use within the project and where they are installed on campus in terms of teaching rooms and computing labs. Students from
previous years were often unaware that software was pre-installed and available to use in certain rooms on campus. Previously, the students had had to source the software elsewhere which was deemed as being incredibly frustrating to the majority of students. A list of the software and its location was sourced from the University’s Technology Information Services (TIS) and embedded into the toolkit. In addition to software, students also fed back that they did not have access to powerful enough machines that could render their virtual reality (VR) or AutoCAD models. A meeting with the business partner for the faculty led to the introduction of six additional powerful high spec rendering machines that the students could utilise. Their location was also listed in the toolkit for ease-of-use.

10. **Managing Time Effectively** – the students undertaking these modules were given additional support and recommendations on how they could manage their time effectively. The submission deadlines for the video project corresponded with other assessments and exams in their courses. Students in the focus groups felt at times overwhelmed with the amount of work they had to juggle and so guidance was put together to help support them in this.

11. **Online Storage and Collaboration** – during cycle one of the action research students fed back about the issues with collaboration with their team members having different timetables to themselves. In order to
support the students a number of online storage recommendations were listed and guidance provided on how the students could use this when working in their interdisciplinary groups. A variety was listed to ensure cross-platform fairness and availability.

12. **Video Conversion** – part of the feedback from both the academic module leader and the students themselves during cycle one of the action research discussed the issues of video conversion in terms of their AutoCAD models and other multimedia. Recommendations were put forward and listed on freely available software for both the PC and for the Mac on how to convert video types.

13. **Do’s and Don’ts of Filming** – feedback from the academic module leader and the students discussed the quality and sound issues of some of the produced videos. As a result of this, a series of key points on factors to take into consideration when creating a video was listed including resources on lighting, audio, voice-overs and the importance of backing up their work.

14. **Video Production Resource** - the last page in the toolkit provided a link back to the first Video Production Resource toolkit.

Both toolkits were designed and developed to allow use from the slowest of Internet connections. An off-line version of the toolkit was offered to the
students should they need it which was tested in an off-line environment on a PC.

3.5.2.2.2 Acting methods – implementation of the prototype toolkit

To introduce the toolkit to the students, two brief individual lectures were given to both cohorts of students. The lecture introduced, and took the students through both of the toolkits and explained the rationale behind them. As both toolkits were exported in an HTML 5 version, students were encouraged to access the toolkits during the lecture.

An alternative introduction was also provided to the students by email for those that were unable to attend the lecture. A permanent link to both the toolkits was also embedded into the student’s virtual learning environment.

3.5.2.2.3 Evaluation activities - Focus Groups

After the implementation of the prototype resource toolkit, the effectiveness and process of students using this had to be validated. A further three focus groups were planned to obtain the students views and opinions on a variety of areas relevant to the research, repeating some general questions used in the first cycle of focus groups in the action research and focusing in on the reflection and evaluation of the new toolkit prototype developed as a result of the first cycle of action research discussed in Section 3.5.2.1.

Topics of discussion in the focus group included;
• Views on the topic of engineering design concept skills including what the student thought that that entailed. This also included views on whose responsibility it is for the design of a project.

• Reflections and thoughts on their work on the interdisciplinary project

• Opinions on the use of computer aided design (CAD) and virtual reality (VR) within the context of engineering

• Views and comments on their experience of Engineering Education and how they see this changing in the future

• Thoughts on how technology may impact on working practices in Engineering Education in the next ten years

• Feedback and evaluation on the video project and what, if anything, the students felt would have helped them in the process

• Justification of their choice of delivery of the video work and whether they used a simple PowerPoint video conversion or whether they embraced less traditional methods utilising multimedia.

• Feedback and comments regarding the use of the prototype ‘Toolkit’ developed as a result of the first cycle of research and what if anything they felt was missing.

• Discussions around digital literacy and in particular its relevance in the field of engineering
Students were once again given the option to follow up the focus group with any additional comments by email of which one or two participants made use of. The first focus group methodologies to be discussed within this action research cycle will be focus group three.

3.5.2.2.3.1 Focus group three

Focus group three was carried out in January 2014 and consisted of four first-year undergraduate engineering students. The students had recently completed their video assessment and were the first cohort to use the integrated video resource toolkits which takes part in cycle two of the action research.

1. **Give the students the quote and ask them to discuss?**

   “Today’s engineering students are proficient in detailed design tools but lacking in conceptual design and ideation”.

   The same question was given to both the industry based survey and to the focus groups during cycle one for the same reasons previously discussed in the other focus group methodologies. This provides a greater amount of data to explore.

2. **What is your understanding of the term engineering design concept skills?**
This question had been repeated during cycle one of the action research focus groups and also in the industry based survey. Again, its duplication was in order to gather a greater set of qualitative data to explore.

3. **Do you believe it is the job of an engineer to understand and work through a design concept for a project, or do you believe that responsibility would lay with another role for example an architect?**

This question was added in during the second cycle of action research following on from responses in focus group one and two. Some students believed it was not the job of an engineer to be creative which contradicts literature arguing that engineers should have design skills (May & Strong, 2011). This question was included to explore these views and to find out what role the students felt the engineer has during a design process.

4. **How useful are virtual reality (VR) walkthroughs in assisting with the design concept process for engineering designs i.e. building projects?**

   a. **What do you feel gives a proper understanding of the design of a building/project... a physical model, a virtual reality (VR) walkthrough or a combination of both?**

This question, similar to the first three questions, was repeated again during this cycle to compliment and expand to the data gathered during
the focus groups during cycle one. It was also compared to professional responses gathered using the industry based survey.

5. Thinking back to the work that you have just recently done with your design concept video
   a. What part of that did you particularly enjoy?
   b. Which parts did you find more challenging?

Student’s reflection was again required to gather views and opinions on their experiences whilst undertaking the two modules including the design concept video. A comparison between the responses from this focus group and from the focus groups gathered during cycle one was analysed to see if any changes made during the second cycle of action research affected student’s attitudes.

6. Did you create a PowerPoint video or did you create a video using other multimedia methods?
   a. Why did you choose that method?

Students had full control over what platform they chose to deliver their video. They could choose either a simple PowerPoint conversion video or they could create and develop a multimedia-based video using video editing software such as Windows Live Movie Maker or iMovie. This question explored the student’s decision on their chosen methodology for creating the design concept video. Whilst the first initial question
would only be a choice between two outcomes, this was then followed up with an open ended question that would investigate and explore the justification in their choices.

7. Did you use the toolkit that was created to support your video project?
   a. How effective was it?
   b. What else would have been beneficial to you in the toolkit?
   c. How important to you was it that the toolkit was mobile compliant (i.e. works on iPads, smart phones etc.)?

The toolkits implemented during cycle two of the action research were evaluated using a set of four questions that would explore the student’s experiences in using the toolkits. The first question determined whether or not the students had used the toolkit, students that hadn’t were asked to discuss why they hadn’t and students that had used the toolkits were asked further exploratory questions in order to evaluate the toolkits effectiveness and what if anything the students felt was missing from them. During cycle one of the action research, students in the focus groups were asked how important it was that a prototype toolkit was mobile compliant and worked across smart phones and tablet devices. Following the implementation of the toolkit, and it’s designed mobile compliance, students were asked how important it was to them that the
toolkit they used worked on mobile devices. They were also asked if they had viewed the toolkit on their mobile device and if so in what context.

8. One of the issues Engineering Education is facing is being able to teach large groups of students due to space and time restrictions. Educational institutions are looking to utilise technology to accommodate the problems.

What ways do you think the university could utilise technology more effectively for teaching students?

There is a lot of literature surrounding teaching issues associated with large groups of engineering students (Crede & Borrego, 2012; Mazzolini, Daniel & Edwards, 2012). Students were asked their thoughts on how educational institutions could potentially utilise technology to resolve the problem. The use of technology to facilitate large groups has been discussed in Engineering Education (Barragués, Morais & Guisasola, 2011), however this question sought to obtain the students thoughts and ideas around the topic. Literature suggests that students are behaving more like consumers and partners (Kay, Dunne & Hutchinson, 2010), and data gathered from this question was analysed to highlight innovative ideas and thoughts from the students themselves. As identified during the literature review in Chapter 2, this is a method with limited adoption in Engineering Education research.
9. What would you like to see more of in terms of your teaching material?

Views from this question was analysed and compared to a similar question used in the industry based survey to gain a perspective from both students and from professionals who are directly impacted by engineering graduates. Responses were compared to existing literature on students’ views of Engineering Education as a practice in current UK and worldwide curriculum. This open ended question aimed to gather qualitative data and was analysed drawing out common themes and ideas students.

In this section the aims and objectives of focus group three were discussed. Continuing within this action research cycle, focus group four methodologies will be outlined in the next section.

3.5.2.2.3.2 Focus group four

Focus group four was carried out in January 2014 and consisted of a mix of fourteen first and final year undergraduate engineering students that were enrolled on both modules associated with this research study. Its primary aim was to carry out an open discussion on the future of Engineering Education and to explore student’s opinions on how this may change and what impact technology could have on it. Digital literacy and its relevance to Engineering Education were discussed along with an open discussion on taught aspects of Engineering Education as a discipline.
Questions used within focus group four are defined:

1. Please read and discuss the following quote:

   “Today, technology is an influential factor in education as it has ever been. A new generation of engineering students is entering Higher Education with significant computing knowledge, and with higher expectations that academic institutes went use them to appropriate technologies for their successful transformation into industry. Academic institutions are challenged by these new technological requirements and must adopt appropriate strategies to meet innovative educational demand”. (Abulrub, Attridge & Williams, 2011)

   This quote was included to represent the growing literature suggesting that technology is influencing the ways in which students learn and the ways in which academics deliver their teaching. The aim of the quote was to act as an icebreaker at the beginning of the focus group to begin discussions around the speculations of students entering with significant computing knowledge and the difficulties faced by Higher Education Institutions to support this. Data collected from this quote would form an understanding of how students believed technology impacts on their learning and what issues would arise as a result of this.

2. How do you see the teaching of engineering changing in the future?

   This question was repeated throughout the focus groups and the industry based survey to form data on students’ thoughts on how Engineering Education would be delivered in the future. This question was also
repeated in the industry based survey to gain compare the results between students and professionals practising in industry.

3. **How would you like to see it change?**

Data collected from this will identify and discuss students’ needs and understand what students feel missing from the current curriculum. This question was also asked to industry based professionals to later compare the results between students and practitioners in the workplace.

4. **How do you think technology will impact on working practices in engineering over the next 10 years?**

As discussed in previous sections there is growing literature speculating that technology will play a pivotal part in working practices in engineering. The student’s opinions on this will again be compared against industry responses from the survey to identify any correlation of opinions and identify differences.

5. **Do you believe that an undergraduate Engineering course could be taught completely online?**

This question was also repeated in the industry based survey for later comparison. As literature suggests technology will play an important part in delivery of engineering in the future, this question will determine if the students believe it is viable to teach a course completely online.
6. Apart from experience, do you think engineering graduates lack any specific key skills when they enter the workplace?

As another question that was repeated in the industry based survey, this question aimed to get the students to reflect on what skills they believed they would lack when they enter the workplace. Experience was removed as an option in the discussion as students would naturally lack a certain amount of experience prior to entering the workplace unless they had entered Higher Education later in life.

7. How important do you believe it is that engineering graduates are digitally literate when they enter the workplace?

"Digital literacy is the ability to effectively and critically navigate, evaluate and create information using a range of digital technologies. It requires one "to recognize and use that power, to manipulate and transform digital media, to distribute pervasively, and to easily adapt them to new forms".

The terminology of digital literacy is growing in literature as discussed in the literature review, and is often controversial due to the perceived stereotype of students being naturally digitally literate. Data collected from this question would again be compared to the same question in the industry based survey.

8. Whose responsibility do you believe it is to teach students ‘digital literacy’?
Recent literature suggests that institutions are attempting to embed digital literacy training as part of the curriculum. The responsibility of digital literacy is debated in this question and the student’s thoughts and reflections will be analysed to form a greater understanding of the student’s expectations from their University education.

**9. How digitally literate do you think students are as a whole?**

The literature review in Chapter 2 discussed varying opinions on how digitally literate students are. Results from this question will later be compared to literature in Engineering Education and in Higher Education as a whole to form an understanding of how the students perceive themselves in terms of their skills in this area.

**10. Should students be responsible and aware for their ‘Digital Footprint’ or is this something that should be covered in their time at University?**

a. **How do students think this could affect their professional career?**

Graduate employability is a key concern for Higher Education, the increase of technology innovations have created opportunities for people to present themselves online in a professional and social context. The idea of digital footprint as discussed in this question and student’s opinions will be discussed on how this could impact on their professional career.
11. Should ‘teaching staff’ be as digitally literate as the students they teach?

There is limited literature available on the digital literacy of teaching staff and its relevance to the way in which they teach their students. This question was presented to understand from students if it was important to them that their teaching staffs were as digitally literate as themselves.

12. Do you think engineering teaching staff uses technology effectively in their teaching materials?
   a. Could any improvements be made?

The students were asked to reflect on their experiences of engineering teaching and whether they had observed any effective use of technology in their teaching material. They were also asked to give their opinions on what improvements could be made to help enhance their teaching methods.

13. Would you like to see more use of embedded technology in your teaching/learning materials?

With growing literature suggest that technology is pivotal to the future success of Engineering Education, the students were asked if they would like to see more use of technology in their learning. This question would
form an understanding of differing opinions on what students expect and need from their academics and institutions.

14. **Ask if there is anything else they want to add**

The students were given an opportunity to add in any additional comments they felt would be relevant to this research study.

This concludes the chosen questions and methodologies for focus groups four. The methodology for focus group five will be discussed in the next section.

3.5.2.2.3.3 *Focus group five*

Focus group five was carried out in January 2014 and consisted of ten final year undergraduate engineering students who had recently submitted to video assessment and was the first final year cohort to use the integrated video resource toolkits referred to in cycle two of the action research. The questions mirrored those used in focus group three; however slight variation occurred as a result of some of the students’ responses to allow further exploration of points and comments.

3.5.2.3 *Justification on action research methodologies*

Mixed methodologies within action research was utilised within this research study in order to gather a variety of qualitative and quantitative data to underpin the research aims and objectives of the study. Utilising mixed methods
provides greater flexibility and tools to gain a thorough understanding of the data.

Action research was chosen within this context to be able to evaluate and reflect on the experiences of the implementation of Technology Enhanced Learning within engineering. This method is underrepresented in Engineering Education and has been recommended by various researchers as a methodology for future work within this discipline.

It aims to evaluate the implementation of Technology Enhanced Learning within two module cohorts in engineering curriculum. Additional techniques such as focus groups were used within the cycles of research to gain data to contribute to the evaluation and impact of the implementation of technology. The two year cycle of action research will create an opportunity to implement a technology, reflect on its impact via evaluation and implement further recommendations and changes for a further cycle which will also be evaluated for future recommendations.

The combination of mixed methodologies within these action research cycles will ensure that the data collected is a thorough representation of the field of study being research. As discussed in previous Section 3.8, individual methodologies are limiting in their scope but combined can be a powerful contribution to research.
This section discussed the methodologies used within the action research cycle. In order to validate and compare the results collected from the students in this section, an industry based survey gathers data from practising professionals within the fields of engineering and architecture will give an understanding of the impact of Engineering Education methodologies to the industry sector in which graduates are employed. The next section of the methodology chapter will introduce the industry based survey.
3.5.3 Industry Based Survey

A web based survey consisting of sixteen questions was developed and distributed to professionals in practices such as engineers, architects, urban developers, construction developers and project managers. The target group was chosen due to their direct and influential link to both employing, and in some cases mentoring, graduate engineers in both the workplace and in educational environment.

The potential participants were informed of the aims of the survey at two critical points; one during the initial dissemination requesting participation via email, newsletter etc. and two in the introductory page of the survey before the participants had to click to start the survey. This ensured that the participants understood which end-user this research study was looking to investigate i.e. architects, engineers and engineering educators etc.

The main objectives of the survey were to:

- gather opinions from professional representatives from industry such as architects, engineers, engineering educators etc. on existing practices in engineering around the subject of design concept process.
- understand an industry perspective on the importance and place of virtual reality (VR) walkthroughs in a professional environment.
Methodology

- gain an industry viewpoint of the skills of current engineering graduates in the work environment and which areas they feel students could improve on before entering the workplace.
- collect views on how Engineering Education is evolving and how technology is impacting on changes in engineering practice.
- Align results gathered from the survey to compare against data collected during the action research cycles implemented during this research study.
- use data gathered from the survey combined with data gathered during other stages of this research for future recommendations on engineering curriculum.

Participants were also informed that they could withdraw from the survey at any point by closing the browser window. Full ethical clearance was obtained from the University prior to the distribution of the survey and can be found in Appendix 9.3. Respondents filled out the survey anonymously in line with cleared ethical protocol and were allowed to skip questions.

The survey was active for a period of eight months during which time the survey was circulated by various mediums including email, web advertisements and newsletters, details of which can be found in Appendix 9.4.

To reinforce understanding and viewpoints from industry based professionals, the survey question design mirrored questions asked to the students in the focus groups as part of the action research evaluation cycle which is explained.
later on in this section. This gives views and opinions from all stakeholders involved with Engineering Education for this piece of research.

The survey was designed using a variety of question types, some closed and some open ended. Open ended questions and options for additional comments allowed respondents to further explain their answers and thoughts. The nature of this survey was designed to be utilised mainly for qualitative research but a few quantitative style questions were added to gain statistical analysis around questions. Contact details were also provided should the participant wish to add any further discussions or thoughts to the research study which was followed up by a number of respondents.

The main topics used in the survey were on graduate skills capability, digital literacy in engineering students, use of virtual reality (VR) in engineering design, the teaching of Engineering Education and online delivery of engineering in undergraduate education. A quote discussing the concern of the lack of design skills in undergraduate engineers was taken from a recent journal (Taborda et al., 2012) to obtain views around the topic. The same quote was then given to the students later in the focus groups discussed under the action research cycles to see how the views compared.

3.5.3.1 Question Methodology on Survey

A breakdown of the questions used in the survey are defined and justified:
1. Please enter your professional job title

Defining the job title survey helped create and break down the survey responses into categories such as educators (those actively involved in teaching) and industry based professionals (engineers, architects, construction managers etc.).

2. Which field do you work within?

This field again allowed with the analysing of data so that responses could be broken down and question responses filtered into the different categories outlined in the beginning of this section, for example industry based responses and educational based responses.

3. How long have you been working in this field?

Participants were asked how long they had been working within the field. Data could then be explored to see if those newer to the field had similar views to those that had been practising in industry or education for a number of years.

4. What are your own views on the following quote?

“Today’s engineering students are proficient in detailed design tools but lacking in conceptual design and ideation”. Taborda, Elkin, et al. "Enhancing visual thinking in a toy design course using freehand sketching." ASME international design engineering technical conferences and computers and information in engineering conference. 2012. (Taborda et al., 2012)
This quote was also given to students participating in the focus groups during cycle is one and two of the action research. Views of the students and the industry responses were compared and analysed to draw any conclusions of differing opinions or contradictory views. The quote chosen was up-to-date and relevant to views both under education engineering research and to those practising in architecture and design fields. As design skills in engineers become more vital for a modern engineer (Dym et al., 2005), this quote made a strong statement to generate discussion and thoughts. To gain full exploratory data, and unlimited text field and open response was selected for this question type.

5. Apart from experience, do you think engineering graduates are lacking any specific key skills when they enter the workplace?

Literature states (Lamb, Arlett, Dales, Ditchfield, Parkin & Wakeham, 2010; Sageev & Romanowski, 2001) that engineering graduates are entering industry with key fundamental skills that an engineer should have missing such as team working and interpersonal skills. This question was asked in order to compare views found in Engineering Education research to those found in the survey responses. Differing opinions and similarities were explored during the analysis of the responses.

A multiple response question was used in this instance to allow participants to select as many choices as they wanted from the following options which
was formed as a result of reviewing existing literature in Engineering Education research:

- **Team Working Skills** – team working skills are continually referenced in Engineering Education literature and its importance is becoming more prominent in recent literature surrounding the requirements and needs of a ‘21st-century Engineer’ (Galloway, 2007b).

- **Interpersonal Skills** – interpersonal skills are one of the “soft skills” that is deemed as being vital in the new breed of engineers. As the role of an engineer requires more than just technical capability, the need for an engineer to have good communication and personable skills has increased in its demand (Lamb, 2010).

- **Design Concept Skills** – as discussed earlier in this section, design is considered to be an integral part of engineering in particular the design concept/process. However, literature states that the teaching of design under the sphere of Engineering Education has only recently started to appear in literature (Lamancusa, Jorgensen & Zayas-Castro, 1997). To compare and contrast this, this option was given to participants in the survey to see if this view is reflected.

- **Technical Knowledge (construction detailing)** – engineering has traditionally been referred to as a technical subject. Literature states that some of the more traditional methods use in engineering teaching that lend themselves to technical detailing are not effective
in producing the kind of engineer that society needs (insert references). This option was included to explore if those practising in industry felt that engineering graduates lacked this skill.

- **Freehand Drawing Ability** – with more emphasis being placed on the use of computers and technology in Engineering Education (Allenby, 2011), this option in the question aimed to investigate if traditional sketching and freehand drawing skills were still needed and if so where they are missing in engineering graduates.

- **Time Management Skills** – time management skills, whilst not a new notion, is said to be one of the soft skills that engineering graduates should possess to become a modern engineer. This option was included in order to investigate its relevance to skills found to be missing in UK engineering graduates.

- **Computer Aided Design (CAD) Skills** - The role of technology and computing skills is ever more apparent in engineering now as it ever has been. According to literature, engineering graduates must be proficient in computer aided design skills (Ye et al., 2004).

- **IT Skills (such as Cloud Computing)** - An option to include IT skills outside of those normally associate of engineers for example computer aided design skills, was added to analyse its needs for engineering, and whether this was missing from graduate skills capability.
An additional option of ‘other’ was added in along the free text field to provide participants with the ability to add in their own choices and thoughts.

6. Have you seen any change in the graduate capability in the last ten years?

Please explain your answer:

Respondents were asked to reflect on their own experience of graduate capability over the last ten years. Data gathered from this question will later be compared to literature discussed in the literature review and from the reflections from the students during the focus groups.

7. How important do you believe it is that engineering graduates are digitally literate when they enter the workplace? “Digital literacy is the ability to effectively and critically navigate, evaluate and create information using a range of digital technologies. It requires one "to recognize and use that power, to manipulate and transform digital media, to distribute pervasively, and to easily adapt them to new forms".

Discussions and literature around the concept of digital literacy has been well documented (Santos, Azevedo & Pedro, 2013). An open ended question was added to gain and explore opinions and views from those based in industry and practising education on how important they felt it was that engineering graduates were digitally literate when they entered the workplace. A definition of digital literacy was added to ensure that participants knew the reference behind the question.
8. How useful are virtual reality (VR) walkthroughs in assisting with the design concept process for engineering designs i.e. building projects?

Please choose from a rating of 1 – 5 with 1 being 'Not very useful' and 5 being 'Very useful':

The discussions around the use of virtual reality and in particular virtual reality walk-throughs in engineering are seen to be a beneficial way in assisting with the design concept process (Sampaio et al., 2010). A Likert scale question was included to investigate how useful participants felt that the use of virtual reality walk-throughs were in assisting with the design concept process for engineering designs, for example building projects. A rating between one of five was used to gain statistical data and create a small sample of quantitative responses to use in the study.

9. Would you like to see more usage of virtual reality (VR) walkthroughs in student work?

To complement the previous question, participants were asked if they would like to see more usage of virtual reality walk-throughs in students work. This was an open ended question to gain qualitative data for further analysis. Responses from this question were also further categorised to see if the views correlated between those based in education and those in industry. A further categorisation was made during the analysing process and responses
were filtered down into those under the umbrella of engineering as a discipline and to those and architecture/design as a discipline

10. Would you rather have a student proficient in building physical to scale buildings or student with proficient skills in computer-aided design (CAD) and virtual reality (VR) walkthroughs?

In both of the modules associated with this research study, the students have to produce either a physical model of the design or a virtual reality/computer aided design model. In the first year module students have to produce both. To investigate if this is a representation to practices seen in industry this question was asked in a multiple choice format to gather statistical analysis on which of the skills they would rather have in an engineering graduate. Four initial multiple choice options were given with this question; physical skills, digital skills i.e. Computer-Aided Design (CAD) and virtual reality (VR), a combination of both and don’t mind. The ‘Don’t Mind’ option gave participants the ability to indicate that they had no strong feelings towards either. An additional free text field was included to allow participants to define and other response if they felt none of these options relevant.

11. What do you feel gives a proper understanding of the design of a building/project... a physical model, a virtual reality (VR) walkthrough or a combination of both?
This question was also given to the students during the focus groups carried out in the action research cycles. Responses to this were compared to those of the students to gain a clearer picture on the relevance of the process used within the modules to that of practising industries. Three initial multiple choice options were given with this question; a physical model, a virtual reality walk-through and a combination of both. An additional free text field was included to allow participants to define and other response if they felt none of these options relevant.

12. How do you see the teaching of engineering changing in the future?

This question also used during the focus groups of students during cycles of action research, was included to explore practitioner’s views on how they perceived the future of Engineering Education and whether this correlated to views reflected in current educational literature and to the students.

13. How would you like to see it change?

There is much literature surrounding the need for change in Engineering Education (Felder, Stice & Rugarcia, 2000b; Galloway, 2007a). This question explored views from those who are directly affected by Engineering Education for example those that employ engineering graduates after they finish the course. The same question was also asked to the students during the focus groups to explore any common or contradicting themes or suggestions.
14. How do you think technology will impact on working practices in engineering over the next 10 years?

There is vast literature predicting that technology will play a large part in transforming the future of Engineering Education. To investigate these claims, participants were asked on how they think technology will impact on working practices in engineering over the next ten years. This was an open ended question to allow participants to discuss this as they wanted. This question was asked again to the students during the focus groups to gain a comparison and both sets of data were analysed and to explore any common thoughts.

15. Do you believe that an undergraduate Engineering course could be taught completely online?

a. Please explain your answer

During the exploratory stage of this research little evidence was found of an undergraduate engineering course that was taught completely online. The Open University have engineering courses online but the physical assessment side of engineering in terms of laboratories, was often taught using residential summer schools. However, with the discussed speed of innovation in technology within Engineering Education and the access and benefits that online learning is said to give to education (Bourne, Harris & Mayadas, 2005), this question gathered initial statistical responses on
whether an engineering undergraduate course could be taught completely online. This multiple choice question consisted of three answers; yes, no or unsure and additional free text field was included for participants to add their own answer if they felt it didn’t lend itself to any of three initial choices. The exploratory follow-up question then asked participants to expand on their reasoning behind their answers. This open ended question allowed for qualitative data analysis which was later compared to student responses when asked the same in the focus groups.

Mixed design of a survey allowed for the integration of both quantitative and qualitative research methods. Fixed response questions allowed for some statistical analysis but the additional free comments were also allowed in relevant questions to give the participant the ability to add information if their answer was not reflected in the question. As Feilzer recommends, using free comments in addition to fixed comments promotes and creates opportunities for “new and deeper dimensions to emerge” in the work (Feilzer, 2010).

The data from the survey was analysed using a combination of manual and electronic methods. All survey responses were printed out and scan read to highlight key points manually. The main analysis of the data came from the inbuilt analytic tools found in SurveyMonkey itself. All individual responses were categorised under two initial themes; industry based responses and educational based responses. Educational based responses were defined as participants
who are actively working in Higher Education Institutions for example academics, teachers and technicians. Industry based responses were defined as participants who are actively involved in working practices outside of education for example; engineers, architects, urban planners, designers and construction workers.

The categorisation for each response can be seen in Figure 20.
Each individual question response was organised into this categorisation to explore any continuity of the responses and to investigate any differences in opinions.

The results from the survey will reinforce methodological choices in the research study for the action research cycles within the two engineering module cohorts. The questions mirroring those of the focus groups will later form the comparison of viewpoint summarised in the discussion chapter.
3.5.4 Chapter Summary

This chapter outlines the methodologies used within this research. Relevant literature underpins methodological approaches and discourses used to collect data at different points during the research.

Current practices in Engineering Education research were outlined, concluding weaknesses in utilising singular methodological approaches to evaluating research within the field of engineering. Research discussed during the critical literature review in Chapter 2 was summarised and emphasis drawn on methodological approaches, both historically and currently, used to evaluate practises in Engineering Education. Limitations of small scale implementation in Engineering Education were discussed, particularly when referring to the application of Technology Enhanced Learning in engineering curricula.

Individual methodologies used within the research were outlined and considered against relevant literature. A research road map discussed in Section 3.5 explained the relationships of each individual piece of research and how they correlate to the overall vision for this piece of work.

The subsequent chapters discuss the results and evaluation of each of the individual elements of research used within this study.
4 Preliminary Research Results

In this chapter the data from the preliminary stage of the research is defined. This stage of the research contains a series of observations from two different undergraduate engineering modules and an analysis of three semi structured interviews. Data gathered from the preliminary research stages formed the guidance and objectives of the following two year cycles of action research.
4.1 Methodology of results

The result chapters will be broken down into three sections; the preliminary research stage, results from the action research stages and data results from the industry based survey. An outline of the presentation of the results is seen in Figure 21.
Chapter 4. The preliminary research stage consists of a series of observations from two different undergraduate engineering modules and an analysis of three semi structured interviews. The preliminary research forms the aims and objectives of the subsequent action research cycles. Data gathered from the preliminary research stages formed the guidance and objectives of the following two year cycles of action research.

Chapter 5. The action research cycles concentrate on the use of case studies and the application of Technology Enhanced Learning in Engineering Education. The first action research cycle focuses on the implementation of video assessment within the modules chosen for this stage of the research. Two focus groups were carried out during this stage and analysis from this form the objectives for the second year of the action research cycle. The second action research cycle year concentrates on the results of the implementation of Technology Enhanced Learning in the form of two resource toolkits created using Xerte Online Toolkits. Evaluation and analysis were carried out using three focus groups on the impact of the resource toolkits and discussions surrounding the research area.
Chapter 6. The final chapter of the results sections will display data from the industry based survey to validate chosen methods used during the action research cycles. Industry viewpoints obtained on key areas relating to this research will then form a comparison against student viewpoints gathered during the action research cycle stages.
4.2 Preliminary Investigatory Work

This next section presents results from the research gathered during the preliminary stage of the study. Observations were used in conjunction with interviews to baseline current practices seen in undergraduate Engineering Education against reflections and studies in literature.

The next section will introduce the results from the observation stage of the preliminary work.

4.2.1 Observations

This next section outlines observations carried out during the preliminary stage of the research. Results from the observations will later be combined with the analysis of the semi-structured interviews discussed in Section 4.2.3, to form the aims and objectives of the following two research cycles.

Two individual modules were observed to gather data on potential issues and methods used in the teaching of undergraduate engineering. The first module observed was an interdisciplinary focused module and the second is a predominantly practical laboratory-based module on materials and manufacturing.

This next section reports on the findings from the observations and is broken down individually by module. The first module discussed is a large first year module called Manufacture and Materials 1 which will be referred to as MFMT101 (the module code). The second module is a proportionally larger
module for first year undergraduate engineers, referred to as Integrated System Design (DSGN143).

Reflections and results from both observations will be discussed individually and a summary of findings will conclude the observation section.

The next section will introduce the first of the observations using a first year undergraduate engineering module, Manufacturing and Materials One (MFMT101).

**4.2.1.1 Manufacturing and Materials One: Background on Module**

Manufacture and Materials 1 (MFMT101) is a 20-credit module undertaken by first year engineering undergraduates consisting of both BSc and BEng engineering undergraduate students. The module is run over the autumn term and the spring term. The observations were carried out over the autumn term to primarily concentrate on the practical element of the module using laboratories. This was to understand and compare to literature, the current methods used to give undergraduate engineering students a practical experience.

The module aim is to introduce students to the basic concepts of materials structure, performance and selection for engineering applications in order to give students a practical and theoretical appreciation of how engineering products are manufactured. The content of the module is designed to be an introduction to the multidisciplinary and rapidly changing field of materials
within engineering. It aims to provide students with an insight to how materials perform in difficult environments so that they are later able to use their knowledge to use materials efficiently within their professional domain.

In the next section, the teaching structure, assessment practices, laboratories and issues encountered will be discussed and analysed. Observation notes from MFMT101 can be found in Appendix 9.5.

4.2.1.1.1 Teaching structure

During the autumn term, students were taught using a combination of lectures and tutorials over a six-week alternating cycle. A practical laboratory was run every week of the autumn term starting from the second teaching week. Each student had access to one laboratory session which will be discussed in subsequent sections.

The lecture material was uploaded to the virtual learning environment (VLE) used at the time which was based on Microsoft SharePoint technology. The use of Microsoft PowerPoint for lecture dissemination and teaching hand-outs were predominant during both academic terms. Additional learning material was provided in the form of Microsoft Word documents or PDF’s. Additional books for students to purchase were recommended and listed.

4.2.1.1.2 Assessment Practices

The module was assessed using a combination of examination methods and coursework. A three-hour exam counted for 50% of the total module mark
which took place in the summer time of the academic year. Coursework made up the other 50%, comprising of a laboratory report in the autumn term and written assignments in the spring term. The observations of the module took place during the autumn term and will concentrate on five laboratory observations and two lecture observations.

4.2.1.1.3 Practical Laboratories

Students were split into groups containing between eleven to twelve students in each group. One group of students per week had a practical laboratory session lasting approximately three hours. In total a maximum of six practical laboratory sessions could be scheduled during any one academic term.

In addition to attending the laboratory, students were asked to write a formal laboratory report on the work they had carried out during the laboratory based on predefined laboratory hand out sheet.

The objectives of the laboratory work for the students were to:

- gain an understanding of the procedures of data collection and analysis involved in a tensile testing of engineering Materials
- produce a formal technical laboratory report explaining and discussing results from the test using a variety of available datasets

At the start of the laboratory the students were given between a thirty and forty minute introduction to the laboratory setting including health and safety
announcements and the aim of the laboratory. Students who had undertaken the laboratory in the first two weeks of the autumn term had not received the lecture introducing the laboratory, whereas students who had been timetabled after were aware of the nature and aims of the practical session.

The grouping allocations within the laboratories were large and had been changing and more recently had seen an increase in numbers making the laboratory difficult to run effectively.

A breakdown of increasing group numbers observed during the duration of this research study is shown in Table 2. Numbers varied due to some students not attending their allocated laboratory and having to move into another session.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Students</th>
<th>Number of Student Groups</th>
<th>Students per group</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013/2014</td>
<td>68</td>
<td>6</td>
<td>11 or 12</td>
</tr>
<tr>
<td>2012/2013</td>
<td>32</td>
<td>5</td>
<td>6 or 7</td>
</tr>
<tr>
<td>2011/2012</td>
<td>48</td>
<td>5</td>
<td>9 or 10</td>
</tr>
<tr>
<td>2010/2011</td>
<td>57</td>
<td>6</td>
<td>9 or 10</td>
</tr>
<tr>
<td>2009/2010</td>
<td>68</td>
<td>6</td>
<td>11 or 12</td>
</tr>
<tr>
<td>2008/2009</td>
<td>46</td>
<td>5</td>
<td>9 or 10</td>
</tr>
<tr>
<td>2007/2008</td>
<td>53</td>
<td>5</td>
<td>10 or 11</td>
</tr>
</tbody>
</table>

Table 2: MFMT101 laboratory class sizes for last seven years
4.2.1.3.1 Laboratory Methods

The laboratory was split into two sections, a steel sample and a polymers properties and identification. The objective of the laboratory was to get students to carry out a tensile test on a range of different specimens, measuring key engineering properties such as strength and stiffness.

The learning outcomes for students were to learn about the equipment and procedures involved in tensile testing, as well as the characteristics of tensile failure in metals and plastics.

The first test involved a steel sample being loaded into the tensile test and having an extensometer ¹ (a device used to measure changes in the length of a specimen or object) attached.

To begin the students were introduced to the tensile test machine, an Instron 5582 followed by an introduction to the software used within the experiment and equipment. Most of this was a visual introduction with the technician demonstrating.

The students are then shown an overview of the software used with a tensile test machine called Bluehill®. The software is a materials testing package designed for providing automatic test control, data collection, results analysis and reporting. The demonstrator then allocates one student to be in charge of

¹ A device used to measure changes in the length of a specimen or object
the software aspect, and one student to be responsible for removing the extensometer once the specimen fails. The device (extensometer) must be removed before the physical break takes place as this can cause damage.

Once everything is checked out the test is activated. Students observe from a few feet away although due to group size and physical space visibility is not always equal for all. On the software the students will observe a graph plotting showing where the sample breaks or fails, this is not necessarily a physical break but deems the material no longer safe to use in building or construction.

At this point the software gives an alert asking for the extensometer to be removed and the nominated student will do this. After this the actual steel sample begins to thin in the middle and about a minute after the test begins there is a loud bang when the sample breaks. The test is stopped, the two pieces of sample removed and the students must then re-measure the sample and make observations.

If there is time, sometimes a second steel sample is put in which has been heat treated previously so the properties of the material are different. The test is repeated as discussed above and the students can make observations. During the observations of laboratories there was not always time to do this. This was particularly true for those groups with full attendance of ten or more.
The students were required to fill out their laboratory hand out sheet which contained various tasks that the students should carry out and record during the laboratory such as:

- make a sketch of the tensile test specimen showing important dimensions
- describe how extensions and strain are measured during the test
- describe the steps carried out in the test and how information is recorded
- record and measure specimen length before and after the test
- observations of behaviour during the test and sketch the fracture surface of specimen;
- calculations of results
- provide evidence for validation of results and to comment of accuracy and possible sources of error

In the second part of the laboratory, the students were introduced to six coloured plastic specimens. They were informed that each one was a different polymer and that the objective of this part of the laboratory is to carry out a tensile test again but with one of the plastic specimens. The students were asked to draw a diagram of the specimen and take measurements, although as each polymer has the same height and width this was only necessary once. The demonstrator explained again how to change settings on the software and how
to enter the specimen into the machine as before. Once everything was confirmed the test was activated. Students again observed from a few feet, but for the majority of students they were unable to view easily due to the large numbers. The software again plotted a graph showing where the sample breaks. The physical observations in the polymers are more visual with some of the plastics stretching whilst others broke quite abruptly. Once the test was over the students were again asked to re-measure the polymers, observe the fracture point and record the results on their laboratory sheet.

After the first test the demonstrator then asked the students to do the other 5 specimens themselves. Although they were observed they were left unsupervised to carry out the tests and many struggled to understand what they had to do.

After all six specimens were tested the students were asked to then see if they could identify which polymer was which. As with the other test, if there was time they were also asked to carry out further test, such as observing how they burn, do they float in water etc. The students could follow a flow chart diagram which would ultimately lead them to the identification of the correct material.

Students were requested to record the following on the polymer test:

- comment on why the polymers sample differ in shape in comparison to the steel sample
- carry out the tensile test for 6 polymer tests
• observe strength, ductility and toughness of specimens on fracture

• using their results identity which coloured sample relates to which polymer

After the laboratory students had to submit a report detailing what happened during the laboratory and their results from the specimens.

4.2.1.1.4 Issues Encountered

Notes taken during the laboratories can be found in Appendix 9.5.

As the students were first years, for most of them this was their first experience inside a practical engineering laboratory. Students were unaware of what to expect, particularly with the first two laboratory classes as the students had not received the lecture explaining the aims and objectives of the laboratory as this was scheduled for teaching week three of the module. Students also arrived unprepared and had forgotten to print out the laboratory sheets that were uploaded to the student’s virtual learning environment.

Health and safety guidelines were presented at the beginning of each of the laboratories and took at least twenty minutes to explain. Students who were late to the session had to have a brief catch up with the technician involved prior to the commencement of the laboratory testing.

Whilst the technician carried out the majority of the laboratory instructions, in one observation a research student was brought in to run the session and had
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no experience with either the laboratory or the equipment. Students found this frustrating.

Large student groups were problematic during the laboratory. Groups consisted of between ten and fourteen students and were too large to comfortably host. Most of the activities were based around one independent machine and could not fit more than three students around it. The other students had to observe in the background, and whilst the instructor gave each of the students a turn on the equipment, this meant other students were simply standing around and disengaged.

During the laboratory it was difficult to maintain the student’s interest when access to equipment was limited to one or two students at a time. If an experiment went wrong, there was not always the option to repeat the experiment due to time constraints and students had to utilise other data.

In most of the laboratory sessions observed, the technician ran the laboratory rather than the academic. At times the academic was present at the beginning but then went and the laboratory was then supported by the technician. This caused some communication issues, particularly with assessment deadlines and where the data could be uploaded to on the virtual learning environment.

Laboratory groups of seven or more were too large for a small room and students disengaged when unable to see the computer or the apparatus. The
majority of students forgot to bring the laboratory report to fill in which wasted more time when the technician had to go and print more.

This module had experienced an increase in class size for the teaching year 2009/2010 resulting in the scheduling of three more laboratory classes than previous years with student numbers of 9 or 10 per group. Similar to the literature discussed in Chapter 2, the module has had large groups in laboratory classes due to timetabling and resources. An issue within this particular setting was that some students were scheduled to carry out practical work prior to being given the theory lecture that was supposed to support practice. This practice and problem has been reflected in other studies (Hashemi, Majkowski & Anderson, 2003).

4.2.1.1.5 Discussion of Results

It was evident from the observations that students felt unprepared and unsure of what to expect when they arrived at the laboratory session. Whilst information relating to health and safety is important, a lot of time was spent on this in addition to explaining the aims and the objectives of the laboratory. This could have been prepared and executed beforehand using the flipped classroom methodologies discussed in the literature review in Chapter 2.

When the equipment or test failed, students had to rely on their peers and use their data.
The laboratory report was very traditional, asking students to sketch out what was happening to the materials during the test using a pre-determined laboratory hand-out sheet.

The students were interested in the laboratory, but felt disengaged due to the limitations caused by large student groups and equipment access. Due to the large student groups, the exercise and tests had to be repeated for each couple of students which for the majority of the time left the other students disengaged with the learning process.

Many students missed their allocated session as they simply forgot or hadn’t attended the lecture that told them when they’re designated laboratory session was. This meant that some groups ended up being larger than others as students had to be slotted into other group sessions.

On talking to the students, the students felt they would have preferred to have been fully prepared on the laboratory prior to attending. The most frustration was felt from the students who had not received the lecture on the principle behind the laboratory due to timetabling issues. Some felt that filling in a paper-based hand-out was rather traditional and school like and would have liked an electronic alternative.

On observing these laboratories, several recommendations can be made to improve the experience for the students and staff utilising Technology Enhanced Learning, including:
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- the use of flipped classroom techniques to provide students with the necessary guidance and knowledge needed to undertake the laboratory

- use of video to create a visual introduction to the laboratory and the equipment that students could watch prior to attending the laboratory. Students would then be able to visualise and make themselves familiar to the laboratory equipment and the settings. This would mean less time would be spent on this at the beginning of every laboratory session with the potentials time-saving of up to half an hour which could then be spent on more in depth experiments and learning

- creation of a small online formative computer aided assessment test to make students work through prior to the attendance of the lab to ensure they understand what will be expected of them along with health and safety recommendations relating to the procedures carried out during the laboratory.

- use of pre-set up alerts on the virtual learning environment to ensure students are reminded of when their scheduled laboratory session is.

The next section will introduce the second module observed for this research using the Integrated System Design module (DSGN143).
4.2.1.2 Integrated System Design (DSGN143)

Integrated System Design (DSGN143) is a large first year multidisciplinary undergraduate engineering module undertaken by both BSc and BEng students. This module has been running since 2006 and has strong links and support directly from the Royal Academy of Engineering (RAE). A definitive module review can be found in Appendix 9.1 and observation notes for DSGN143 can be found in Appendix 9.6.

The module design gives students the opportunity to experience and develop skills that are considered to be vitally important for success in the workplace.

Skills include:

- interdisciplinary team skills
- report writing
- presentation skills

The main teaching methodology is centred on problem-based learning, where students are put into interdisciplinary groups of between four and six students to simulate how project teams work in the real world. The groups then choose a case study or problem and have to come up with a design concept as a group that validates their research and thought behind the design. By using this approach students experience typical problems faced by practising engineers. In traditional Engineering Education, models of teaching are discipline specific, whereas the reality of industry workplace indicate that employers expect
graduate engineers to be able to work within multi-functional and disciplinary
teams.

4.2.1.2.1 Teaching Structure

The learning outcomes and delivery of the module is broken down into six main
components consisting of:

- introductory lecture
- design theory lectures
- case study lectures associated group by group
- producing formal documentation
- presenting ideas and research

Students attend traditional lectures for both their case study work and also for
the module in general. In addition, meetings are set up with teaching staff so
that the students can gain feedback on their work so far and for academics to
identify any issues earlier on with regards group work and progression.

Once students are placed in their groups, they then have scheduled timetabling
allocations where the students can meet to discuss their work and plan their
research around their case studies. Whilst this is in the student’s module, due to
timetabling issues with students being in different courses this was sometimes
difficult to facilitate.
4.2.1.2.2 Assessment Practices

A combination of assessment methods are used within this module to assess the student’s knowledge including in-class tests in the form of an online multiple choice test, group presentations, a design project report and project presentation day including a number of sub assessments. A breakdown of the assessment criteria and weighting can be seen in Table 3.

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Percentage of Final Module Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term 1: In-course test (On-line multiple choice test)</td>
<td>10</td>
</tr>
<tr>
<td>Term 1: Design Concept Presentation</td>
<td>15</td>
</tr>
<tr>
<td>Term 2: Design Project Report (includes a percentage of peer assessment)</td>
<td>50</td>
</tr>
<tr>
<td>Term 2: Project presentation day (group viva/Poster/Model/CAD)</td>
<td>25</td>
</tr>
</tbody>
</table>

Table 3 Breakdown of assessment methods and weighting for DSGN143

The in course test consists of a series of multiple choice questions that were designed and created using the University’s selected computer aided assessment package; QuestionMark Perception. Students were able to complete this assessment in their own time due to the flexibility of the online platform.
However, students only had one attempt at the quiz which counted for 10% of the final module mark.

The design concept presentation consisted of the groups presenting their preliminary research and work completed so far on their design concept for their chosen case study. This was done in a lecture room setting with their peers present.

The design project report was a large technical piece of work which would draw together all of the work the students had done on the design concept including their planning, design, costings etc. This aimed to replicate large reports that engineers are required to complete in industry and required group members to work collaboratively based on their areas of work they were assigned.

The project presentation day took place in the later part of the spring term and was a final showcase to their peers, academics within the school and industry based guests that were invited to attend the day.

The mark was made up of multiple elements including:

- an assessment from an external visitor (or local academics)
- a poster that should explain the design concept to a potential stakeholder
- a physical model of their design concept
- a virtual reality model of their design concept
The presentation day also included additional invites from industry based professionals from local companies that would potentially hire graduate engineers.

4.2.1.2.3 Issues Encountered

Observation notes for the integrated system design modules can be found in Appendix 9.6.

The large cohorts associated with this module were problematic in terms of timetabling lectures and providing support to students. As students were part of the interdisciplinary group, students were from different courses and outside of the module left it very difficult for students to get together to collaborate on their group work.

Students were given a platform using the Microsoft SharePoint technology for their groups to collaboratively work. However, students didn’t always use these and would often use their own ways of collaboratively working including the simple use of email. Their areas that were set up for them to collaborate online, were structured and students felt that they would have their work constantly watched over. For the students that did utilise these areas, they were simply used as a repository for uploading word documents rather than true collaborative working online.
The group presentations where students from each group demonstrated their preliminary research findings for the design concept were difficult to host physically in terms of university space. Most of the time students used Microsoft PowerPoint for their presentations which limited creative freedom and innovation.

The group presentations also took time out of the lecture allocation as it meant that several sessions had to be used in order to host these. In its highest cohort year, DSGN143 had over three hundred and twenty students enrolled which meant a minimum of fifty plus groups to individually present.

There was a lot of structure and processes involved in the module, and whilst this was a fairly accurate representation of how an engineer would need to work in industry, it did not allow students much creative freedom when presenting their design concept and work completed.

4.2.1.2.4 Discussion of results

The integrated system design module was incredibly popular with students as it was made up of many different elements and practices that one would expect from an engineer in industry.

However, large student groups hinder the creative process within the design concept and careful thought and consideration is needed to fully utilise time spent in the lecture environment with staff.
On observing the module and following informal conversations with the academic staff responsible for the module, several recommendations can be made utilising Technology Enhanced Learning to enhance the learning process and experience, including:

- replacing the design concept presentations to an online format using video as a delivery mechanism
- provide more training on the use and creation of virtual reality models within the engineering design concept process
- give students advice and guidance on different online collaborative technologies that would assist them in working on a project together rather than enforcing an area that is structured and limited
- give students more creative freedom in their delivery and presentation of the design concept process to aid different learning styles and preferences

### 4.2.2 Conclusion of observations

Results from the observations reinforced issues and problems have been reported in Engineering Education literature. Large module groups are problematic in terms of administration and physical space allocations.

Observations of the practical laboratories were conclusive and repeated frustrations reported in Engineering Education. Large practical laboratory
classes are difficult to administer and results in students becoming disengaged with the learning process. The practical laboratory sessions were particularly relevant where students had not received the theory behind the practical laboratory before undertaking the session. This is a common problem that has been repeated in literature and despite the availability of technologies that can potentially enhance and reinforce learning outcomes, the uptake of this on the more traditional engineering courses is still limited.

Observations from the interdisciplinary module demonstrated the importance of reflecting industry methods and practices in engineering curriculum program. Working in multidisciplinary teams is often problematic for students particularly when timetabling clashes occur when students are not on the same course or have different availability in their free time. When students were given access to an online platform in which to collaborate, many preferred to use their own methods rather than an institutional area.

The interdisciplinary module demonstrated student innovation when presented with a design concept problem and case study. However, lack of physical lecture spaces to cater for large modules results in a lot of time wastage which could be spent teaching students at a deeper level.

Both modules observed would benefit from more innovative uses of technology to both support and enhance the learning process and experience of students. Alternative assessment practices could potentially create a greater
understanding of the process and also create a more inclusive assessment for different learning styles.

When a practical laboratory is needed, time should be freed up as much as possible to ensure that the time spent in the laboratory itself is more effective and beneficial to both the students and the staff.

The results from these observations will be combined with the results from the semi-structured interviews to form further recommendations and outline the next stage in the research process.

The next section will display results from the semi-structured interviews carried out in parallel to the observations.
4.2.3 Analysis of Semi-Structured Interviews

This section introduces the approach used to analyse the qualitative data gathered during the three semi structured interviews. Each individual interview was independently evaluated and data gathered in conjunction with the literature review, form the baseline for the research aims in subsequent sections.

Each interview is evaluated and data analysed in the order in which they were conducted. The first and second interviews discussed with engineering academic staff working within the Faculty in which the research is based and the second interview is with a technician who works within the engineering department, in particular with practical laboratories.

4.2.3.1 Analysis of Interview One

The first interview was with an engineering academic working within the Faculty of Science and Technology at the institution in which the case studies of this study is based. That academic had over thirty years’ experience both as a lecturer and utilising engineering laboratories within teaching. During the interview, initial notes were taken by the researcher can be found in Appendix 9.7.

During the initial background questions, the interviewee demonstrated a clear history in utilising laboratory work to give undergraduate engineering students a
practical experience. Their thoughts on their role within engineering laboratories were discussed as:

“The lab session is an opportunity to teach students in practical environment, to point out features and issues we will cover, or have covered in the classroom, to make them aware of a range of test equipment, to show them how difficult it sometimes is to get practical results and to give them a feel for real engineering accuracy”.

The interviewee reinforced the importance of giving students a practical experience and referred to the laboratory as a way of reinforcing information distributed to students during a classroom environment, such as a lecture.

Questions regarding the observations from the last few years sparked great discussion from the interviewee. When asked about the changes they had observed in the last few years in regard to providing a practical engineering laboratory to students, responses regarding the pressures of staff time and resources were identified.

“Pressures on both staff time and space leading to a reduction of the amount of lab work in the course. A need for all lab work to be directly assessed, otherwise students don’t engage with it”.

Discussions during the interview indicated that teaching on the whole had increased but laboratory allocation and timing was decreasing due to time and financial constraints which mirrors what the literature had reported regarding the future of Engineering Education (Jennings, 1998a). As discussed in the literature review, Higher Education Institutions are struggling to maintain their
expensive equipment and also have less physical space to teach students (Lipsett, 2008b).

Large student groups were also discussed within this section of questions. The interviewee was very clear on their opinions on how large groups affect the structure of how laboratories run.

"More lab groups, demanding either more concentrated effort from the staff member, or spreading the sessions over more weeks which make them more remote from the point at which the material was taught”. 

This reinforced the issue of students participating in practical laboratories before receiving the lecture containing the theory and pedagogy of the practical. This was identified during the observations discussed in Section 4.1 of students coming into the laboratory unsure what is expected of them and what they are going to learn.

The interviewee was unable to offer any experience or involvement in delivering engineering laboratories or courses online and was unaware of any current ways in which the University could have facilitated it.

The interview then moved on to focus on the specific laboratories that we used during the observations carried out in the preliminary stage of the research. The tensile test laboratory was discussed and questions asked on the relevance and importance of this specific practical.

The interviewee felt that this particular laboratory was important as it gave students a real-life exposure on how to test a range of materials and equipment
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and measure practical results in order to analyse them. After identifying time lost in the tensile test laboratory during the observation stage, the interviewee was asked how they would potentially make use of any time that could be freed up during the laboratory. The interviewee had difficulty speculating how time would be freed up and didn’t see how any time could be saved.

Discussions then moved on to the use of virtual laboratories and simulations within Engineering Education. Views on the use of virtual laboratories correlated with many views that were found during the initial literature review. In order to baseline the definition of a virtual laboratory, the interviewee was asked to give their definition.

“A simulation (usually a computer one) of a real laboratory experiment in which students can change variables and record results”.

The interviewee mentioned they had mixed feelings towards the use of virtual laboratories and saw the use of such technology used in the context of being able to emulate something which could not be experienced otherwise.

“Mixed feelings. A particularly good simulation may be able to emulate what could not be experienced otherwise (e.g. the Navigation Simulator, or a ship’s engine room control panel), but these are very expensive. Other more simple examples can aid student learning, but if too simple they can be trivial (beam bending falls into this category – one independent variable, one dependant and a linear relationship between them – the benefit of actually doing the lab is in experiencing the physical situation and practical difficulties; I suspect this would not be recreated in a virtual lab)”.

As the literature reviewed in Chapter 2 suggests there is an increase in the use of simulations and virtual laboratories in Engineering Education, the interviewee
was asked if they had used or seen any effective simulations of engineering laboratories. Whilst the interviewee had experienced a couple of simulations, they believed them to be too trivial to facilitate engineering knowledge. Discussions did conclude that he had seen some excellent simulations and virtual experiments in the field of medicine but that this technological innovation had not reached across into the engineering discipline. This again mirrored discussions indicating the discipline being behind other educational fields in terms of technology application which is repeatedly referenced within Engineering Education research.

In concluding the interview, the future of engineering laboratories as a whole was discussed with the interviewee being asked to speculate on how engineering laboratories could be taught in the next five years. Concerns were raised on further pressures to reduce space and staff time. The interview also felt there would be a reduction in physical assets used to teach undergraduate teaching in terms of equipment due to the expense of maintaining them. When asked if they saw technology playing a role in the future of how engineering laboratories are taught, responses indicated that if technology was used to completely replace a physical laboratory then this would be a backward step in terms of Engineering Education. They did however feel that it could be used as learning enhancement to the laboratories.

“As long as it is a support for real, physical, hands-on, then it has the capacity to enhance learning. If it becomes a complete substitute, with
In summary of the first interview analysis, the engineering academic viewpoint approached the use of virtual laboratories and simulations within engineering with great scepticism. They also reconfirmed the discussed state of play in Engineering Education research for teaching institutions on pressures relating to time, space, increasing student groups and reduction in financial investment. The first interview highlighted key points to observe for in the subsequent interviews.

4.2.3.2 Analysis of Interview Two

The second interviewee had been involved as an engineering lecturer for over seventeen years and had vast experience in the involvement of engineering laboratories. Notes were taken during the interview to form a subsequent transcript as a respondent wished for no audio recording, notes can be found in Appendix 9.8.

The respondent’s current role at the time of the interview was an engineering academic and admissions tutor for various undergraduate engineering courses within the Faculty of study for the research.

During the initial background introductory questions the respondent identified their role in relation to the use of engineering laboratories within teaching.
“As the lecturer, I undertake the following tasks in connection to lab sessions:

- identify which laboratory available is relevant and at what point in the course it should be most appropriate
- prepare practical sheets and instructions for carrying out the laboratory, readings to be taken and guidelines on analysis the students must do
- divide the class into suitably sized groups to undertake the laboratory
- liaise with the technical staff to ensure that all equipment is working and the lab space is available
- supervise the laboratory class, ensuring students understand the purpose of the lab is, how it fits in with the rest of the course, ensure they have meaningful results and discuss these with them”

During this phase of the interview, some initial thoughts were formed on potential time wastage occurring in laboratories. This was also found during the initial observations carried out and discussed in Section 4.2.1. A lot of time was spent during the actual laboratory advising students on the purpose of the laboratory and how it relates to other aspects of their taught course. The academic also spent time identifying availability of physical assets relating to the laboratory and manually divided the course into groups of students to undertake the laboratory. These types of administration were often seen as frustrating time constraints on already pressured lecturing time and was a view repeated with both engineering academic respondents.

In the general questions surrounding the observations for the last few years, this interviewee indicated changes for the better, including some investment in new equipment. This contradicts most literature, and in fact interviewee one
who argued that changes observed had been of a negative element including less investment.

“Generally changes for the better, with some new equipment being added. However, in some areas some of the equipment is now ageing and the results from these can be spurious. There are more computers in laboratories too, and while this can be useful, it can sometimes detract from the hands-on tasks required. Students who are not particularly comfortable with computers tend to let others take control. With more competition for laboratory space, they need to be organised well in advance and is therefore difficult to carry out any impromptu demonstrations”.

In this particular instance, the interviewee felt that the introduction of technology into the laboratory had more of a negative impact and actually added to the time preparation needed for the laboratory. This contradicts literature reviewed in Chapter 2 where many mention the investment of technology in laboratories as a timesaver rather than an added hindrance.

As discussions moved on to the impact of large groups numbers in laboratories, the interviewee reconfirmed what both literature, and interviewee one had stated.

“Larger groups make structuring the laboratories much more difficult. Due to time constraints, it means that you can do fewer labs since you have more groups. It also means that synchronising the topic studied in labs and in lectures becomes much more difficult, with some students to the practical work before the topic is taught in lectures and others the other way around”.

This experience became more prevalent as the interviews continued. It again reinforced the initial observations carried out despite being a completely different taught module. This interviewee did however have experience in
teaching distance learning students. They did not feel that the university facilitated the students, and despite being distanced taught the students had to physically come down to the University to carry out laboratory work.

“The university did not really facilitate this, the students were required to come down to the University to carry out the laboratory work, the any concession we made was to allow them to undertake more than one laboratory on one day. Some distance learning students were not able to do all of them and had to therefore read about those that they did not do themselves”.

This method of teaching distance learning students in engineering is extremely common. The Open University facilitate practical laboratory work with either summer school residencies or home kits. The interviewee did also add that the University learning management system at the time did not facilitate distance learning at all.

The respondent also utilised the tensile test laboratory as this is a baseline laboratory used within many of the undergraduate first-year modules. They again reinforce the importance of this laboratory as all mechanical and civil engineers must have an understanding of how materials behave in order to make the correct choice in specifying materials.

“It gives a good deal of information about the mechanical properties of the material, including its strength, stiffness, ductility, and the way it fails in tension. Since all mechanical and civil engineers use materials to build components and structures, an understanding of how materials behave is a fundamental requirement for engineering graduates”.

Repeating the question asked to the first interviewee, the respondent didn’t feel there was a way to free up any time in the laboratory and saw the addition
of more laboratory classes as the only way to facilitate additional learning. As it
currently stood at the time of the interview, there was a very limited window of
opportunity in which the practical sessions could take place and any variation
would further disrupt the flow of teaching. They did not feel that there was any
way that technology could aid or enhance this process.

Further questions probed the use of virtual laboratories and similarly to the first
interviewee, the respondent did not feel that a virtual laboratory could
completely replace the experience operating machinery or carrying out
experiments.

“They have their merits, but cannot completely replace the experience of
actually operating machinery, measuring, using tools, etc. and seeing
how things go wrong”.

Their definition of a virtual laboratory again mirrored views found in the first
interview.

“I understand a virtual laboratory to be one in which the experiment is
simulated, either by using a video or more likely a computer. The student
might interact by controlling the speed or the load added to the structure
and observe the effects of their actions”.

Whilst they had a clear idea on what a virtual laboratory simulation could do
they had not seen or experienced any that were effective or usable for
engineering. During their time spent at the current University, they had not
witnessed any investment in technology that would enable virtual learning for
practical laboratories.
In concluding the interview, the respondent discussed their concerns in the way they believed engineering laboratories might be taught in the future. Fears over a decrease in a practical experience were highlighted and concerns rose due to the practical nature of engineering. Feedback from students was discussed, indicating that students particularly like the large amount of practical work they had to undertake during the module. However, the interviewee was also aware of the expense of the upkeep and maintenance of equipment and felt this would lead to the decline in availability to the students.

“My fear is that we will see less being taught in laboratories, due to the expense of the upkeep and maintenance. I hope not, because in a practical subject like engineering I think they are invaluable, even if they sometimes seem to be boring, just sitting there taking readings.”

The speculation of aspects being boring to students was further probed with the interviewee indicating that due to the restrictions in time and large groups of students didn’t always have as much of a hands on experience as initially stated. Most students according to the academic, would have to stand and witness others using the equipment and that the time spent interacting with the actual equipment was limited.

In summarising interview two, many views were repeated for the first interview in terms of the appropriateness of virtual laboratories and simulations. They also felt that technology, when introduced was not necessarily a positive addition and believed that the only way to improve a practical laboratory was to increase the frequency of them which is unfeasible given the current state of
financial reductions in investment. This interviewee did however experience some initial investment in equipment but also discussed reductions in other.

4.2.3.3 Analysis of Interview Three

Interview three with a technician who worked within a number of the engineering laboratories, more specifically the structures laboratory which contains the tensile test practical discussed during the interviews. The technician had been involved with engineering laboratories for a minimum of thirty-five years and employed within the University used within this study for over twenty years. In addition to notes made during the interview, a full audio recording and transcription was made with full clearance from the respondent and can be found in Appendix 9.9.

The technician interviewed was present during the preliminary observations discussed in Section 4.2.1.1.

During the background questions the role of interviewee three was very different to those of interviews one and two.

“They call me a materials engineering officer, but to you and I it’s a technician with some experience. Basically, you look upon yourself more or less as a facilitator. You provide support to the academic staff, so they can use the laboratory, you provide for the students so they can work safely, and work with the equipment in the laboratory you are providing, and you work with the researchers and the professors, so their work is done safely within the laboratory. So it’s really running the laboratory, but you’re covering all areas. We also do a certain amount of consultancy. So you’re facilitators for all those areas”.

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When further probed, the interviewee elaborated and stated that they look after approximately fifteen to twenty different types of equipment for various subject areas predominantly based within engineering.

In the general questions regarding their observations from the last few years, the interviewee repeated opinions felt by interviewee two and stated that investment had been made in equipment.

“Investment in equipment. In the last, shall we say five, maybe a bit longer years, there’s been a good investment in equipment, mainly because of the people further up the change, the heads of school and the deans, have actually invested in the laboratories in terms of equipment”.

Whilst the respondent felt equipment had been invested in, the reduction in staff that had occurred over the last few years in both technicians and academic staff was mentioned.

Large groups in laboratories caused concern to the interviewee. As the respondent had been involved in the observation process for the laboratories discussed in Section 4.1.1, discussions focused on their experience of how large groups affect the learning process in laboratories.

“If you mean do large groups function well within a laboratories then the answer is no because of the equipment that they use. I take the approach that students are here to use the equipment so I like them to get hands on. Now hands on means that you can only have a couple of people on the machine at one time with a few people watching so you have groups larger than 4 or 5 then the rest aren’t paying much attention”.

When probed on an ideal number of groups, smaller numbers were quoted as being more effective, but due to timetabling constraints and ever-increasing
module sizes, this would prove to be impractical with a modern engineering class.

“I’m not in favour of large groups overall I like to see small groups because I think smaller groups get more benefit from the experiments”.

In subsequent branching questions, the respondent felt that increase in student numbers had been steadily increasing over the last few years and had no visible signs of stopping. Concern was felt that this would just mean even larger groups with less student engagement due to physical limitations of interaction with equipment.

The technician had no experience working with online distance learning students, however they did feel that supporting distance learning would require even more resources and physical manpower to facilitate.

Questions then focused on the tensile test laboratory which the technician also felt was vital in terms of practical experience.

“Essential, in a nutshell, it’s the backbone of the laboratory, students get so much information from the data and they get from the tensile test”.

They later went on to elaborate that the main piece of equipment used within the tensile test (the actual tensile test machine) was used across all years and all courses of engineering within the University. Similarly to the interviews with the academics, the respondent was asked what additional work could be carried out within the laboratory if time was freed up. The technician felt there wasn’t much more you could do with the actual laboratory equipment as it is fairly
limited in its experimentation abilities. Alternative factors could be added into the materials, for example; heating and cooling down of the specimen, which referred to observations gathered during the preliminary stages discussed in Section 4.2.1.1.

In considering alternative provision, virtual laboratories as a concept were then explored. When asked for their definition of a virtual laboratory:

“A virtual laboratory, where they don’t in fact actually do anything as such, perhaps just sit in front of a computer, look at the screen and change a few varying parameters like the size of the specimen, modulus of specimen, type of material”.

He was also asked whether they were a viable alternative to practical laboratories:

“I think they can be very good but in my own personal opinion they will never replace the actual hands on and the actual work experience of doing an actual test because you don’t get that experience from watching a film”.

The future of engineering laboratories was then discussed, more specifically how technology may impact on this. The interviewee felt that technology related to number crunching within equipment rather than the broader picture.

“Well, you’d be able to do more complicated things easier, because technology is good at number-crunching. Number-crunching, as we all know, is the fundamental basis of doing lots of technical, getting lots of technical information and I can see that’s going to be the way it will go”.

Despite further probing, the use of technology as an enhancement to the laboratory process was not considered and thoughts were very much centred around the use of the laboratory equipment in its physical form. There was
additional discussion around the idea of centralising the University’s equipment as a whole and thoughts on joining forces with other disciplines.

4.2.4 Summary of Interview Analysis Methods

Qualitative data gathered during the three interviews was analysed the key themes and compared against existing literature. The aim of the interviews was to identify key areas of concern and viewpoints over the current practical experience provided to students in laboratories in general and how technology could potentially impact on this with the introduction of virtual laboratories or simulations.

4.2.5 Conclusion of preliminary research stage

The preliminary research stage consisted of two elements; observations of two different undergraduate engineering modules and three semi structured interviews with teaching and technician engineering staff.

This stage positions the research in context of the current Engineering Education literature discussed in Chapter 2 and will form the recommendations for the next stage of the research study.
The observations of the two engineering modules gathered data on current teaching and assessment practices in undergraduate engineering modules and were compared against Engineering Education literature in order to understand current practices.

The observations can conclude that there are frustrations felt from both students and the academic staff in relation to restrictions in investment and infrastructure issues. Large module sizes in engineering are proven to be difficult to administer and disseminate a practical experience to students. Often students were unprepared for the laboratory and on occasion some students received the theory and rationale behind the laboratory after they had undertaken it. Due to restrictions of the practical laboratory time scale, students often felt disengaged and unmotivated particularly when they were unable to see the equipment or were waiting around for their peers to carry out the same experiment.

When comparing the observed practical laboratories against Engineering Education literature, similar issues and concerns are raised by other practitioners on being able to expose students to a realistic practical experience.

In a lecture room scenario, large student groups are problematic due to timetabling and locating adequate learning spaces. In the lecture observations, students were sometimes unable to hear the academic and were witnessed looking up non-subject specific materials on their mobile devices or laptops,
including social media such as Facebook. On talking informally to students this was not necessarily due to the subject content, but more due to the delivery of the material in terms of the environment and teaching methods.

Assessments in engineering witnessed during the observations were very traditional and similar to the assessment methodologies often discussed as being inadequate to fully prepare an undergraduate engineer for working practices in industry. When alternative assessments were created, for example group presentations, this resulted in large amounts of time in the lecture being spent listening to the presentations.

Interdisciplinary work as discussed in the literature review is critical to creating a modern successful engineer able to solve real world problems. However, administering and delivering a module using interdisciplinary methods is problematic again due to university infrastructure limitations such as timetabling across different program courses and suitability of learning spaces.

The data gathered from the semi-structured interviews were compared against the findings discussed during the literature review and findings from the observations. Academic staff also experienced frustrations and difficulties when dealing with large student groups, particularly delivering a practical experience.

The use of technology to either enhance or replace a practical experience within an engineering curriculum, such as simulations and remote laboratories, were referred to with caution with both academics. Both of the academics discussed...
the lack of effective simulations available to an engineering discipline, with one academic saying they had only seen good pedagogic examples in the field of medicine.

Both the observations and the interviews highlighted potential to make more effective use of the time spent in either a practical laboratory or a lecture by utilising technology. Referring back to the literature review section on Technology Enhanced Learning in Chapter 2.5, there are several ways in which the effective use of technology within the curriculum could create more time for deeper learning, and enhance the learning experience for the students.

The next chapter in this thesis is Chapter 5, which will outline the next phase of the research utilising action research methodologies which will bring together some recommendations from the preliminary work to implement and evaluate the application of Technology Enhanced Learning within Engineering Education curriculum utilising action research in a mixed methodological approach.
5 Results of Action Research – Implementation of Technology Enhanced Learning

This chapter introduces the data results from the action research cycles which implement and evaluate the application of Technology Enhanced Learning within an Engineering Education curriculum utilising a mixed methodological approach within a two year cycle.
5.1 Implementation of action research methodologies within Engineering Education

The next two sections will discuss and analyse the results from the two year cycles of action research carried out in the second phase of the research study. Action research was used during this stage due to its appropriateness in evaluating and reflecting new practices within the discipline. This method of research is underrepresented in Engineering Education and has been highlighted in recent literature as having the potential to be an effective methodology by many researchers (Case & Light, 2011).

Within this research, a two year cycle of action research within two cohorts of undergraduate engineering modules were implemented and embedded into the curriculum. This is illustrated in Figure 22.

Additional techniques were used within the cycles to gain further qualitative and quantitative data using focus groups and student satisfaction and skills audit survey. These methodologies will evaluate the implementation of new assessment techniques utilising Technology Enhanced Learning and form recommendations for subsequent years in the action research cycle.

The following segment describes the application of the first cycle of action research relating to this study. The aims and objectives of this phase of the research step are explained including the implementation of the methodology.
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Figure 22: Action research cycles illustrated in full
5.2 Action Research Cycle One - Implementation of video assessment

Following on from the observations discussed in Section 4.2.1, an alternative method of assessment was implemented and evaluations made using focus groups and student satisfaction end of module survey.

This section will introduce how the video assessment was implemented within the module and discuss each element of the action research cycle shown in Figure 23.

![Figure 23: Action research cycle one diagram](image_url)
5.2.1 Results of “Planning” activities – observation of traditional assessment

Traditionally students were assigned a physical presentation to work on in their groups to fellow peers during a scheduled lecture. Due to constraints discussed during the observation discussed in Chapter 4, this was becoming difficult to physically deliver due to a combination of space limitations and time in addition to a lot of lecture time being used to listen to the presentations.

Following discussions with the module leader, a video assessment was implemented initially with a small pilot group and later expanded to run across the entire student module for both the first year undergraduate module of DSGN143 and the final year Masters level interdisciplinary design project modules.

During the preliminary research stage students used Microsoft PowerPoint to deliver the majority of their presentations. The presentations took place over a series of two lectures in which the students had to sit and listen to their peer’s presentation in a crowded lecture room.

Due to the volume of assessment and case studies used within this module, lecture time was valuable and precious. In informal discussions with the module leader, they felt that this was an ineffective use of time and that lectures could be better spent strengthening the students learning with additional learning material and visiting speakers.
The traditional mode of assessment appeared to hinder creativity, students were rushed through their presentations and due to the large lecture room and volume of students, it was difficult to maintain student’s engagement and enthusiasm. It was difficult for students to include examples of the design concept process within their presentations on the screen. The presentations took long to load and students found difficulty incorporating images and virtual reality walk-throughs in their work.

Following on from the preliminary observations, recommendations were formed using Technology Enhanced Learning to specify an alternative assessment mode that will allow students creative freedom to convey the design concept process in an innovative and engaging way using video.

The specification of the alternative assessment is discussed in the next section.

5.2.2 Results of “Planning” element – specify alternative assessment methods

An inclusive alternative form of assessment was developed using video technology as a platform for the students to deliver their content for the design concept work.

The assessment specification for the assessment was as follows:

“The purpose of the Marketing Video is to sell your Business Plan to potential investors to convince them that:
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- you have a project that they should invest in so that they will recognise that you have an innovative and deliverable proposal to receive a suitable return on their investment
- Fund you to move forward with the build phase of your proposal.

Your company has:

- The detailed understanding of the project
- A capability to act as a consultant during the implementation of the project”.

The assessment aimed to promote students working in a team-based scenario to replicate how engineers work in industry. As discussed in literature, industry professionals are requiring educational institutions to rethink their curriculum to ensure that engineering graduates are industry ready (Lamb, 2010; May & Strong, 2011). One of the key requirements from industry, is the development of ‘soft skills’ which include collaborative team working and communication (Rao, 2014).

As part of the project, students are expected to nominate a project lead and secretary to ensure the smooth running of the project. Project management, is another soft skill included in industry specifications for engineering graduates. By giving students ownership of the project, students have responsibility for areas within the project and are expected to collaborate and contribute as a team to specify the design concept brief that is marketable to their potential stakeholder.

The assessment also acts as a method of developing problem-based learning skills which develops cognitive abilities in students by giving students a real
world scenario to solve. In engineering, problem-based learning is key to developing an effective and successful engineering graduate (Mills & Treagust, 2003). As discussed in the literature, many institutions have done studies in the effectiveness of this method in Engineering Education (Perrenet, Bouhuijs & Smits, 2000; Yusof et al., 2004).

The next section will outline how the video assessment was implemented.

5.2.3 Results of “Act” element – implementation of video assessment

In order to implement and support the video assessment, a series of techniques and methods of delivery were created.

To inform students of the assessment, a lecture at the beginning of the term was given to outline the assessment methods used within the module and explain the justification for the assessment in terms of how it relates to engineering practice. Various literature state that assessment modes in Engineering Education should reflect working practices in industry to contextualise students learning (Hassan, 2011; Olds, Moskal & Miller, 2005). During the lecture, the students were made aware of expectations of an engineering industry as outlined by the Royal Academy of Engineering documentation (Lamb, 2010). The module leader associated with the module is part of a contractual teaching agreement with the Royal Academy of Engineering in order to provide an interdisciplinary module that reflects working practices in engineering.
In addition to the lecture, information relating to the assessment brief was uploaded and listed on the virtual learning environment used at the time of the research study based on Microsoft SharePoint technology. Figure 24 contains a screen grab of the portal page for the DSGN 143 module and Figure 25 shows the front page of the IDDP module.

Figure 24: DSGN143 module home page screen grab
An additional announcement was placed on the front news forum of the module page as well as an online submission area setup that the students would upload their design concept project videos to.

Emails were also sent out to the students along with reminders from the academic staff during their one-to-one group meetings with the students.

The different communication mediums ensured that students were aware of the assessment brief and the justification for using that method.

For the majority of students, this was the first time they had experienced video-based assessment in their university education. To support the students, a
A support site was specifically set up dedicated to assisting students with the production of the video assessment.

The support site was created within the student’s virtual learning environments module page to ensure students had easy access to the information without having to search for it.

A screen grab showing the support site for DSGN143 can be found in Figure 26. The support site contained a series of pages relating to the work students were expected to produce as part of the module including:

- video assessment support
- presentation day support
- peer assessment support

The site aimed to be a one-stop shop for students to access support materials relating to their assessments in the module.
Figure 26: DSGN143 support site home page

The video assessment page illustrated in Figure 27, contained a series of links and tutorials to existing material relating to video production software and techniques such as Windows live movie maker and iMovie. There was also links to video tutorials specifically created for this module.
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Figure 27: DSGN143 video support page
During the literature review in Chapter 2, it was identified that speculating a student's digital literacy skills is dangerous and can impact on the students learning if assessments utilising technology are inadequately supported (Margaryan, Littlejohn & Vojt, 2011; Santos, Azevedo & Pedro, 2013).

Following recommendations on limiting assumptions made on student capabilities (Jones et al., 2010b), the video support page contained an extensive series of software and techniques that students could use to support them in the creation of the videos including software guides, YouTube guides, production of video using Microsoft PowerPoint tutorials and a step-by-step guide on how students could submit their video using the universities online submission system at the time of the study.

In addition to online resources, a workshop was made available to students on a drop-in facility to help students in the use of camera equipment and editing processes. This took place in the library in a small video editing facility capable of holding up to five video editing machines with students having access to a video technician for support. At the time of implementation of this study, the machines contained Adobe Premiere Pro as its main video editing software. This is a complex piece of video editing software aimed at producing professional level videos and not aimed at novices or beginners. Other software such as Windows Live Movie Maker was not available on the machines at the time of study.
The workshop had limited capacity and was unable to support the students as a complete group. Each student group had different ideologies on how they were going to produce their video as well as different platform needs such as Mac or PC based systems. This took time from the workshop and many students had to make alternative arrangements with a technician for further assistance.

A skills audit was implemented at the beginning of the academic term which aims to evaluate the student’s current experience to producing videos along with assessing the student’s access to equipment such as cameras and recorders.

The next section will describe the results gained from the audit.

5.2.3.1 Analysis of skills audit results

The skills audit carried out approximately two months prior to the submission of the first design concept video was non-compulsory and as a result not all students participated in the skills audit.

The aim of the audit was to evaluate and assess the student’s digital literacy skills relating to the creation of video production. The survey was embedded into the student’s virtual learning environment and asked them a series of
questions relating to their experience of video creation, confidence in creating media and access to equipment.

5.2.3.1.1 Breakdown of audit responses for integrated system design (DSGN143)

The responses from the skills audit were normally carried out by those students who had been responsible for the video task element, although the majority of the students did get involved within the project. In total twenty-two students responded to the survey.

Students experience in video production was varied with 45% of the students not having any experience. The diagram of the responses from this question can be seen in Figure 28.

![Figure 28: Responses from students on their experience in video production](image)

For those students who said they had experience with video production, they were asked to elaborate on their experience.
“Filmed using flip cams and iPhones to produce videos with friends. These videos were made for a YouTube channel”.

“Secondary school computing projects where I used cameras to make a short animated film by using stop motion animation techniques”.

The majority of students had amateur experience through home personal use; however some students had been producing videos as part of secondary school projects. There was a small percentage that had done media or film-based studies during their A-levels who had vast experience. The students who had this experience were the first to volunteer to take responsibility for the video element of the group work.

Student’s video editing experience was evaluated with 59% of students having experience in video editing software as shown in Figure 29.

![Figure 29: Responses on student video editing experience](image)

Students were again asked to elaborate on their experience of video editing software.

“I have used Windows Movie Maker previously to make small promotional videos”.

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“Edited the clip using Windows Movie Maker”.

The majority of experiences of editing software was using user-friendly designed software such as Windows Live Movie Maker, iMovie etc. Those with more experience used more technical software such as Adobe Premiere and animation techniques.

When asked if they had access to a computer or Mac at home, all students that responded had access to their own machine at home. Figure 30 graphically shows this result.

![Figure 30: Student responses on access to a PC or Mac at home](image)

This was then elaborated to find out what type of operating system they used to ensure that recommended software would be available to all platforms. The results from this question are shown graphically in Figure 31. The majority of students used a Windows-based operating system with three students using Mac orientated software.
Student’s experience editing and recording audio files demonstrated that approximately 59% of the students who responded had experience in recording and editing audio files. Figure 32 illustrates a graphical representation of the results.

When further probed on their experience with audio, a large number of students at 68% had not created a separate audio file and then imported within a video. Figure 33 shows the results of this in respect of participant numbers as well as percentages. Figure 34 shows the results of student’s access to a microphone.
Students were less confident in the use of audio editing and creation than they were with video editing. 50% students had no access to a microphone which when combined with the responses on experience with audio, identifies an area that will need additional support and resources.

The final question illustrated by Figure 35, rated the confidence of students using Microsoft PowerPoint. This rating scale question depicted a general consensus of confidence when using Microsoft PowerPoint with the majority of students rating themselves between confident and very confident.
A general analysis of the responses from the first year module cohort skills audit demonstrated a clear and mixed range of abilities and experience relating to the production of videos, audio and Microsoft PowerPoint. There were clear discrepancies between results shown on the skills audit in comparison to literature stereotyping a digitally literate student, particularly among the younger students entering university (Jones et al., 2010b).

4.1.1.1.1 Breakdown of for interdisciplinary design project (PRCE510 and DSGN502)

The next section will outline the audit responses from the master’s level students out of which ten students responded. The same questions were used for the final year students beginning with questions surrounding the students experience with video production. Out of the respondents 50% of students had experience as shown in Figure 36.
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When asked to elaborate on their experience the majority of students who responded referred to their knowledge as amateur level and only in a personal context.

“Very amateur home film productions using video cameras, no editing or anything like that”.

“Using camera phones and handheld camcorders”.

Experience using video editing software was again equal, with 50% of students having experience with software use for editing as demonstrated in Figure 37.
On further exploration, students experience was for the majority, at an amateur level for personal use. One student had experience in using Adobe Photoshop which is industry professional video editing software.

"Editing the mountain bike footage that I recorded on my handicam. I used a program like movie maker, but a bit fancier"

"Windows movie maker basics and extensive Photoshop editing"

Student’s access to a machine at home was 100% conclusive with all students having access to a PC or Mac as visualised in Figure 38.
Similar to the responses from the first year cohort, the majority of student’s operating system was Windows-based with any two respondents using a Mac-based system as shown in Figure 39.

![6. If so what operating system are you using:](image)

**Figure 39: Student’s responses on their personal operating system**

Figure 40 shows the results on student’s access to equipment for video recording, with 40% of the students not having access to technology that supports video recording. As many smart phones and tablets contain camera functionality, this representation does show that not all students have this availability. As mentioned in the literature review, there is an increasing amount of students who are bringing their own devices to the University environment, as these results show this is not universal across all students. It is therefore
important that institutions ensure that students have access to equipment if they are required for an assessment.

![Bar chart showing results of student's access to video recording equipment]

Figure 40: Results on student's access to video recording equipment

Results around audio recording were similar to the first year skills audit with more students having less experience and ability to create audio recordings as shown in Figure 41.
Figure 41: Results on student's experience in audio recording

Figure 42 reflects the limited knowledge of creating external audio recordings for importing into a video project. 70% of students had not created a separate audio file and would therefore need additional support available to them for creating the video project.

Further exploration in the open-ended question found that the students who did have experience with those who had been using videos in a professional context and were comfortable using the technology.

“Recording footage - putting voice over - adding music”

“For the mountain bike films I made I would dub music into it. This would involve cutting and levelling the music at the right points”.

Students who had access to a microphone for this project were proportionally higher at 60% to those who didn’t. This is reflected in Figure 43.
The final question on student’s confidence in using Microsoft PowerPoint shown in Figure 44 were placed slightly higher in the confident scale to those of the first years. The majority of students placed themselves between confident and very confident with no students rating themselves as unconfident.

The final year Masters student’s results were more varied than the first year responses. The creation and use of audio recordings in videos was not an area that the students were overly confident.

In addition to the first years, the final year students would also benefit from detailed resources on creating audio effectively the nature of the project. However due to different types of recording devices mediums, this would need to be flexible and take into consideration different outputs such as .MOV files and .mp3 etc.
5.2.3.1.2 Summary of the skills audit responses

As the skills audit was non-compulsory the participation level was low. However, some generalisations can be formed particularly within creating audio files and processes behind video editing.

Despite much literature surrounding bring your own devices (BYOD) discussed in Chapter 2.5.8, it is clear from these limited results that institutions should not assume that students have access to equipment with recording capabilities etc. It is therefore important to ensure that the assessment is inclusive and students are supported to allow them to produce coursework of high standard.

Based on the feedback received from the skills audit, additional online support was uploaded to the student’s virtual learning environment on both module cohorts which was discussed in Section 5.2.2. This included links to online resources created externally, information on where students could loan equipment and links to various pieces of software that students could use to produce their design concept video.

The next section will discuss how students produce their videos and include examples from the 2012/2013 cohort for IDDP.
5.2.4 Results of student’s work –design concept videos 2012/2013

Students submitted their initial design concept videos in the middle of December 2012 and their final marketing video in April 2013. The examples used in the following section were taken from the April 2013 submission.

The final year students, due to the nature of their skills and experience, produced high-quality pieces of work incorporating elements of their virtual reality models and CAD work.

Examples taken from the 2012/2013 cohort of students used within this study utilising a VR element of their videos are illustrated in Figures 45, 46 and 47.

Figure 45: Example of VR work from IDDP submissions
Figure 46: Example of VR work from IDDP submissions

Figure 47: Example of VR work from IDDP submissions
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The students took ownership of the videos and wanted to make them as high-quality as possible to showcase their skills and work they had spent the majority of the year working on.

Within the videos, the majority of groups in the final year cohort incorporated VR walk-throughs to visualise and convey their design concept. All IDDP groups produced a CAD model of their design, but the animation of the modules created a complete walk-through of their designs and allows the viewer to understand the reasoning behind their design. During the literature review, the use of virtual reality models in Engineering Education is on the increase (Sampaio et al., 2010), many educators are beginning to realise the potential of embedding virtual reality as part of the design concept process (Daud, Taib & Shariffudin, 2012).

Students created names for their project groups and treated it as if it was a real business. To convey this in their videos, some students booked out rooms and recorded scenes as if they were having a project meeting. One student group gave each member of the team a realistic role that you might come across in a real engineering consultancy firm, including housing officer and project manager. The group introduced their roles in the video using a short film with the title and role of the person in displayed on the screen. This is illustrated in Figure 48.
Another group recorded their ‘group meeting’ and had the design concept model playing in the background which is shown in Figure 49.
In other submissions, groups used other multimedia methods to help convey the design concept and demonstrate work they had undertaken during the project. Some students used Microsoft PowerPoint, but embedded video and page links to make it appear like a website. This is shown in Figure 50.

Figure 50: IDDP multimedia techniques in video submission

Students also included animated photos to evidence planning drawings and designs they had used as part of the project as illustrated in Figure 51.
All of the students used voice-overs in their videos to talk the viewer through their design process and how they researched their work. Other groups used software such as Google Earth and had printed T-shirts made in the same design and logo as their video in preparation for the open day. They wanted to show potential employers attending the open day, that they took their project seriously and felt it gave invaluable experience of how an engineer might work in industry.

The students work was of a high standard and when given creative freedom, students used different digital techniques to convey the design concept in their video. Some of the techniques used within their presentations had not been supported by module staff indicating that students had either taught
themselves or had existing skills. As the skills audit did not identify existing experience, speculation of students self-teaching additional techniques was made. To further explore this, the next section of results will discuss the evaluation of the implementation of alternative assessment using focus groups.

5.2.5 Results of “Evaluate” element – evaluation of focus groups

In order to evaluate the impact of the implementation for alternative assessment within the modules, two focus groups were carried out following the submission of the students design concept videos in term one.

The first focus group consisted of nine first-year undergraduate students who had recently completed the design concept video in the DSGN 143 module.

The second focus group consisted of nine final year engineering students enrolled on the IDDP module who had also recently completed and submitted their design concept video.

Focus group techniques were used as an effective way of gathering qualitative data on student’s views and experiences. As discussed in the methodology chapter, focus groups are advantageous in allowing the researcher to explore participant’s knowledge and experiences and quantified justification on why a participant feels the way I do about a certain topic or question.
Stewart and Shamdasani (Stewart & Shamdasani, 2014) identified that the most effective qualitative data gathered is between the discussion of the participants themselves. The researcher is then able to further explore points raised by the participants to understand a topic or question more fully (Gill *et al.*., 2008b).

The next section will describe how the data resulting from the focus groups were interpreted and managed using a combination of manual and electronic methods.
5.2.5.1 Use of Nvivo for data management of focus group evaluation results

All five of the focus groups were fully transcribed in accordance to University ethical clearance procedure. Documentation evidencing ethical clearance can be found in Appendix 9.3.

The transcription data was imported into NVivo 10 which is a piece of qualitative research data analysis software (QRDAS). This software is a popular choice of analytical software for qualitative research as it allows the researcher to draw out themes in textual and multimedia qualitative data. However, in this study the software was used to facilitate and manage the data collected from the focus group evaluations.

Each individual focus group was imported into NVivo and data was analysed by manually categorising the textual data into common themes and by the questions raised in the focus group. A diagram of the nodes created for the evaluation the focus groups is listed in Appendix 9.10. According to Basit (Basit, 2003), the process of coding is the most crucial part during the analysis and organisation in qualitative research.

The next section of the results will introduce each of the focus groups were evaluated during this cycle of the action research.
5.2.5.2 Analysis of focus group one

The first focus group to be analysed was focus group one, which consisted of nine first-year undergraduate engineering students who had recently completed the module DSGN143 and had participated in the new method of assessment using video.

The next section will discuss the results from the first focus group and highlight key points derived from the data.

5.2.5.2.1 Results of discussions surrounding design concept skills in engineering students

The first part of the focus group discussed themes around design concept skills and engineers, including a recent quote that proclaims that engineering students lacked conceptual design and ideation.

The quote served as an icebreaker and initiated discussions around the concept of design abilities in engineering students. The quote was printed and given to the students to read:

“Today’s engineering students are proficient in detailed design tools but lacking in conceptual design and ideation” (Taborda et al., 2012).

In the first focus group responses to the quote were mixed, some of the students felt that conceptual design and ideation is not a topic that can be taught, and is only learnt through experience.

“I would say it’s not something you are taught, conceptual design and ideation. Certainly I don’t feel I’ve been taught any of that, but it’s not
something that’s lacking with all the students. I’m not particularly good at it myself, but there are students within my group that are very good at conceptual design and have come up with ideas completely out of nowhere”.

Other responses mirror the literature detailing the concerns of industry over students being proficient in software rather than understanding the pedagogy behind it.

“I do kind of agree with it. I take the point that some students, you know, are just very good at using some of these pieces of software, but in general it’s the exception rather than the norm”. We’ve done all the calculations and we’ll know it works, but seeing that thing, there’s no link between doing the detailed design and conceptual sort of visualisation of that design”.

Elaborating further, some students felt that these skills would only be learnt by working on large-scale projects in the workplace.

“I’d be tempted to say almost, like as students until you’ve had sort of, seeing as we don’t have experience working on large-scale projects, it’s hard to sort of teach conceptual design as a separate thing. I think it’s almost something you kind of have to pick up from working on an actual project or something really I suppose, from sort of maybe building on tools that you’ve learned sort of specifically”.

One student described engineering as a theoretical taught subject and didn’t see the need for conceptual design in the curriculum.

“Traditional engineering subjects are very theoretical as well. So it doesn’t sort of have the need for that sort of conceptual design”.

Students who disagreed with the quote focused on their experiences in using technology to form a design concept and felt they had sufficient skills in being able to understand and come up with an overall design concept for a project.
“I think I would tend to disagree to some extent as well, especially from what I’ve just done recently in DSGN143. As you say, Solidworks has very much got sort of rendering capabilities and stuff, that’s why we’ve done a lot for this recent project in sort of visualising and a complete design, sort of an overall view of how that would sort of come together has, yeah, it’s quite been a key bit really”.

Students’ ability to conceptualise their learning has come into discussion frequently in both engineering and architecture literature in recent years. It has been argued that the evolvement of technology in computer aided design (CAD) software has produced a group of students who are proficient in using software but have limited skills on the logic behind the design concept (Daud, Taib & Shariffudin, 2012; Ye et al., 2004).

5.2.5.2.2 Results on views of interdisciplinary design project work

The students were then asked to reflect on their experiences within the interdisciplinary design module. The first question explored the student’s views on what parts of the modules they enjoyed.

Whilst literature discussed in Chapter 2 argues on the appropriateness of using software to form a design concept, students particularly enjoyed using technology to communicate their design concept.

“I’ve particularly enjoyed actually using the software to sort of model ideas that we’ve come up with, or I’ve come up with personally, and use that to sort of communicate exactly what your thoughts are. Because you can have a picture in your head, sort of quite a grand sort of scheme and
it can be, you think it’s really good, but to give somebody else that same sense of how everything fits together, the whole, as I say, sort of design concept, can be quite challenging without, for example, using some sort of software to do a VR model. That really helps communicate, so that’s been really good”.  

The use of virtual reality (VR) in the students’ work was evident within the group and was an area that students particularly enjoyed working in.  

Working within mixed discipline groups was a popular with the majority of the students.  

“DSGN143 was really good because it was the mixed disciplines, so you were working with people from other courses, which made it really interesting I think, seeing how they all linked together”.  

“It’s quite good to have somebody come from a slightly different perspective just because they go about doing things a different way from what they’ve learned. So that can kind of keep things fresh and sort of help you not get stuck in a rut on one way of thinking that might not always be the best, so that’s been good”.  

For many of the students working in an interdisciplinary mode allowed them to understand and appreciate different ways in which people work and produce ideas. Again reference was made to the use of technology enabling collaborative working and to portray and communicate ideas.  

“I’ve recently built an actual model that we made for our design project. So I didn’t do a lot of the Solidworks, but I had to work with the person that did. So seeing his ideas in Solidworks form, it was a lot easier to make the model and the constructions. Even if you took away the measurements that he’d got for it, it was a lot easier to actually understand what he meant by things if he could show me it on the designs”.  

The students were then asked if any parts of the interdisciplinary design module were found to be difficult. Within this focus group, the first years debated on
whether interdisciplinary work should happen later on in the curriculum as they believed that not all students have the correct work ethic and the work effort was equal.

“I think it’s more of a work ethic thing. I think that’s how you learn, is you go away and you do it. I mean you might not ever use it again, but it’s more the skill of going away and learning yourself, do you know what I mean? Like thinking, “okay, I know how to use that’, like it’s not as though you might not ever use it again, but I think that, yeah, it needs to come later, but more, because then you’ve got everyone on the same page I think, like sort of everyone wants to do that”.

“If the project is too big, you’ve got a small proportion of the group want good marks, the rest of the group don’t want good marks. That puts a lot of strain on the ones that want good marks to kind of keep the work level up, and you don’t tend to get that so much”.

Other discussions around this area saw different backgrounds and work experience playing a crucial factor in how the work was distributed amongst the team. Some of the first years had come straight from school and had no experience in the workplace, whereas others had been in industry and had worked with software and programs relevant to this module.

“I think it’s like testing our knowledge from our previous degrees, or life, or experience. For example, I was in a team with more students who just came from school and they had no experience with these programs, and I made all the 3D program with AutoCAD, because it happened for me to have the experience from an office where I was working for years”.

Whilst interdisciplinary team skills are seen to be crucial in industry, a few students felt the group work was frustrating due to less engaged peers who did not contribute as well as others.

“Everyone else seemed to vanish, just didn’t turn up”.
“I think working in, it was a good point, it was also I think, for me especially, I had quite a bad team in my first year”.

5.2.5.2.3 Use of virtual reality (VR) for design concept process in engineering

Discussions then moved onto the use of virtual reality (VR) walk-throughs within the design concept process for engineering.

Students were asked how useful they felt VR was in assisting with the design concept process for projects similar to what the students had just completed.

All students felt that it was pivotal in portraying the design concept and felt it helped them understand and communicate the idea behind the design.

“For us especially I would say it was critical to be honest”.

“Seeing some of the other projects, it’s quite hard to get an overall, some of them, especially where maybe the actual, physical model wasn’t that sort of great at communicating, or it was quite hard to see. I don’t want to sound too harsh, but so whereas some, groups that have put together a VR walk-through, you can see instantly what the idea is, the intent. It just communicates it very clearly, and sometimes to try and pick out sort of language through the report or whatever, you can clearly tell something straight away”.

Whilst discussions were positive around the use of virtual reality in engineering design concept, the students felt frustrated they hadn’t been given adequate training in the area and had only recently been introduced to standards such as Building Information Management (BIM) which impacted on their abilities.

“I mean we literally had just been introduced to like BIM, building information management system etc., so we tried to do it on that, but we’d had no training, so first we had to learn it all ourselves, which is fine,
you know, that’s fine. But then we hadn’t even got the facilities available to really make the most of it”.

Conversations moved on to discussing the roles of traditional building models and virtual reality and which gives the better understanding of the design. Students were asked their opinions on what they felt give a better understanding; a physical model, a virtual reality walk-through or a combination of both. To gain further qualitative data, students were asked to expand on their answers.

The majority of students from this focus group leaned more towards the idea of a combination of both methods.

“Yeah, definitely a combination. You’ve got them both physically there. With us we had the VR model literally right next to the physical model so people could, like watch, or look at the VR model virtually, but then even then sometimes you want to like touch it, you want to see how it’s actually going to be put together I guess”.

Students were cautious of the appropriate methodology to use depending on their project. For example some students felt that a large-scale project would justify the need to have a physical model to give an idea of scale.

“It’s getting the amount of detail right as well, like you were saying. Like on a large-scale it’s just getting proportions really, isn’t it? It’s to get an understanding of scale, whereas a VR model is less about that, it’s more about the sort of visual, impressive bit”.

In other examples, students felt that VR was a more flexible approach to demonstrating a design.

“Some things you can put in the VR one that is impractical to put in a physical model”.

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5.2.5.2.4 Teaching of Engineering Education

Students were asked to reflect on their experiences of Engineering Education as a whole and discuss what methods they had preferred. In this focus group students focused on the teaching ability of the lecturer rather than the method in which they distributed the teaching.

“Sometimes you have one lecturer and he makes the subject seem awful. And then next year you’ll do the same subject and you have another lecturer and all of a sudden, “oh, I really enjoy this.” So the lecturers make such a big difference”.

Many of the students referred to the teaching staff of many of their lecturers being too traditional which in turn made the students unengaged.

“I think it’s probably a bit easier when you can interact, like sort of, maybe than rather just traditional lectures, it sometimes can be more useful when you’ve got a bit more interaction between people and the lecturer or just between yourself really, just to discuss something”

“But yeah, we’ve had some amazing teachers and we’ve had some absolutely awful teachers, and yeah, that’s the big thing to me. Some people want to teach, some people really care about students and what they are learning and they are always there to help and to give feedback, some just want to get the hour over with and get back to their office”.

The students discussed the use of Technology Enhanced Learning in their modules and referred to instances where lecturers had used technology to enhance the learning process.

“We had a Structures lecturer who recorded his lectures and then put them up online, webinars, or something like that, and they are really, really good”.
“I mean it would be good maybe in more traditional lectures if it was just like a shot of the board, or whatever, you know, with all the sums on it, but then you’d have the problem of never going to lectures so”.

However, where lecturers had created material such as podcasts, the students felt this would deter students from physically attending the lectures. Debates then continued about whether this would create a ‘lazy student’.

“You don’t want to make students too lazy though, do you?”

During the discussions around Technology Enhanced Learning in Engineering Education, it was evident that students had used their own initiative to gain further knowledge around subject. Many students had utilised YouTube to find tutorials and guides on how to use software.

“I have been on You Tube at times”.

“Yeah, there’s some really good stuff on You Tube. Certainly with new software and followed it through, and it’s quite a nice technique to do it”.

To follow on from this discussion, the students were asked if they felt that the teaching of engineering would change at all in the future, and if so how. Whilst some discussions on their hypotheses were raised, most students started to discuss how they would want to change.

Some students focused on more project-based interdisciplinary work as they believe this is how engineers work in practice.

“I think more and more people are looking for it to be sort of relevant by the time, maybe more project-based stuff perhaps? Because at the end of the day, when you go into work as an engineer, that’s what people are going to be looking for you to work on a project usefully, I mean it’s not going to be kind of “here’s a little chunk of module for you to do.” You’ll
need to work in a team; I think there could be more towards that kind of stuff perhaps”.

“Especially as these days, you are probably less likely to have several engineers from different disciplines, like you might have an engineer who would be expected to actually know a bit more outside your discipline as well, even if you say had done civil or mechanical, you would be expected to be able to cope with a bit, sort of, a variation there. So yeah, more interdisciplinary things are probably the way it’s going to go”.

The idea of making an engineering course more coherent was also raised, where students felt there was no structure or link between modules. They often felt frustrated that some lecturers were unaware of what they had been told previously in other modules and time was wasted going over material that they already had learnt. In contradiction, some students felt there was an expectation that they had already been taught something from the reality was they hadn’t.

“I think it would be nice if it seemed like there was more communication between different modules. Because sometimes, there’s been a few occasions, especially with the coastal stuff where we’ve been expected to know something in another module that we didn’t know because it wasn’t taught to use in coastal. But that person thought that we should have learned it, so we ended up having to go through all of that again. And just maybe make the courses a bit more coherent, so maybe there’s a few running themes through them, even use modules to do like bigger projects”.

5.2.5.2.5 Discussions around the prototype to support the video design concept assessment

Discussions moved on to the work they had recently completed on the design concept video assessment. Reflecting on their work, students were asked what could have assisted them in understanding the design concept process and
assessment. The concept of the prototype toolkit was discussed with the students which would later form the baseline for the contents of the toolkit.

“It would be good for groups that didn’t have prior knowledge of things like video software, especially in sort of DSGN143. If it just showed the workflow and process that you’ve got to do, because most people didn’t quite understand that, so I think that would be good if it was sort of tailor-made to each course”.

“Yeah, definitely because like there has been times where I haven’t actually known where to go for a resource, so if there was something to just like swipe on your phone, and like say you wanted to buy some materials, like I had no idea you could buy materials in Brunel until like a month ago. So just swiping your phone to see if you could do that would be pretty good”.

Many students made reference to the idea of being able to access something on their phone. To explore this further the students were then asked if they would access a toolkit using their mobile device, and if so, how important would it be that it was mobile compliant.

“I think a good way of looking at it for a start is to think about the layout of the projects that we are given. I mean the fact that we have to do things like scopes. So because, you could say “well these are tools for doing that, and these are tools for doing that”, but when you do your scope, and when you do your outline of what the project’s going to be, you need things that are going to help with locations and things like that”.

The majority of students felt that they would access the toolkit using a computer because they would already be at a workstation creating their work when needing to access it. However, the students that felt they would already use their mobile device in conjunction with the workstations.

“I think tablets would be quite good, just because I use, I have my desktop and I use my tablet at the same time, just because, like dual connection”.

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It became evident that it user centred and each student had their own way in which they worked.

“It’s just a habit, like to be able to just, like everyone’s got a phone now, so just to be able to just go “oh right, what do we need to do?”

“I still say that, to me, there’s a big distinction between what you can do on a mobile phone and what you can do on a laptop”. 

Results from this section of discussion were later used to form the baseline for the prototype that would be implemented in cycle two of the action research discussed in Section 5.3.

5.2.5.2.6 Impact of technology in working practices in engineering over the next ten years

Results around the impact of technology on working practices in engineering were varied. As this particular sampling group were first years, not all of the students would have had experience in industry and some speculated that the working environment is still quite traditional in terms of engineering.

“A certain generation isn’t quite up for that much change yet, and if you bring an iPad onto site they’ll probably just laugh at you”. 

During this section of the focus group students discussed the use of BIM and how it would become an integrated part of engineering work. However, students were aware that in order to implement a large-scale technological change, significant resource and investment was needed which came at a cost
financially. Students alluded to engineering being somewhat traditional in the way that they work and aren’t always open to change.

“To get everyone working, yeah, to get everyone working on the same, off the same hymn sheet, it’s going to cost so much money, and you have to literally change things from the technological side of things. You have to change the attitude of people, you even have to change the whole way a project is put together, you know? The way a project has worked for probably hundreds of years pretty much, you know, you have to change all of that to bring all these new kind of integrated systems in where everyone is working off the same file as Tekla and Revit would like you to. So that’s going to be the biggest challenge is who is going to pay this money?”

Furthermore the students believed that the Internet would continue to have an influential impact on the way in which engineers work both in project teams and in isolation. Cloud computing was mentioned significantly during this section, with a lot of students already working collaboratively using cloud systems such as Dropbox.

“I think like Cloud systems are going to be used massively”.

Further speculation included the possibility of rendering and analysing online instead of relying on in-house computational power.

“Just for doing like final analysis stuff as well, because then companies won’t have to have all the computing power, they’ll just have an internet connection”.

“With the Cloud things, you don’t need a massive outlay. I mean there’s still some way to go, but if you can, for example, work on a project and then you say “okay, I need a render of this”, send it off, you don’t need the big outlay to be able to afford a big rendering file on your own premises”.
Students felt that technology would enable smaller companies to be more competitive to larger companies.

“As technology gets cheaper it sort of shortens the gap between larger companies and what they can do and smaller companies”.

5.2.5.2.7 Conclusion of focus group one

The aim of the focus group was to obtain students views and opinions on areas relevant to the research in particular:

- views on engineering design concept skills
- reflections on work carried out on the interdisciplinary project
- feedback and evaluation on the design concept video assessment
- discussions around a proposed prototype toolkit to support the students in the creation of the video work
- discussions around Engineering Education, including speculation over changes to the way in which engineering is taught in the future and the impact of technology within this

The first year students in this focus group had a mixed background, with some coming from industry and some straight from A-levels in colleges. Students focused very much on the technology when discussing the design concept skills rather than the core engineering skills. VR walk-throughs and CAD modelling featured highly during the conversations and students felt that more educational emphasis was needed on industry based standards such as BIM.
They felt that design concepts and ideation was not an area that can be taught, and is only learn through experience alone such as placements.

The students felt that working within interdisciplinary groups helped shape their design concept work and gave them an appreciation of different learning styles and methods with their peers. Working with students from different courses helped build the students skills on problem-solving as each student had different ways of approaching the task. Motivation to work on the first year was however seen as a frustrating element for a few students. Some students experienced lack of motivation with their fellow peers and believed they didn’t really care as the marks in the first year weren’t factored in to their final year course. One instance was stated where a student had only two members in the group contribute to the group work.

Teaching methods were seen to be lecturer driven rather than the way in which it was delivered with many students feeling disengaged with traditional style lecturers. YouTube and other technology driven methods were favoured with students who wanted them to be used as an enhancement to their learning. However, most of the students believed that implementing technology would deter students from attending physical lectures.

The concept of providing students with pod casts or recorded versions of their lectures was heavily discussed and where students had witnessed this, they wanted it to be consistent through all the modules and courses. The use of such
technology in teaching seem to be an isolated case and most lecturers had stuck to the traditional mode of lectures and only provide the students with PowerPoint files on their virtual learning environment.

The next section will introduce results from focus group two evaluations.
5.2.5.3 Analysis of focus group two

Participants from this focus group consisted of final year mechanical engineering (MEng) students who had recently undertaken the interdisciplinary design project (IDDP) module. The aims of the focus group are the same as focus group one which is discussed in Section 5.2.5.

5.2.5.3.1 Results of discussions surrounding design concept skills in engineering students

As with the first focus group, the icebreaker quote was used to start the discussion. Many of the students had recently done a placement year in industry and the majority of students within this focus group agreed with the quote.

“I done a placement and I know we get taught obviously all the detailed design stuff, certainly the structural design and things like that, but it’s really important that we can visualise how things go together so that we can make something that practically works, rather than just sort of works on paper”.

“We get taught a lot that’s design a single element of a structure, so a beam or a column, but learning how they all fit together in the whole building is something we don’t do”.

“One thing I noticed when putting our building together, especially with services, is usually we just put our columns, beams, seal it all and then we figure out how do we have vents, piping, electrical work going up through the building? So then we have to just redesign it straight away anyway, because we just forgot about some stuff, which we never even really thought about”.

Whilst discussing the quote students referred back to the design concept video project and felt that it helped them reinforce and put into practice everything that they had learnt during their course.
“I think also as well, since we’ve done this video this final year, it’s sort of, and I’ve done a placement as well, so I can sort of visualise what I’d be doing as an engineer, and I think it helps me realise that if I was to be in practice, maybe this would open my eyes now. I think “well that could be something else that I could use if I was put on a project, to help support our design”, or something like that, which I wouldn’t have thought about before, and I think that now, you know, it’s something that’s lacking in industry. I think if it was used a bit more it would have a lot better effect”.

The use of CAD tools in engineering courses is often met with controversy in Engineering Education literature, arguing students become proficient in the use of the tools rather than design concept skills. However, the students in the focus group felt that the use of these tools enabled them to visualise and create their work.

“You can put it together so quickly because there are so many variables in a building design that you can’t possibly visualise it all in your head, so having an easy to use 3D package where you can really quickly put something together and help you, then look at the whole building concept, it’s really”.

The majority of the group therefore agreed with the quote and believed more interdisciplinary design project work in the curriculum would help create the students proficient in concept design and ideation.

Following on from the quote students were asked to discuss their understanding of the term ‘engineering design concept skills’. This question aimed to explore the appropriateness and views of design skills in engineering which has recently become a more sought after skill for graduate engineers. The
final year students felt comfortable in their understanding of the term particularly after completing their work in the IDDP module.

5.2.5.3.2 Results on views of interdisciplinary design project work

Students were then asked to discuss their experiences on the interdisciplinary design project work. Firstly students were asked to talk about which parts they found enjoyable including the ‘soft skills’ discussed frequently in Engineering Education research literature.

“I feel the skills that I learned have been really, really good, just obviously your team-working skills, but also, as we’ve already said the computer skills and we’ve done so many different assessments, we did a presentation, we’ve done reports, we’ve done these videos which has been really good fun, like quite hard work”.

“Well I found it quite enjoyable. To get a design from the ground up as well, to start going “we want that type of thing”, then they’ll go “have you got the design?” A design which would actually work”.

Students felt the project based work was a realistic representation of work they would be required to do in the workplace, something which all students found beneficial.

“Yeah, definitely, and something that’s real, like a lot of our projects could actually happen in real life, you know? It’s something that’s needed, you feel like your degree is actually”.

Students felt strongly about the design concept video and felt that it was refreshing in comparison to traditional based assessment. Creating the video was a new skill for some of the students and whilst there were some initial difficulties, most students gained satisfaction from obtaining a new skill.
“I think it’s the most rewarding out of the lot, because it takes a lot of time and there’s a lot of finicky stuff, but when you sit back and look at the finished product, you think “wow, yeah”, really either you see that you’ve done a good project, or you clearly see that it’s not really the best project in the world”.

“Actually learning to use that, apart from being enjoyable, although extremely stressful and then getting to the end and then realising you press a button and it does something that you didn’t realise it did that, and it would be really useful to know it did that, would have saved me a lot of time, but learning to do that and actually being able to do that has been very rewarding”.

Elements that the students found more challenging were discussed. The time taken to create the large engineering report that the students had to produce their groups was underestimated.

“We completely underestimated the time that it would take, just to put it together at the end. We’d done a lot of really hard work, detailed design work, throughout the term and then just actually collaborating everyone’s work and then sort of integrate the different sections together, and just make the document sort of neat and presentable was so, so hard work”.

Students also commented on the need to see some case study examples from previous years to gain an understanding of the purpose of the video.

“It would have actually maybe been quite interesting to have seen presentations from other groups and things, because I’ve only just seen the videos that other people have done now, and it’s interesting-looking”.

A competitive stance was seen with the students particularly during the creation of the video. Whilst this came up in conversation and was referred to as a challenging part of the work, students also felt that this was positive as it made them work even harder to compete against their colleagues.
“I think I felt was the hardest aspect was thinking that we’ve done something fantastic and then seeing your next-door neighbour doing something even more better”.

“It was like a constant challenge who can do the best model, and that’s what took time and made, you know, gave it like a bit of finesse”.

“You see somebody else done that little bit extra and you think “well let’s try that”, you learn this and learn that. It’s definitely a very good learning curve”.

Literature discussed in Chapter 2, identified affective pedagogic practices of design based competitions (Buchal, 2011) and how they engage students through healthy challenges against their peers. Similarly to studies found in literature, students took ownership of their work and due to the nature of the competition (Lemons et al., 2010), made extra effort into producing a high quality piece of work.

5.2.5.3.3 Use of virtual reality for design concept projects

The next section discussed the use of virtual reality in engineering design concepts.

The majority of students felt that VR walk-throughs enabled people to understand the concept behind the project design.

“I think it’s incredibly useful for presenting your idea to someone that has no idea of what your project is”.

“You could almost just put the VR walk-through on and just sit there and watch it without anyone saying anything, and you could get so much”.

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One student did however feel that it was more useful in the public domain setting for example a presentation and did not feel that an engineer would use it much.

“It’s more arty and quite, you know, just clients, just for the public, if you have like a, I can’t think of the word, like a presentation for the public and just have that, but, especially an engineer you wouldn’t really use it as much”.

This contradicts literature surrounding the increasing use of virtual reality in engineering, in particular design concepts. Engineering Education literature references the growing trend of using virtual reality in engineering teaching modules and work. Studies were beginning to emerge on the effectiveness of incorporating virtual reality within engineering programs and their effect on the learning process for engineering undergraduates (Abulrub, Attridge & Williams, 2011).

When asked if it gives somebody an understanding of the design you’ve done, a physical model, a VR walk-through or a combination of both, the final year students had different views to those of the first year students from focus group one.

They saw a physical model as costly in terms of time and investment.

“It costs so much money and takes so much time”.
“For like a 3D scanner that you’ve got over in Smeaton\textsuperscript{2}, it’s £500 just for something that big. You can’t get any sort of scale on that, so to do something decent is going to be a couple of grand”.

“I think with technology progressing as well, I feel like the general like old view of how you would look at something is if, you walked past somebody with a physical model, sat down, which was half decent but spent the same amount of time, or you had like two screens with this virtual model spinning around and zooming in and out, you know, there’s no contest really is there?”

The general consensus of the group found physical models to be limiting when presenting to an audience. You can only get a few people around a physical model whereas a VR walk-through can be shared and displayed to any size audience.

There was a preconception that people would prefer VR walk-throughs due to its technological foundations.

“\textit{There’s an outright winner straight away, isn’t it? Because people like technology}”.

“\textit{Really, we are not used to making things, we are used to clicking and typing}”.

Students appeared to stereotype the notion of technology being popular and part of everyday society. Virtual reality walk-throughs were referenced by the students as technology suited to communicating design concepts to novices.

The content and ideology behind virtual reality was discussed on a large scale, with the majority of students referring to virtual reality in a positive manner.

\textsuperscript{2} Smeaton Building is a location on University Campus where the students carry out their practical work.
5.2.5.3.4 Teaching of engineering

When discussing teaching of engineering, a small percentage of the students felt that the first two years of their course was spent learning how to learn. They also felt that the only method of learning was the traditional mode of lecturing with the instructor at the front of the class.

“Certainly you can’t banner engineer into one term, but certainly for the first stage year or two it’s your basic engineering skills and you can only learn that by pen and paper, guy out the front, I think”.

“We learn how to learn in a way. So you learn how to learn your own way as the years go on. I learn more by self-teaching I think now rather than lectures”.

Student’s then went on to discuss their requirement for industry critique on their proposed projects to investigate if their work was a viable option in practice.

“Fantastic, really good just to have that 20 minutes feedback, just to see whether it’s an actual viable option in industry”.

“Industrial contacts would have been fantastic”.

They felt industry was not really spoken about until students went on placement, which by then is too late as many indicated that what they have been taught in the curriculum was not representative of working practice and industry.

“Industry is not really spoken about in the course. So guys that have done, placements, and we’ve come in to do this course, we’ve had a different approach to guys that maybe haven’t. Bringing our ideas together in ways was very good, we’ve come up with very strong ideas, but in other ways when we went to see ***** and *****, they’d say “we don’t want you to do it like that, that’s not how we want you to do it for
the course”, and we found that very hard to get our heads around, because we thought “well if it’s like that in industry, why can’t we incorporate that into our degree and show you what we’ve learned?”

Students felt frustrated by the lack of contextualisation within their studies to working practices in industry. The ability to contextualise their learning was discussed further in the focus groups. Students wanted to be able to look outside of just their project and see how their work would fit into a local scenario or case study.

“I’ve really enjoyed that and sort of the wider scheme, like just looking at whether there’s demand for it, how it fits in with the redevelopment of Plymouth, things like that”.

Vast amounts of engineering literature details the need for Engineering Education assessment and content to be driven and related to working practices in industry (Arlett et al., 2010b; HM Government - Department for Business, 2012; May & Strong, 2011).

Responses regarding how the students saw the teaching of engineering changing in the future were heavily focused on the impact of emerging standards in engineering sectors BIM³.

“This year they have recognised that you do need the CAD skills, you do need the Revit skills, the VR modelling sort of stuff, but more, coming back to this right at the beginning”.

Technology also factored into the discussions with students noticing small changes in some distribution of the teaching. Comparisons were made to

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³ Building Information Modelling (BIM)
Results of Action Research

traditional teaching methods such as lectures with lecturers who have produced alternative material to support the students learning, such as video.

“I think going back to like you just said, the way it’s changing, I think we’ve already noticed it already, because one of our lecturers who joined last year. When we got taught AutoCAD, for example, in year one, it was basically “here’s AutoCAD, here’s a PDF, work it out”, and you sort of went through each stage. Whereas now, one of our lecturers, he’s teaching Revit, but he’s not teaching Revit, he’s still at the front and every student is on their own computer watching a video from You Tube. They are just watching each step, and they’ve got like six hours or whatever, six individual hours to watch and then once they’ve finished that, they do a bit of coursework on it, so, he’s not even teaching. But it’s a lot better than reading a PDF and trying to figure out...”.

Students perceived this lecture as not teaching, when in fact the lecturer was simply using alternative medium on which to communicate key learning objectives. However, the majority of the students felt that the use of videos and teaching methods that enabled students to learn flexibly when needed in teaching.

“I do think that in terms of new teaching methods, like videos and things, are incredibly useful because you can just watch them in your own time”.

The use of technology in education opens up new methods of delivering the teaching and learning to students in a more flexible and innovative environment. By giving students ownership of their learning, the responsibility of learning is passed from the lecturer to the students which encompasses the key themes found under student centred learning (SCL) pedagogies (O’Neill & McMahon, 2005).
During this discussion students also emphasised disengagement they had both experience and observed during their course.

“If you are at the back sometimes it’s hard to hear and then you are lost for the whole lectures. You might as well not be there”.

Students discussed how technology has helped enhance some of their previous modules and how they were able to continue their learning outside of the classroom in their environment. The use of podcasts were mentioned frequently within the focus groups, mirroring the growing popularity of the use of podcasts to enhance teaching and learning (Hill & Nelson, 2011).

“I mean one of the things in the coastal, which linked us to like podcasts and things, you can download those and like listen to them when you are in the car and stuff, and that’s really useful”.

Other general comments around the future of how engineering will be taught, technologies that supported the BIM process were speculated to have a great impact on the curriculum.

As identified in the literature review, changes in industry practice are implemented quickly in businesses but Engineering Education curricula is slower to react to changes (HM Government - Department for Business, 2012). This was strictly applicable with the implementation of BIM by the government with students being aware and keen to have this applied to their studies.

5.2.5.3.5 The role of an engineer

Conversation escalated and students began to debate the role of the engineer in creating videos.
“My comment would be, is it really the engineer’s responsibility to create the videos, the actual videos? Maybe we could create the walk-throughs and some media people who really know how videos should go together, should create those videos”.

“I think if companies are trying to cut budgets it’s becoming more and more the role of the engineers to do the CADs”.

“I think that probably is the change of market, building information modelling and things. You are seeing less of the traditional hierarchy of engineers, draftsman and it’s all a bit isolated”.

Changes in markets and financial cutbacks in the construction industry were mentioned where students believed engineers would take on a more versatile role. The majority of the students had undertaken work placements in industry and had observed these changes which led them to the speculation of a new type of engineer emerging. One student summarised their view:

“It’s evolving into one job, isn’t it? The integrated engineer”.

This view is certainly reinforced by more recent literature and Engineering Education research stating that engineers now have to do much more than just solve the problem; they must also learn how to project manage, design and bring business skills into the role (Martin et al., 2005).

5.2.5.3.6 Discussions around prototypes to support the project

During the focus group, conversation reverted back to the work around the design concept video. The final year students saw this as a fundamental part of their work and made several suggestions on how to improve the application of the assessment. Data extracted from this helped form the content framework of
the prototype toolkit that would support the students when creating their videos.

Recommendations again fed back to the idea of nominating some key software that students would start from.

“This second video has been a bit easier in the sense that we know where to start. I think the first video was quite stressful because we had a lot of people saying “oh this program’s good” or “this program’s good”, and a lot of messing around”.

The students who participated in this focus group of final year students had not been exposed to the concept of the video for assessment. Suggestions were made of embedding this methodology of assessment from the first year and ensuring this was carried on throughout the course to create consistency.

“I would say probably the best thing is to do something with videos in the first year and then constantly get us to do them as we go along, because presentations, we had to do a presentation for one of our modules in the first year”.

Students felt they had no initial guidance or recommendations on the appropriate programmes to use. The assessment criteria gave students complete creative freedom on the choice of the software etc., however the majority of students felt they would like some recommendations for those that had no experience.

“I mean we didn’t even really know which sort of program to use and everything”.

“See that would have been possibly useful, just recommendations on computer programs to use and then like how to do really basic stuff in it. Then from there you can sort of work out how to do more complicated.”
“I think recommend one program, have some sort of PDF tutorial...and say “follow this through at your own pace”.

Content listed in a chronological way was mentioned as being something the students felt was needed when discussing what content should be in the prototype toolkit.

“If it’s structured and it’s chronological and you say “right, okay this is the way I should be doing it”, that would be very beneficial”.

Other students felt the toolkit would need to bespoke but that they didn’t want information spoon fed to them and wanted the option to make their own choices and experiences to their work.

“I think things like that are fine, but something that to a certain extent annoys me is like, you know, the university is tending towards spoon-feeding students, giving them all the information they need online, so they can just sit at home and come to exam time, or come coursework time, “do all that, do all that”, and I think, you know, these tool-kits would be very good, but they would have to be...bespoke, because for certain projects, like you know, the IDDP for example, everybody’s project was very different, and I think having something set in stone wouldn’t allow, would maybe restrict students from adding their own innovation, their own experience, their own ideas”.

Students also felt that at times they dismissed lecture content as irrelevant but then later needed to refer to the material.

“The more general stuff, like the video on, well when the lecturer gave the presentation on costing things up and the discount rate and everything like that, there were bits of that, that at the time, we possibly through “they are not really that relevant”, we didn’t particularly take notes. We took notes of bits and missed out other bits, which then it turns out we really should have paid more attention to. So having that video to go back to would have been really great, instead of making those stuff-ups instead”.
When asked how important it was that the toolkit prototype was mobile compliant, the majority of students stated that it was crucial and referred back to the previous points of people liking technology.

“They like sitting and just playing on their phone or iPad, because again, it goes back to people liking technology, they like their new toys and things like that”.

“That’s the way the world’s moving. So being able to have them things would make people have that little bit more motivation and inspiration to actually do the work”.

“I think it’s just everybody, like if you’ve got the material that you need to learn for a lecture, for example, everybody has their own little way. Like ***** said, you learn how to learn and you know, you start to understand how you think, the way you think is best to learn and if you’ve got something so mobile that you can do it whenever or wherever you want, then you can find “right, well I like sitting in my front room with my telly on and just watching it on my phone”, or “I like doing it while I’m on the train”, things like that”.

The use of technology on a mobile platform was discussed extensively throughout the focus group. Literature discussed in Chapter 2 highlighted trends in student learning and how mobile technology on both smartphones and tablet devices are shaping the way in which students learn (Rajasingham, 2011).

The next section will concentrate on student’s views on the impact of technology within working practices.

5.2.5.3.7 Impact of technology in working practices in the next ten years

All of the participants agreed that technology would play a pivotal part in working practices in engineering in the next ten years. The general consensus of the groups that investment in technology was needed due to the recession and
cautious management of finances, not all companies would choose to invest in additional technology. Students had attended a lecture recently from an industry professional who had commented on their new technological system.

“Everyone that attended the two lectures were astounded by what was going on and just, I say simplicity, it’s a very technical and very complex system that they use and things like this, but all the new technology that come in are so efficient, and made the job almost ten times better and he said he’s only, the guy that came in for Bentley, he said he was only a small business, but he was working on £15 to £20 million projects with his small team because of the technology that he had and the product and the service that he could deliver to the client”.

The same student expanded and believed that bigger companies would be left behind and based his viewpoint from personal experience from time spent in placement.

“Big companies are not interested in the moment in doing. Bigger companies are stuck in their ways and for people that have been in industry, especially for me, I was with a huge company, and for them to, I feel anyway, for them to get out of their routine and start using and investing time into looking at new technologies, I don’t think they are going to be prepared to do that any time soon, which is a massive downfall for them. But for smaller up and coming companies like the guy from Bentley, massive opportunities out there for the technology, just by using it and investing a year, two years to get your head around what’s going on. There’s going to be massive change, and I think the big companies could effectively in areas, particularly certain industries, be left behind”.

Further reference to the use of BIM standards on the use of software such as Revit was discussed.

“That’s all about working with computer technology, the latest computer technology, building these building models which we’ve kind of been doing in Revit and things, and using VR walk-throughs to sell your ideas to
clients and things. It’s what’s being used in, if it’s the up and coming thing in industry we need to be on top of it”.

Views from the students reinforced industry opinions that were researched during the critical literature review. When new systems are implemented in the industry, engineering educational institutions are seen to be lagging behind and are delayed in teaching the students appropriate skills needed (HM Government - Department for Business, 2012).

The next section will compare results between the first year focus group and the final year focus group.

5.2.5.3.8 Conclusion of focus group two

The final year students who participated in this focus group had recently completed a placement year in industry. Their experiences of being in industry environment was reflected in their discussions and thought processes in relation to their project.

They were able to contextualise their project work with practices they had seen whilst being on placement and felt that it was an effective and realistic reflection of how an engineer would work in industry.

The students were more reflective and critical of their own work and discussed ways in which they would change their video and work associated with the module if they were to repeat it again.
All students in the focus group spoke favourably of using VR walk-throughs and CAD modelling to convey design concepts. In particular, they were able to refer to experiences of using such techniques whilst they have been on industry placement.

As the students were in their final stages of their course, it was identified that the students had strong motivation to do well within the project and most felt they had spent a considerable amount of time trying to create a video and project of high standards.

The students within this group particularly enjoyed creating the video as part of their assessment and discussed the need for this technique to be implemented straight from the first year. This group was the first group in the final year stages to undertake the video assessment and had no prior experience to this form of assessment.

The results from this focus group contain similarities of opinions to the focus group consisting of first years; however, there were some distinct differences between the two subject groups which are discussed in the next section.
5.2.5.4 Comparison of results between focus group one and focus group two

Whilst the majority of students shared similar views in the focus groups, there were some distinct differences in the views between first and final year. As one could predict, the final year students were able to reflect more critically on their own skills and identify missing gaps. In particular when referring to the design concept skills, some students felt that they had acquired the skills by using software such as CAD and Revit and saw it as a technological skill rather than the theoretical one. The final year students predominantly agreed with quote on engineering graduates lacking in design skills and ideation, and believed it was only achieved through working experience.

The majority of students in the final year focus group had undertaken a placement year previously and were able to contextualise the learning into their experience from industry. From this, they identified various areas in the engineering curriculum that they felt could be improved in order to better prepare them for professional work, including industry based lectures and more assessment criteria that reflects problem solving in industry.

Students in the final year had been exposed to the use of BIM in industry and felt that engineering practices learnt in industry was different to practices and standards referenced in Engineering Education. They felt that students should be taught skills that were consistent with industry practices. The first years were
also very aware of BIM standards and their perceptions of the way in which businesses and industry worked.

Both groups felt that more implementation of technology to enhance the learning was needed for example video podcast’s and interactive material. The final year students felt that they were more able to make their own decision

When discussing the video project both student groups found they wanted more resources to help them identify the appropriate software to use.

5.2.6 Conclusion of action research cycle one

Data gathered during the action research cycle one identified positive feedback and opinions on the specification and implementation of an alternative assessment using video techniques.

The implementation of alternative assessment using video was viewed favourably by the students with most finding the new form of assessment, refreshing and innovative. They believed that a video can contain more understanding of their design concept than a traditional presentation, and most enjoyed learning a new skill that they felt was transferable into industry.

The final year students took more ownership of their work and spent more time researching new techniques and software they could use for the creation and production of the video. They were able to contextualise the project and compare it to recent industry experiences undertaken during the placement
year. Most of the students felt that this was achieved representation of how an engineer would work in industry and felt that it was valuable to their learning.

The first year students were more hesitant, and felt they needed more direction in how they should approach the task. The majority of students in the first year group were cautious and used Microsoft PowerPoint as the baseline for the majority of their videos. In comparison to the final year students, only a small majority of the students were able to contextualise their learning as many had come straight from A-levels and had no industry experience.

By having complete creative freedom on the production of the video, there was distinct variation between videos produced by each group which promoted healthy competition and peer learning processes amongst the students themselves.

Students became very precious over the project and many took the idea of working in their interdisciplinary project group very seriously and created videos with corporate branding.

Despite the positivity on the implementation of the video assessment, some key recommendations and future work were identified for the second cycle of research.
Although there was some initial support material, students felt that additional tailored resources were needed to guide them through the process of the design concept project, in particular the production of the design concept video.

At times, students felt they were losing their way and were unsure on the justification of certain elements of the tasks.

It was found that creating physical workshops and drop-in facilities were unscalable for module group of that size; particularly take into consideration timetabling clashes brought on by an interdisciplinary module approach.

By taking into consideration the data gathered during this phase of the action research, recommendations were made for the second cycle of action research.

An online toolkit prototype was specified that would support the students and give them access to specialised resources and guidelines in a flexible and readily available platform. Specifications within the prototype based on feedback from the focus groups include:

- access must be available 24/7 due to the flexible way in which students learn
- the developed platform must be mobile compliant to allow students to use the toolkit when they are not a PC or Mac.
- Justification on the reasoning behind the project and contextualisation back to working practices in industry
• recommendations on software for the students to use to create their video
• guidance on where students can obtain equipment from
• information relating to who students can contact regarding problems with their VR walk-throughs and CAD models
• examples of previous years videos so students have a baseline to go against when beginning their project
• recommendations on video production techniques
• guidance on managing projects and aspects to be taken into consideration such as time management
• information on collaborative tools to enable the students to continue to work in their interdisciplinary groups without being physically together

The next section will discuss the implementation of the online toolkit prototype which was carried out during the action research cycle two.
5.3 Action Research Cycle Two – Implementation of Online Toolkit Prototype

Cycle two of the action research focuses on the implementation of an online toolkit prototype that was developed and embedded in module cohorts following on from feedback gathered during cycle one discussed in Section 5.1.1. A diagram illustrating the second action research cycle is shown in Figure 52.

Two online toolkit prototypes aimed at supporting the students in the creation of the design concept video assessment was specified and developed using Xerte Online Objects (XOT) (Nottingham, 2014). The toolkits were developed based on the student feedback gathered during the focus groups from action research cycle one.

The toolkit was embedded in the students learning framework of the module, and evaluated using a series of three focus groups which would later form recommendations for future cycles.

Similar to action research cycle one, a skills audit was implemented again to further support the students by assessing their needs prior to the implementation of the assessment.

This section will introduce how the prototype was implemented within the module and discuss each element of the second action research cycle.
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Figure 52: Action research cycle two illustrated
5.3.1 Results on “Planning” element – Specify toolkit prototype

The prototype toolkits were developed as a result of feedback from students during the focus groups in cycle one of the research. While students enjoyed the video assessment, they felt that there was fundamental elements missing in the support material and wanted further guidance and recommendations for the project.

In the action research cycle one, it was identified that workshops and drop-in facilities did not work for these modules due to the large numbers and limited spaces in the video editing suite.

To support the students, an alternative method of delivering the support materials were identified and implemented by creating a fully accessible and interactive set of guides contained within an online toolkit based on Xerte Online Toolkits technology.

Xerte Online Toolkits (XOT) is an open source application that has been proven to be successful when implemented in an educational course to support students in a blended delivery mode (Mikołajewska & Mikołajewski, 2011).

In a case study from the University of the West of Scotland (UWS), Xerte online toolkits were used to support staff development by providing a set of comprehensive training material in a flexible and innovative way (Walters, 2014). Xerte Online Toolkits are fully accessible, and are suited to an educational setting due to the accessibility standards that it adheres to. Many
institutions all over the world have successfully implemented Xerte Online Toolkits, and literature discussing the success of their use is beginning to emerge in recent literature (Awad et al., 2013; McCarroll, 2014; McPherson & Heggie, 2014).

The predefined templates allow the user to export content created within Xerte to an HTML format which allows content to be viewed on mobile devices including smart phones and tablets. The inbuilt accessibility allow the end-user to specify their own font size, font type, contrast of colours as well as providing narrations and screen reading capability.

A set of two resources were created using Xerte to combine together to form a prototype ‘toolkit’. The toolkit was split into two to avoid a singular large resource that would be difficult for the user to navigate and use.

Based on the student feedback from the focus groups, there were two distinct areas of support to take into consideration, including:

1. justification and contextualisation of design concept video aims and objectives
2. support and training on the physical production and editing of the design concept video project

This led to the creation of two resources that would be delivered together to form the single prototype ‘toolkit’ in order to provide the latest and most
comprehensive set of support materials to benefit the production of the student videos.

The first toolkit was referred to as the ‘Video Production Resource’ and consisted of a set of eight interactive pages to provide students with guidance and justification on the aims and objectives of the design concept video assessment.

The second toolkit titled ‘Video Support Materials Resource’ contained a set of fifteen support pages that supported the students on the use of software, techniques, collaborative tools and general guidance on the physical creation of the video assessment.

The next section will discuss the design and specification of the prototype toolkit and justify the content based on feedback gathered during the focus groups from cycle one.
5.3.1.1 Justification on the design of prototype toolkits

The first toolkit shown in Figure 53 referred to as the ‘Video Production Resource’, contained a set of eight interactive support pages. A complete set of screen grabs for the toolkit as well as its web location, can be found in Appendix 9.11.

![Image of Video Production Resource Toolkit]

Figure 53: Video Production Resource Toolkit

The design of the prototype toolkit was formed using a combination of feedback from the focus groups carried out during the first action research cycle and recommendations on best practice for online learning objects found in recent literature (McPherson & Heggie, 2014; Walters, 2014).

Each section page of the video production resource toolkit will be broken down and validated against the feedback from students.
Introduction to the Resource - the first page introduced the justification behind the concept and rationale behind the creation of the toolkits. It aimed to provide initial guidance on the students on how to use the resource including links to the help section as well as the standard navigation tools.

Design Concept Video – The creation of the video allowed the module lead academic the opportunity to create a short focus video on the pedagogic choices behind the method of assessment in order for students to understand the reasoning behind the assessment and its context in relation to their studies.

In the video the academic takes the students through the process step-by-step and ensures that they understand what is expected of them at each stage of the project process. This allowed more time in the lecture to be spent on student activity and discussion around the project. The pedagogic approach of creating short videos to supplement learning was also proven to be effective in a literature review discussed by Rossiter (Rossiter, 2013), where a series of short lectures were created to help free up time in the lecture room environment. By utilising these methods they found that student engagement and learning experience was significantly improved by the implementation of technology. Students had a point to refer to if they came across any difficulties in understanding what they should be doing at any given point in the process. The video was twelve minutes in size and was uploaded to YouTube to allow students the choice to view the video at a low or high resolution depending on
their bandwidth capability. Instructions were also included to show students how to change the resolution of the video to ensure that no assumptions were made on student’s use of YouTube. A full transcript of the video was also made available to the students.

**Project Concept Diagram** - The project concept diagram was created to show the students in an interactive manner, the module pathway and timeline. The diagram contained a series of interactive module milestones hotspots which the students could click on to find further information and guidance.

For example, under the personal reflective log milestones hotspot, further information was obtained once the student had clicked on the hotspots including downloadable material and guidance notes. It also explained why the students were being asked to complete this activity and how it related to their studies.

This element was included in the toolkit based on feedback from the students during cycle one who discussed that they often felt confused and less confident on understanding what they should be doing at certain points of the module. By creating this resource, it allowed the students to refer back and familiarise themselves with both the assessment criteria, and project milestones that were upcoming in the module.
**Skills Audit** – A page was created discussing the skills audit to promote and encourage students to take part in the audit prior to the production of the videos.

During cycle one, this audit was embedded into the virtual learning environment using a survey tool. To allow greater flexibility, the audit was recreated in Google Docs and linked to from the toolkit. The order in this format was quicker to load and displayed better in multi-platform web browsers such as Safari and Google Chrome.

Similar to cycle one, results from the skills audit was manually analysed to identify any gaps in knowledge and adapt existing support materials as necessary.

**Help in Using the Toolkit** - As discussed in the literature, speculation of digital literacy among students is dangerous and can affect the students learning experience (Santos, Azevedo & Pedro, 2013).

Whilst the navigation and functionality of the Xerte interface is deemed to be simple, no prior knowledge or digital literacy was assumed in relation to using Xerte online toolkit interface. In order to support the students, a series of help files were created to guide the students through using the toolkits including a tree navigation view of the toolkit and its contents.
It also showed students the best way to navigate the toolkit depending on what element they were looking for.

**Structure Your Video Project** – During the focus groups, student’s mention they were unsure on how to start structuring the video project and what factors they needed to take into consideration. A page created that contains advice and guidance including information on storyboarding, to allow the students to make more effective use of their time by carefully planning the content of the video project. This prompted students to consider outside elements such as, booking rooms, obtaining copyright on any material they may need and obtaining equipment and software.

The area also included information on the design brief which referred back to recommendations listed in The Royal Academy of Engineering’s ‘Creating Systems That Work ’document. In order to provide a clearer link to engineering working practices, industry based standards were introduced and allowed students to contextualise their project to the role of an engineer.

This was fed back during the focus group sessions, where students wanted industry input and validation on working practices in their teaching and learning. They wanted to feel that their assessments were valid and would provide them with valuable experience and exposure to professional standards and recommendations.
Previous Video Examples – Many students from the focus groups highlighted the need to see previous video examples to give them an idea of what was expected of them, including level of detail and content type.

To support the students, six video examples from student’s submissions from 2012/2013 were included and contained a short summary from the module leader on why the videos were effective and scored high marks.

These videos were again uploaded to YouTube with full consent from the students to allow the variation in video viewing resolution and give students the opportunity to view the work on their mobile devices.

Video Support Materials Resource - The last page was included to introduce the second toolkit ‘Video Support Materials Resource’, and explained the contents of the toolkit and its relevance to the students for the design concept video.

The second toolkit shown in Figure 54 was referred to as the ‘Video Support Materials Resource’ and contained a set of fifteen support pages. Full screen grabs and online availability is detailed in Appendix 9.12.
Each section page of the video support materials resource toolkit will be broken down and validated against the feedback from students.

As students had complete creative freedom of the production and development of the design concept video, this resulted in students wanting to use different software and techniques to create engaging high-quality videos.

It is difficult to speculate what students will use, particularly if the students had not participated in the skills audit which aimed to identify what students used and what experience they had prior to the assessment.

In order to support the students as broadly as possible, a second part of the toolkit was created to facilitate elements related project including:
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- video editing software support
- information on where to book equipment
- information on booking rooms for meetings and recordings
- VR and CAD support
- information on the location of high-spec machines for rendering videos
- collaboration tools
- video conversion techniques and software

Each of the pages within the toolkit are broken down and discussed.

**AutoCAD Support**: Based on the student feedback from the focus groups, students were unaware that there was a dedicated person to support them on the use of AutoCAD, Revit and Solidworks.

After some initial research, a page dedicated to AutoCAD was created which contained a list of support resources and materials on areas within AutoCAD the students would need to use in order to produce their VR and CAD work for use within the video.

This software is used extensively in both of the module cohorts and students during the focus group had fed back that they were not aware they had to access to a dedicated support person. The location and details of the dedicated
support technician was listed and drop-in facilities were made available by that person outside of the study.

To assist the students, the page also included information on how they could obtain and download a free copy of AutoCAD due to their student’s status. A further list of video tutorials and downloads were made available to the students within this page in the toolkit.

**Solidworks Support** - Similar to the AutoCAD section, students from within both of these modules were exposed to Solidworks from the first year.

The software is used extensively with the students due to its 3-D software capabilities within an engineering context.

Once again students fed back during the focus group that they had limited access to support and were unsure of whom to go to if they experienced any problems.

To assist students a series of self-directed tutorials were listed, including how to access the software and the details of the dedicated technician contact in the University.

**Revit Support** – As discussed in the literature, the use of BIM is becoming more prevalent in engineering and architecture-based practices in industry due to government standardisation (Jung & Joo, 2011).
In order to promote industry standards and recommendations, students were exposed to the use of Autodesk® Revit® which was specifically developed to facilitate bin techniques in engineering and architecture and allows interdisciplinary teams to use the same standards in projects.

Within the University, this software was not implemented until two years ago and therefore had limited support available to students. This was reflected in literature where industry were concerned that BIM was implemented in industry practices, but not introduced into the engineering curriculum effectively and in large-scale (Pikas, Sacks & Hazzan, 2013).

This page contained a list of online resources and due to the recent implementation of Revit, an optional workshop was offered to the students by a dedicated technician to compliment the comprehensive set of online resources that were made available to the students within the toolkit.

**Windows Live Movie Maker** – During the focus groups in cycle one, some students requested that the recommendations were made by the staff on some basic video editing software that the students could use if they had no experience.

As a result of this, a page was created on Windows live movie maker which is freely available piece of software available on every campus machine in the University as well as being freely available for the students to download themselves at home.
A series of guides and video tutorials were created to help the students understand the basic functionality of the software contextualise to what they would need to do within their video project.

The simplicity of the software was appropriate for students with limited experience and due to its availability on campus machines, did not speculate that students would be able to access this on their own machines.

**Final Cut Pro** - Similar to the page introducing Windows live movie maker, Final Cut Pro was the Mac-based version of video editing software available to students on campus machines. Due to Apple licensing, this was not free to students at home but allowed us to recommend to Mac users that would be reliant on campus machines.

A list of online guides were made available to the students within this page, including information on how they could obtain themselves if they wish to purchase it.

**iMovie** - Similar to Final Cut Pro, this page outlined tutorials and links to how students can use this software to produce their video project. This is a cheaper alternative to students using Macs or iPads to create their videos. It was listed to attempt to support as many different video editing software options as possible.
Adobe Premiere Support – As a number of students during the focus group mentioned they used Adobe Premier Pro for their video, this software was listed as an option if students want to pick out one of the rooms in the library that contain the software.

However, this was a sophisticated piece of software and students were recommended to go and speak to one of the video technicians.

Again tutorials and information was listed to support the students on the use of this video software. In addition a free thirty day trial was included on the results page in the toolkit.

Where to Book Equipment – Despite literature suggesting that many students now have access to bring in their own device and equipment to their learning (Miller, Voas & Hurlburt, 2012), information was listed on where students could obtain equipment from on-campus to book out in preparation for their video production. This ensured any speculation was removed and students were disadvantaged by having no access to equipment.

Specialist Software Location and PC Access – Students in the focus groups discussed issues around accessing specialist software and PC access on campus. Many students were unaware of how to locate free computers to use as well specialised software such as Google Earth etc.
To support this, a page was created that listed all of the available software in the university campus and where they were installed in terms of teaching rooms and computer laboratories.

In the previous year, students had to source the software themselves and felt frustrated by the lack of support from the University. They were unaware that the software was available, but not widely advertised.

The list of software and location was obtained from the university’s Technology Information Services (TIS) and embedded into the toolkit.

Following the feedback from students on the lack of high-powered machines for their rendering of their CAD models, a meeting with the business partner for the faculty led to the introduction of six additional powerful high spec rendering machines that the students could utilise.

**Managing Time Effectively** – Feedback from the module leader and the students themselves identified a high consistency of assessment deadlines from other modules at the time of the design concept video assignment date. To support the students on how to manage their time effectively, a page was set up giving the students recommendations on how they could manage their time effectively.

In addition to feedback from the module, time efficiency and management are one of the soft skills that are listed as being detrimental to a graduate engineer
The page reflected the need for students to be able to manage multiple tasks within a tight window.

**Online Storage and Collaboration** – Literature states that a 21st-century engineer should be able to communicate locally and globally into interdisciplinary-based projects (Galloway, 2007b; King, 2007).

The focus groups highlighted difficulties that students faced when working across different courses due to timetabling restrictions and clashes.

To facilitate students working across different courses, some recommendations were made on how students could use technology to collaborate on the project.

A number of cross-platform online storage recommendations were listed and guidance provided on how the students could use this when working in their interdisciplinary groups.

**Video Conversion** – During the feedback evaluation, the students mentioned difficulties experienced when attempting to convert their video into a format that they could submit.

Recommendations were put forward and listed freely available software for both the PC and for the Mac on how to convert video types.
**Do’s and Don’ts of Filming** – Feedback from cycle one identified issues around quality and sound issues of the produced videos.

As a result of this, a series of key points on factors to take into consideration when creating a video was listed including resources on lighting, audio, voice-overs and the importance of backing up their work.

**Video Production Resource** - The last page in the toolkit provided a link back to the first Video Production Resource toolkit.

Both of the toolkits created aimed to support students in the production and creation of the design concept video as well as supporting other assessed elements of their module.

In order to effectively evaluate the use of the video resource toolkit prototype and continued work within the action research framework, a series of focus groups were carried out with students used within the study.

Both of the resources were designed and developed to allow use from the slowest of Internet connections. An off-line version of the toolkit was offered to the students and was tested in an off-line environment.

To implement the toolkit to the students, several methods of delivery were used to ensure students had full awareness of the toolkit and its aims and objectives.
The next section will introduce how the toolkit was introduced to the students.
5.3.2 Results on “Act” element – Implementation of toolkit prototype

To introduce the toolkit prototype to the students, different methods of dissemination were used to ensure that the students were made aware of the toolkit prior to their production of the design concept video.

Two brief individual lectures of approximately ten to fifteen minutes were given to both cohorts of students.

The lecture took place after the students have been made aware of the assessment, and unlike lecture practices seen during the preliminary stage of the research, ensure that the students had received this theory and justification of the assessment criteria prior to the introduction of the toolkit prototype.

During the lecture, students were made aware of the rationale behind the toolkits and how it had been based on feedback from students from previous years. Whilst the lecture was attended by the vast majority of the students, an email was also sent out to the students as well is an announcement made on the front of the module’s virtual learning environment page. This ensured that the information reached the students and they were aware of the support facilities to assist them with their project.

During the brief lecture, the students had the opportunity to ask questions relating to the project and the prototype toolkit.
During the question session, questions were predominantly around formatting of the video itself. Two students asked if they could access the toolkit during the lecture and when they were given the URL, though students access the toolkit using their iPads. It was observed that a small selection of students accessed the toolkit using their mobile phone.

A permanent link to both the toolkits was also embedded into the student’s virtual learning environment.

The academic also referenced the toolkits at various points during his meetings with the students to promote its use within their video work.

In the next section, results of the students work from 2013/2014 cohorts are discussed and evaluated.
5.3.3 Results of students work – design concept videos 2013/2014

Students again submitted their initial design concept video in December 2013 and the final marketing design concept video in April 2014.

The standard of student work improved considerably from the previous year. Students made more use of virtual reality models in their work and different mechanisms of video production were seen in the videos assessed.

Examples taken from the 2013/2014 cohort of students used within this study utilising virtual reality models and multimedia within their videos are illustrated in Figures 55 - 60.

Students took the video assessment very seriously and fully engaged with the concept of producing a design concept in their interdisciplinary groups.

In this year’s submission, students made more use of multimedia tools to visualise and illustrate areas of their design.

In comparison to last year’s submission, students used more professional standard software such as Adobe Premiere Pro and made innovative use of voice overs to illustrate key points to their stakeholders.
Many of the groups spent more time this year researching around their design concept and were able to locate old building designs and locations to validate their design concept. In one group illustrated in Figure 56, the students redesigned a leisure facility and based their concept on the previous historic design to ensure that the team was in keeping to the local environment.
In the video submissions, more student groups engaged with the role-playing scenario and filmed fictional meetings and allocated roles similar to previous year’s student’s videos that were displayed in the toolkit. However, this year the filming was more professional, and students took into consideration elements such as lighting and audio settings during their recordings. There was a significant improvement in comparison to previous years and resulted in a more professional video. Students booked out more equipment to help convey the idea of the interdisciplinary engineering project team. Figure 57 contains a screen grab from one of the groups who filmed a fictional meeting and produced a video overlay of their marketing logo for the company.
The use of virtual reality models improve significantly from previous years and students were able to produce highly polished videos that were smaller in file size than previous years. In the toolkits, guidance was provided to the students on where they could obtain support from and the lecture which introduced the toolkit discussed the importance of setting their CAD models up correctly from the beginning in order to avoid long rendering times.

Figure 57: 2013/2014 design concept video example
The increased scale of the students virtual reality work in their videos this year meant that the assessors and academics had a clearer idea of the students design concept and how they came to develop their designs.

Whilst a lot of the students had watched the previous year’s examples, they wanted to improve on the standard and produced videos of higher quality.

The attention to detail in the students’ work was evident, the students had become more competitive and had spent more time researching new technologies and techniques that they could use within their videos to really convey their justification of their design.
The final year IDDP module similar to the previous year, went into further detail of their project design and justification than the first years. Many of the students had come from placement year and spent time implementing industry based standards into their design by using Revit to comply with BIM standardisation.

As discussed in the literature and previous sections, the use of BIM with government building projects has to be in place by the year 2016 (HM Government - Department for Business, 2012). Students were clearly aware of approaching changes and wanted to include them to evidence their knowledge and understanding of how this would impact on an engineer’s working practice.

The first year cohort from DSGN143 predominantly based their design concept videos around the use of Microsoft PowerPoint, with images and some video
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embedded, an example of this is seen in Figure 60. The reasoning behind this choice is discussed during the focus group evaluations in Section 5.2.5. There was a significant difference in comparison to previous years and students had made more of an attempt to make the videos look less like a PowerPoint presentation and more like a company website by incorporating more multimedia and videos to evidence their design concept.

At the point of submission, more students were prepared and had their videos finalised with more time to spare in comparison to previous years.

There were more questions directed at the teaching team and support from the students on using alternative techniques to make their video standout. One email from a student asked about the possibility of incorporating QR codes into
their video presentation which would point off to further information should the stakeholder wish to investigate.

The students clearly spent a significant amount of time in producing videos that were of a high professional standard. Some students made use of the drop-in facilities with a technician who supported them in their use of their CAD work as well as being able to give the students access to high-powered machines to render their videos.

In summary, the students videos in this cycle had improved considerably from the previous year and students were more comfortable with the assessment process which was evidenced in the quality and structure of the design concept video.

In order to evaluate the student’s experiences and perceptions of the process, an additional three focus groups were carried out to conclude the cycle.

In the next section the results from the three focus groups will be outlined and discussed.

5.3.4 Results of “Evaluate element” – evaluation of focus groups

In order to evaluate the implementation of the prototype toolkit, focus groups were carried out to evaluate and measure the effectiveness of the prototype toolkit.
Results from the evaluations will later form recommendations and improvement on potential future cycles of research related to this study.

A total of three focus groups were carried out during this cycle of the research. Focus group three was carried out in January 2014 and consisted of four first-year undergraduate engineering students.

Focus group four was carried out in January 2014 and consisted of a mix of fourteen first and final year undergraduate engineering students that were enrolled on both modules associated with this research study.

Focus group five was carried out in January 2014 and consisted of ten final year engineering students who had recently submitted to video assessment and was the first final year cohort to use the integrated video resource toolkits referred to in cycle two of the action research.

The first of focus groups to be discussed within this cycle of research is focus group three.

5.3.4.1 Analysis of focus group three

The next section discusses the results from the focus groups used during action research cycle two in the research study. The first to be discussed is focus group three which was undertaken in January 2014.
Following the implementation of the prototype resource toolkit, the effectiveness and results of students using this had to be validated. Focus group three was the smallest of the groups using during the second research cycle consisting of four first-year undergraduate engineering students who had recently completed their video assessment. They were the first group of students to use the prototype toolkit developed as a result of action research cycle one.

The primary aim of the focus group was to obtain student views on areas relating to the research topic and to evaluate the implementation of the resource toolkit prototype used to support the design concept video assessment. Students were also asked if they felt anything was missing which would form recommendations for future work.

5.3.4.1.1 Results of discussions around design concept skills

The engineering quote given to students during focus group one and two was repeated in focus group four.

“Today’s engineering students are proficient in detailed design tools but lacking in conceptual design and ideation” (Taborda et al., 2012)

Repeating views from previous focus groups, the students believed that conceptual design and ideation is a skill that cannot be taught and is a learnt through experience.

“I think there’s only so much you can teach in three years. I think the conceptual design and ideation bit is supposed to be — that’s more
someone’s own. It’s more of a trait rather than, it can’t be taught, especially in three years”.

“I’d agree to the point where I couldn’t come up with a conceptual design that would work. I can come up with something, what it looks like, or what I want it to do, but you’d have to know how to engineer it first. I think that comes a lot later”.

When discussing their understanding and definition of the term ‘design concept skills’ responses were again mixed.

“Being able to, say you are given an area, told what said building has to be able to do, and then you actually having the ability to design, make something unique that fills the space efficiently and can do its job and many others, just like that”.

“I think it would be more to do with communication. If you’ve got an idea that you’d want to become reality, you’d have to get your ideas across exactly how you think they are, because everybody interprets it different”.

The definition of the design concept is subjective, with each student having their own idea on what it means in terms of an engineer’s role. Whilst each view was slightly different, students were fully aware of how important design is an engineer’s role.

Students were then asked whose role they believed it would be to come up with design concepts when in industry. The majority of the students believed this role would fall to that of the architect and did not see this as an initial role of the engineer.

“I’ve never done architecture, but my view of architecture is, they come up with a design that could work, something that’s feasible rather than just – like an artist will do something that would just completely never work, and an architect would design something that would then go onto the engineers, and the engineers would take it back between the architects and the engineers, then it would go to final”.

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“I think it would an architect’s job to come up with the design, and the engineer to actually come through and build it”.

One student however felt it was a combination of both an architect and engineer, of the design concept and should work together to come up with the most appropriate solution.

“I think engineers also have quite a part in it, because new designs and things using the extent of materials. So, as an architect would just know bricks can support bricks and the more basic study of things, being an engineer you would know the severe limits and what would feasibly be possible, would look normal, and what would just look downright bizarre, but would still work. So an entire building on three legs overhanging the sea or something”.

All of the participants from this focus group were first year engineering undergraduate students and uniquely, all had come direct from further education colleges and had little or no experience in engineering industry. In comparison to results from the IDDP final year focus group from the previous year, the first year students felt that it was the role of an architect to come up with the design whilst the final year students from last year felt that it was a combined effort from both the architect and the engineer.

5.3.4.1.2 Use of virtual reality the design concept projects

When asked how useful the students thought that you’re walk-throughs were in assisting with the design concept process, the majority of students felt they played an important role. When asked to elaborate, comments around flexibility and visualising in greater detail was mentioned.
“Because you’re able to, rather than just being able to say or speak a design, or show some drawings of it, you can actually move throughout it, show all the sides from it, all the details, what it physically looks like, size, proportions, rather than just having the knowledge of like two metres”.

Many students mentioned how the use of virtual reality and CAD modelling helped in the creation of a design with all students agreeing that the earlier this type of technology was brought in more effective it would be for students.

“As engineering does cover so many topics as well, whether that’s specifically into design, thus using the CAD, getting these renderings and walk-throughs, or whether going on to be like mechanical, or more car engineering, where it’s more, you’re just using the parts normally available”.

“I think it’s something, the earlier you bring it in, the better, more efficient you can use them”.

When asked what they felt give a better understanding of the design concept; a VR walk-through, a physical model or a combination of the both, responses were mixed. One student spoke of the need to have something physical to refer to as they don’t believe that a VR walk-through could contain that much detail needed to portray the design.

“You do need something physical to be able actually to see that you can’t have the same detail as you can in a virtual model”.

Cost and time efficiencies regain mentioned my reference on the use of virtual models in engineering with students commenting that innovations in software are more advantageous than using a traditional model.

“A virtual model I think’s a lot more efficient nowadays. Solidworks, for example, you can even calculate the mass of what you’re building”.
The views from the students were reflected by literature discussed in Chapter 2 where practices in industry commented on the use of technology to support time efficiency in projects (Froyd, Wankat & Smith, 2012).

5.3.4.1.3 Results on view on the interdisciplinary design project work

When reflecting on the work they had recently completed on the module, students spoke favourably over the design concept video assessment. One student spoke of his experience of creating videos prior to starting his engineering course at college, and enjoyed the fact he was able to utilise the skills as this method wasn’t implemented elsewhere on his engineering course.

“I think the whole idea of making the video, I quite liked, because previous I’ve made videos before, done short films and so forth. So actually still being able to use things like that was very different to everything else on the course”

One student, despite liking the video assessment, felt that it should still exist in the course that should not be assessed as they did not feel fully prepared to carry out the work. Unlike previous first year comments from other focus groups who had come straight from college, they felt the video assessment task was very difficult and did not know where to start. However, this student later admitted to not reading any of the assessment criteria, previous video examples, support material or accessing the prototype toolkit.

“I think it should still be there, but I don’t think it should be marked, because I’ve come straight from sixth form to come here, and first term is more getting used to everything, didn’t know how much depth you had to go into, anything like that. When it came to actually making the video, I made our group’s video, and getting other people, I’ve never done
anything like that before. I did maths and physics A level and PE, which just didn’t help at all”.

When further probed the student was asked if a piece of work was set an unassessed, would they complete the work, the student along with the rest of the group answered no, therefore contradicting the previous point of making an unassessed piece of work.

Parts that the students found challenging in the video assessment was due to technical issues which was down to the University system and internet connections, variables which are outside of this research study. Lack of student contribution within groups was also discussed and similar to the focus groups discussed in Section 4.4.2 was blamed on first year marks not going forward to In the final course mark.

5.3.4.1.4 Further discussion on the design concept video

Students discussed their methods for producing their design concept video. As discussed in Section 5.3.3, the first year students had used Microsoft PowerPoint as their platform of delivery for the video in comparison to the final year students who had used video editing software to combine their resources.

“For our group it was using other multimedia. Using, well [laughs], we started off by making a PowerPoint with the main points and how the video would be laid out. So the intro, what would be said during that, then it was the first lot of research we’d done, interested parties, then the CAD work and how that would all fit together. Then just using many different filming and VR models and things, put that into a final video”.
Another student utilised their background multimedia from college to create an intense multimedia video.

“For the actual video, putting the video together, I used a modified movie-maker, with a few codex I’d written so it was more open. You could put different type of files, you can change them, change all the colour gradients. All the audio levels, and mixed that in with Flash for frame by frame animation transitions for the buildings, so you get normal building turning around, and then the roof comes of it, and it splits apart and then”

Students who only used Microsoft PowerPoint were further questioned on their choice of software

“It was the easiest to gather work as well, because half our group are on Mac, and half are on PC, which meant that any work that we did, most of their slides where sent to me in emails, as in, not attaching the slides, they were sent in the email, in the main body text. So I had to be able to put it into slides that way. It was just easier, it’s universal”.

The student felt that it was an easier option and felt less confident in using video editing software. His team members had been collaborating using different platforms such as PC and Mac and they felt that this was the most convenient way of collating all the data from their peers into a singular format.

5.3.4.1.5 Results regarding the use of the prototype toolkit

Students were asked if they had access to prototype toolkit created using Xerte online toolkits. The responses were split with half of the students accessing the toolkit and the other half had not seen it at all. Those that had not seen the toolkit were asked why and one student responded that they did not know it was there. As discussed previously in Section 4.5.1, students were made aware
of the toolkits using various mediums including a timetabled lecture, emails and information made available on the virtual learning environment. The student therefore admitted that he didn’t check emails and was quite disengaged during the process. Another respondent was aware of the toolkit but had chosen not to access it.

“I can’t lie, I haven’t seen it yet. But I know it’s there”.

When probed further on their justification as to why they didn’t use or view the toolkit, the student was honest and reflected on their own motivation in work generally.

“You’re not going to do any more work than you have to, which is, I’m inherently lazy, so that’s one of the reasons why I haven’t seen it. If I wanted to get an amazing grade I would have done it”.

The other students had used the toolkit and felt it was an effective way of working their way through the resources and deciding on appropriate platform to create their videos.

“I went through the whole thing and all the programs are for like Adobe, the simpler iMovie. I thought it was quite good, and the way it was set up, if people had no idea about how to do it, it was quite straightforward, so they could go straight for whichever program suits them most”.

When evaluating the toolkit focus group was asked if they felt anything was missing from the toolkit.

“I’d probably say something like a screen capture. A lot of the models you can do. The walk-throughs on the programs all predetermined path lines, and they are quite complicated to set through, but there’s another method where you use a screen capture”.
Students wanted to be able to screen capture their models and import them separately rather than importing a full scale CAD model due to rendering problems and file size issues they had encountered.

The students were asked if they used the toolkit on a mobile device or had seen other people accessing it in this way.

> "Everybody who is on the robotics course, as part of joining, gets a free iPad, working on that, it was quite helpful. Because during the lecture, everybody’s just able to go straight onto it and have a look then and there and see what it was”.

It was evident that many students have access the toolkits on their own devices both during the lecture, and when developing their work. Students found it helpful to be able to refer to what was being discussed at that point in the lecture rather than just being told about it.

5.3.4.1.6 Teaching of engineering

Views and opinions on teaching methods in engineering were discussed, in particular how technology could impact on the way engineering is taught in the future. The students were asked how technology could help facilitate large groups often seen in engineering and asked how they would solve the problem. Lecture capturing and webinars were frequently mentioned in addition to Skype for the more personal tutorial based sessions.

> "The idea that just popped into my head was Skype. Especially, well for the larger ones. So say, as a group, and it’s too large to even fit into a room, to instead have something like that, could be an alternative”.

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One student however expressed that he would find it difficult to be motivated to learn online and watch a lecture and that he preferred turning up for a physical lecture.

“If they put them online and didn’t check your attendance – I like that way my course runs at the moment. You have to bleep, scan into your lectures, and not on its online. There’s PowerPoints and stuff on Tulip, but I don’t have any online lectures at all. I have to go into all of them, which is, I like it at the moment because I’m actually getting out of bed!”.

I asked the same student that instead of attending an online lecture, would they watch a podcast created by the lecturer if it was an additional learning material that would complement the subject discussed in the lecture. The student admitted that he would do this.

Discussions moved on to the general teaching of engineering that the students had observed. Several of the students mentioned the traditional methods they had experienced during their studies.

“All my lecturers are quite old-fashioned. One lecturer used a PowerPoint once, and that was to introduce himself! He likes using this Whiteboard that spans the length of the room”.

Another student who was enrolled on a completely different discipline and enrolled in several computing based modules spoke about a different experience with the computing based lecturers.

“He puts all of his lecture notes, further notes and more information about the material onto Dropbox. So you can then just go onto that and you can see everything we’ve done and will be doing, which is also very good”.

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Students were asked what they would like to see more of in their teaching and learning. A game industry experience featured heavily in the conversation, with students using their own initiative to gain that professional exposure.

“I want more industry experience. I joined the MMC Society, and we went to Babcocks and Kawasaki, and they are two completely different places. I learned more from that than I do when lecturers tell me what happens in industry”.

They elaborated further indicating that modules relating to that practice were boring but when they saw it in the workplace they felt more engaged.

“Especially, yeah, especially for the manufacturing module, because it’s tedious. It’s boring, but if you see it in industry, the scale they can do stuff, is immense”.

Whilst the students appreciated that site visits were always viable, they felt that lecturers could use technology such as videos to demonstrate and contextualise their learning.

“Videos that are relevant, like slide shows and stuff like that. When they say something’s used in industry, then have the video showing it being used and how it’s actually helpful”.

They had also talked to their peers who had just come back from placement who had received almost a culture shock from what they were taught in comparison to actual working practices in industry.

“I think when, for people that are coming back of placement, their placement people have said to them, “yeah, you’ve got a lot of knowledge”, but it’s a bit like, it’s like a driving test, you don’t always, you don’t come out and do that, do you know what I mean? They know everything, but to the point where some of them are coming out knowing the set-up of casting machines, but not knowing what they look like in real life at all”.

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Aside from industry, students also wanted more supplementary learning materials to complement their lecturers including podcast versions of lectures and more interactive material.

5.3.4.1.7 Conclusion of focus group three

This focus group was a small representation of students from the first year DSGN143 module. Despite being a small representation, some key conclusions and observations can be taken from the focus group.

It was clear that despite significant effort in ensuring that students were aware of the toolkit and its justification of existence, not all students used it as they chose to ignore emails or didn’t think it would be of use. However, when discussing the issues they encountered when producing their video project such as how to bring data together and edit video techniques, they admitted that they would have found the toolkit useful and in reflection should have used it.

The first year students were understandably less aware of industry standards and had a linear view on the role of an engineer and what would be expected of them in the workplace. Two of the students felt that it would not be up to the engineer to come up with the design process or to particularly get involved during the development of the idea. However, literature states that the twenty-first century engineer must be more flexible and able to work through and understand the rationale behind the design in order for them to become an effective problem solver (King, 2007).
When discussing the idea of using video as an assessment mode, the views within the group were mixed. Two of the students felt that it was a lot of hard work and difficult to know where to start. However, both of the students were students that had not referred to the toolkit which would have taken through the entire process and given them a point to start from.

The student that found the video assessment refreshing and innovative was very positive about the entire process and was able to bring his skills learnt from he’s A-levels into his engineering course. During the focus group the same student commented on supporting his colleagues due to his existing skill base. The same student was very keen to see more use of technology within his teaching and learning materials and wanted lecturers to become more engaging and proactive in their effective use of technology to support their learning.

Other students were less keen to see technology being used to teach the students and preferred the more traditional modes of delivery. When further probed these students admitted that the physical requirement of the students to attend the lecture motivated them to attend, and felt that had they been asked to attend a virtual webinar they would not attend.

This refers back to literature discussed in Chapter 2 on different learning styles among students (Felder & Silverman, 1988; Felder & Spurlin, 2005b). Lecturers must ensure that teaching and learning is relevant and in a format that assist
students with different learning abilities and styles to ensure they are fully engaged and motivated during the course.

The next focus group to be discussed and evaluated is focus group four which consisted of a mix of both first and final year engineering students.

5.3.4.2 Analysis of focus group four

Focus group four was carried out in January 2014 and consisted of a mix of fourteen first year undergraduates and master level engineering students that were enrolled on both modules associated with this research study.

The primary aim of the focus group was to carry out an open discussion on the future of Engineering Education and to consider students opinions on how methods may change, including the impact of technology on the engineering curriculum. Student’s opinions on digital literacy and its relevance to Engineering Education were discussed.

5.3.4.2.1 Analysis of discussions around Engineering Education and the impact of technology

The students were given the following quotation to discuss based on increasing literature in Engineering Education discussing the impact of technology in engineering.

“Today, technology is an influential factor in education as it has ever been. A new generation of engineering students is entering Higher
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*Education with significant computing knowledge, and with higher expectations that academic institutes went use them to appropriate technologies for their successful transformation into industry. Academic institutions are challenged by these new technological requirements and must adopt appropriate strategies to meet innovative educational demand*. (Abulrub, Attridge & Williams, 2011)

Opinions in the focus group were mixed about the speculation of engineering students entering Higher Education with significant computing knowledge. No student disagreed with technology being influential factor but technical knowledge and abilities and students were heavily discussed and debated amongst the group.

“I definitely agree with the technology being an influential factor, but I don’t know if necessarily engineering students are entering with significant computing knowledge”

Other comments concentrated on technology being used as a platform in which teaching materials are delivered with students identifying issues of academics being able to keep up to date with relevant technology that students may expect.

“It’s not so much the specialist knowledge, like you’re talking about CAD; it’s more the general understanding. You’re saying young people with iPads now, by the time they come to university, the current academic staff won’t be at the same level of general IT awareness perhaps as the students are, and that is going to be where the problems start, where the students are expecting the content delivered in the new way, and the academic staff have to try and keep up with that, even though there’s a generation gap”.

New changes in curriculum for primary school years were also brought up by one of the students who commented that changes in IT awareness are being implemented at such a young age that by the time they enter Higher Education
students believed they’ll be an even bigger gap in knowledge between students and teaching staff.

“\textit{I think there’s even more to it than that now as well, because they changed the curriculum with the younger years and they are bringing in programming and all that kind of stuff. There’s no way a lot of people on the teaching side of it will have that kind of knowledge. Whereas pretty much every person coming to uni – so yeah, there’s a big difference, a big gap}”.

There are many discussions in Engineering Education literature regarding the impact of technology, particularly in recent years. However, some students hypothesised that this would always be the case and that young people in education have more free time to explore and investigate technologies in comparison to somebody who would be working full-time. They speculated this would be the same for them once they are in active work.

\textit{“I think that’s always going to be the way, that the lecturers are slightly behind us, because some of us might be lecturers in ten, 15 years’ time and the technology will advance, and we might not be used to it because we’ve got full-time jobs where we can’t play around on IT, but children, teenagers have the time to do”}.

The group discussion initially was heavily focused on students being digitally aware of new technologies however, one student opened further debate by questioning if the excessive use of technology could result in a negative influence on learning.

\textit{“It’s interesting that your first line is saying your technology is an influential factor in education, but could you say that the excess use of technology is a negative influence on learning? So if your lecturer is trying to get you to use a piece of technology for the sake of it, it doesn’t}
actually have any benefit to you and it’s going to be detrimental perhaps?"

This statement refers to the appropriate use of technology that is pedagogically appropriate in an educational scenario. The literature review in Chapter 2 highlighted the importance of ensuring that choices in technology driven by pedagogy and not the other way round. Students also agreed that the initial teaching ability has to be in place and that technology would not replace ‘bad teaching’ and could potentially enhance it.

5.3.4.2.2 Analysis on discussions around the future of Engineering Education

The students were asked their views on how Engineering Education would change in the future. Some students believed that the teaching of fundamental engineering skills would be replaced with more emphasis on software which wasn’t always perceived as a positive change.

“It’s turning quite a lot into how to use software and things as opposed to understanding the basics and the fundamentals behind it. I think that’s already happened quite a lot. You know, we’ll know how to use a software and get it to work, but we won’t know why it works. Then it becomes harder to understand why things go wrong when they do go wrong”.

One student was particularly concerned that the increased use of technology and software within an engineering context would have a negative impact.

“Well we are in danger of producing an entire generation of brilliant engineers who can’t build anything”.

Further exploration of this statement discovered a few students were concerned that they weren’t fully prepared for engineering practice and that
everything they had learned over the past four years was completely theoretical with limited practical knowledge.

“I’m very, very concerned that – you know, there was a young guy on our course last year and he came to see me really quite upset and said, “look, I’ve been here three, I’ve done a placement, I’ve done four years”, and he said, “I still don’t know what’s inside an engine. I’ve seen some pretty pictures, but I haven’t got a clue”.

This reinforces views from previous focus groups when discussing areas around design concept skills and that knowledge to date was theoretical and not contextualised to industry scenarios. The lack of practical knowledge and exposure to laboratories was evident during the focus group with students feeling disappointed with their access to practical equipment and knowledge.

Some of the first year students felt they didn’t have that much of a voice as they were at the start of the engineering career. Following the focus group, one student sent some additional thoughts on behalf of two of the first year students as it did not feel able to say anything due to the strong characters within the focus group.

“Engineering requires technology, it has almost gotten to the point where you can design and construct without any practical experience due to 3D printers. This has many pro & many a con depending on the circumstance. Current engineers just need to become more flexible in what and how they do it for this future to arrive. This includes the teaching of it”.

This view is represented by a number of recent literatures in Engineering Education argue that the role of a modern engineer is interlinked heavily with technology working practices and methods (Grimson, 2002; King, 2007).
The role of practical work within engineering sparked heated exchanges of views where some students argued that the only way in which to learn these skills was from gaining experience in industry or placement and the role of a modern engineer came into debate once again. Some students believed that engineers didn’t have to be practical and that the role of an engineer in modern day work scenarios was more of a manager and problem solver than being able to physically build or create something.

“I have to say though; do you really think that engineers are really practical now?”

“Engineers are managers”.

The need for engineers to have practical knowledge was heavily debated for a great deal of time within this focus group. One student was adamant that practical exposure was vital for an engineer to enable them to carry out calculations and understand the way in which material behaves.

“If you haven’t had any practical experience whatsoever, you won’t know whether they are valid or not. If you’ve never actually held a piston and a con rod, and felt what it feels like in order of magnitude of the forces, you could be miles out with your calculations and wasting your time unless you have had some practical experience, some feel for the springiness of the material, how it behaves, heat transfer”.

Contradicting this, some students believed that the process at University was to teach students how to learn

“I don’t think you learn that at uni though. You learn how to learn”
Students further elaborated on this and discussed the importance of student attitude and how they should not rely on the taught aspect of their course to get a full picture of what being an engineer would encompass.

“If you’re doing an engineering course and you’ve got interest in, say, engines, you’d go away and you’d find some resource on engines and you’d learn about it, you’d read about it, as well as doing your university course. It’s all part of becoming a whole encompassed engineer”.

Lecturers contextualising their teaching material came into discussion with many students commenting that the more relevant to actual working problems the better.

“If lecturers were maybe encouraged to contextualise what you were learning, so you’re not just learning about, you know, carbon fibre, you’re learning about it in the context of F1 and the result is they are providing you, in a context that you understand. That would be more beneficial, do you think?”

Other students commented on the use of technologies

“I think lecturers are missing an opportunity by not using technology to contextualise some of the stuff we’re learning. For example, from a civil perspective you get taught first year CAD and then you get taught structural design. I think it would be a much better idea, and we’re taught this separately and we never combine it”.

Discussions around industry contextualisation continued with the students commenting that there was no correlation between engineering methods learnt at University to working practices in the workplace.

“You’re quite right, and some of the modules that I’ve done in design, being taught to do technical drawings, I’ve then gone out into industry and found that what I’ve been taught isn’t right. It’s not how it’s done in industry. I think that says a lot about the way that particular academics are teaching their courses and maybe not fully understanding the
content. They are just teaching a piece of software. They are not teaching how to apply it in an industrial situation. That’s where the key needs to be is getting the material to you, but also making sure it’s in a context that you can actually use in industry”.

The students concerns mirrors literature from industry stating that engineering curriculum is often out of date in comparison to working practices in industry and called for stronger alignment to professional practice (Beckman et al., 1997; May & Strong, 2011).

5.3.4.2.3 Analysis of how students would like the future of engineering to change

Discussions moved on to how students would like the future of Engineering Education to change. Many students commented on increasing the amount of interdisciplinary work similar to the IDDP module where students are able to utilise skills learnt during the course and apply them to problem-based scenarios.

“I think that our IDDP module with the interdisciplinary project, is really good and it’s strengthening our learning. I did two placements as well, and I think they strengthened my learnings. This IDDP module is going to strengthen my learning in a similar way, because you understand how stuff fits together and you’re not just doing pile design for the sake of pile design. You are designing your piles so that you can build a structure”.

The idea of industry sponsored modules also featured highly during the conversations with students requesting more relative input from professional practice.
I think if you had industry-sponsored modules, so if you had one or two modules a year which were a module sponsored by a car company, or a module sponsored by a marine company.

Students also wanted more guest lectures around topics relevant to rules being taught on the module. They saw this as having mutual benefits as the engineering students were potentially the next generation of engineers about to enter the workplace and the more exposure to industry during the course would create a more rounded engineer.

The importance of placements for undergraduate engineers was repeated during the focus group with students reporting improvements on grades and understanding of working practices that was only achieved by doing a placement year.

I think the best way to get a feel of industry is to do a placement. It’s not only beneficial to you, I think all industry students come back and improve on their grades, I certainly have. But it also acts as like a one year interview to the company that’s employing you. I think that’s the best way to strengthen your understanding and build relationships with an industry.

Placement years and industry experience is invaluable to engineering graduates as it allows students to experience working practices within the sector. Students were very aware of the need to have exposure to working practices and contextualise their learning.
The impact of technology on working practices in engineering over the next ten years

The next section was concerned of the impact of technology on working practices within engineering of the next ten years. Views again were mixed from the students, with technology being seen as a time saving efficiency route.

“Technology’s meant to aid your, make your job easier. So whereas it would take maybe a draftsman maybe 20 hours to draw something that would take an hour and a half to draw on CAD, the aid is that it’s cut your time massively”.

One student spoke of the impact of technology changing how engineers will learn and therefore impact on industry once graduated. Technology has been frequently mentioned in recent Engineering Education research literature and is speculated to be a catalyst on the impact on educational practices and professional working methods in industry (Arlett et al., 2010b). One student looked at this in a different way and debated the idea of technology change in the way in which engineers learn as well as practising industry.

“Could you look at it at a more fundamental level? Technology is going to change the way that engineers are learning? Because traditionally you’d view an engineer, so you’d be taught by an academic, you’d be in lectures, you’d be doing assignments, but with technology can we change the way that that’s happening so that you’re guided in lectures and then there’s more content online perhaps that you can go and use to learn beyond the course? And the need to carry that on into industry, so you’re still carrying on to learn out in industries while you’re working”.

The use of BIM in industry was brought up with students being aware of the increasing use of the standard and industry. Students on the Masters year had
not been taught Revit and some have decided to learn how to use in their own
time to improve their CV.

“I think the way that industry’s going, as I said before, companies are now
using BIM. I spent the morning trying to learn how to use Revit, and
***** given me these tutorials to look through so I started drawing a
house. From just drawing this house you can pull out a plan for each
evel, sections through for each level. No way would you have the
amount of time to do all those sections, and you could draw a house in an
hour and product 15 drawings. So I think, and we haven’t been taught
Revit, I think it would be of benefit to us”.

During the focus group it was evident that the students, particularly on the
Masters year were quite proactive in reading around this subject in their own
time. Whilst they agreed that the teaching of software was important, they also
felt that students had a responsibility to self-learn using tutorials found on the
web etc.

“I think you can find a lot of tutorials online already, and a lot of stuff is
so specific and there’s so many different functions in, say Revit, that you
could never be able to produce a full set of tutorials to cover it, I don’t
think”.

The use of software within engineering was predicted to increase and engineers
would have to adapt and become more technically competent.

5.3.4.2.5 Can an engineering course be taught completely online?

Whilst discussing the impact of technology on engineering working practices,
students were also asked if they believed an engineering course could be taught
completely online. The majority of students similar to the survey results
discussed in Section 4.6 agreed that it could not be taught online.
One or two students did however offer different viewpoints and referred back to previous point that many students had reiterated that the skills learnt at University were purely theoretical and therefore why couldn’t they learn a course online.

“There’s actually, what do they call themselves? The School of Everything, that you can now learn anything online, and they have hundreds of thousands of students enrolled on their courses, and it means that all their electronic resources are available online. Everything you do, all the quizzes and things, all the bits of work you do are automatically assessed by the system, or they are assessed by your peers. So you instantly get feedback as to what you’ve been doing. So you learn all the theory. As we’ve been saying, engineering at university is theory, there is not practical element really”.

As discussed during the literature review, Technology Enhanced Learning is having a huge impact on the way students learn with access to information available on a range of devices and mediums. However, students disagreed on the basis that one of the fundamental skills an engineer needed to have was team working skills and you could not do this online. When further probed the students were asked if there was a way that this could be facilitated online. Students discussed the idea of Skype and screen sharing technology but most of the students within the group believed that it didn’t represent how you would be working in industry.

5.3.4.2.6 Discussions around digital literacy in Engineering Education

The next section of the focus group concentrated on the subject of digital literacy in engineering of both staff and students. The term ‘digital literacy’ is
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being used heavily in educational contexts and as discussed during the literature review is also a topic that is highly controversial.

When asked how important the students believed it was that engineering graduates were digitally literate by the time they enter the workplace students were given a definition of digital literacy to ensure they understood the terminology.

All students agreed that it was crucial that students were digitally literate, with many students commenting that it was impossible not to be in today’s society.

“You couldn’t not be, you couldn’t be digitally literate in this day and age”.

The question was explored further and students asked to elaborate their thoughts. Digital literacy was thought to be a skill that would come out of university but not necessarily something that was being pushed or promoted during their studies. Others saw this as being bigger than just an educational context, and that digital awareness was a way of life.

“I don’t think it’s necessary saying that university is pushing necessarily, it’s just more a way of life”.

Further speculation on engineers being more digitally literate than others due to the technical nature of the discipline was debated.

“Especially engineers are going to be digitally literate. I think that sort of thing goes with that sort of thing. It’s like maths, obviously computing and engineering, they all sort of attract the sort of person who would be digitally literate. Sorry, if I’m stereotyping, but I mean it seems that, I don’t want to say that”.
“You’re technology-based, so you are going to know technology”.

Others thought that engineering would attract the type of student that would already be confident in using technology in life and learning. The importance of being digitally literate was linked into working practices in industry, where students commented on how you might work with colleagues and how security issues went hand-in-hand with technology.

“When industry works in that way your company might have ten offices across ten different countries, you need to be able to transfer data and things like that, and you need to be able to do things, not necessarily use CAD or use Ansys, but understand that someone over in India who is doing the design work and you need to be able to get the information from him, and contact him, whether digital literacy means like videoconference, or emails, or file transfers”.

“I think you’d definitely need an awareness of security. If you’re entrusted with corporate documents and things, you need to know how to keep those secure, not do anything stupid with them”.

Discussions continued around digital literacy, and whose responsibility it was to teach students to be digitally literate. The majority of students stated that you couldn’t teach digital literacy as such and it was something that was picked up through experience and exposure to technology.

“I don’t think, you’re never taught it, but you pick it up. Whenever you sign a digital policy at a company, that’s you saying, “I am literate enough to know that I’m not going to share confidential documents and things like that. I don’t think I’ve ever been taught it, but it’s common sense”.

Students were then asked if there was a stereotype that all students were digitally literate due to their age or was it dependent on other factors. The general consensus among the group was that students who had come straight
from school A-levels into Higher Education would automatically be digitally literate but that students who had come from other channels and perhaps the more mature student might have a different experience. This was also seen as an advantage where older students who had more experience of industry could share their knowledge with their peers.

“I’d say pretty much everyone who has come through standard channels like school, A levels, or college and then uni, I think any of those people would be pretty well-versed in computer everything, especially the basics. I don’t mean CAD. Then people like yourself who come through different channels, and maybe a bit older too, you are not going to have the same experience, you’ll have a very different experience which will benefit you in different ways to us. It’s just different angles of coming at the same thing”.

During the discussions students mentioned different levels of awareness of technology from different students on how their time spent at University would help enhance their knowledge of appropriate technologies to use in the right situation.

Discussions moved on to the importance of a digital footprint. All of the final year Masters students were aware of a digital footprint and how a potential employer could Google a candidate. The students however used this method themselves when searching for the manager of the company they had an interview for to give a greater understanding of a company or person.

“I think definitely when you’re applying for jobs, like a lot of us are now, you need to be aware of it. I think it’s just a common sense kind of thing to assume that if you are asking someone for a job, they can so easily Google you. I think we were made aware in some lectures of making things private, things like LinkedIn profiles, things like that”.

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Suggestions were made of having more information available on the impact of a digital footprint in terms of employability for students from the first year or perhaps an induction during fresher’s week.

The skills and knowledge of academics surrounding digital literacy was debated well within the group. When asked if an academic lecturer should be as digitally literate as the students they teach, responses were mixed. Initially, students didn’t feel it was necessary for the staff to be as knowledgeable as them that they should be an expert on the area in which they teach. For example; an academic teaching CAD should be more knowledgeable than the student whom they teach.

However, the impact of academics literacy capabilities was thought to be problematic if it started to affect the students learning. All students thought that their lecturers should be consistent in making teaching material supporting their learning available online, including the basics of uploading the lecture notes or PowerPoint presentations. It was clear among the group, that this varied among the teaching team in the same subject area in the faculty.

“Sorry, if it starts to affect your learning, then I think they should be. I think if you look at the online portal, some people’s resources that they put up there, some lecturers are brilliant, some have nothing on there, they won’t use it. I think if it starts affecting your learning then they should definitely need to improve it”.

Leading on from that question, students were asked if lecturing staff used technology effectively in their teaching and what areas of improvement could
be made if applicable. Again, references to consistency in uploading the basic materials were mentioned, however generally, the students would only benefit from the use of technology in their teaching material if done appropriately. Students also raised concerns of lecturers using technology inappropriately and just for the sake of it and didn’t believe this to be a viable pedagogic route.

“If they are no good at technology I don’t think they should use it. It’s what the lecturer can actually use to make an optimum lecture”.

The use of technology to engage and motivate students was recommended with examples brought up using clickers and voting devices in a lecture room scenario.

“If it’s done well, yeah, use it. I think that would be good. I mean the maths students they have, I don’t know if it’s everyone’s cup of tea, but they are given a question on the board and they work through individual in a lecture and they have these buzzers, you know, A, B, C, D and then they all do it and it comes up on the board. I think it gets them involved”.

Expanding on this, students were asked what would engage them and what methods they preferred. It was clear, that there was no one size fits all solution and that lecturers should be flexible and offer different platforms and methods of learning to suit different learning styles. Technology wasn’t seen as a solution unless the academic was effective teaching in the first instance.

“You could have a rubbish lecturer with all the best technology, and it’s a rubbish lecture, or you could have an amazing lecturer with a whiteboard and it’s the best lecture you’ve ever had”.

Traditional teaching methods mentioned in literature during the initial literature review were evident from the student’s comments. One student commented
that they would like to see more digital videos being used in their learning material but was frustrated by one of their lecturers still playing a video on a small TV in the front of a lecture room rather than looking for a digital alternative.

“Things like videos, I personally would like to watch videos and things like that, which we do have. For example, I think in one of our lecturers is still getting the Open University VHS out form the ‘80s wheeling the TV in and things like that. I mean You Tube does exist, I don’t know if you’ve noticed, but all this, all this stuff is so, whether it’s available or cheap or just out there, just digital content and we’re still using VHS videos”.

The use of video in teaching to enhance or reinforce a concept was mentioned frequently within the group. Many students had learnt around their subject material and interests and saw it as a way of understanding a perceived ‘boring’ subject in a relevant contextual format.

“I’m addicted to How It’s Made on the Discovery channel, and you can watch, if you had a whole day off uni and you just sat watching Discovery channel, you would learn so much about all these things that are out there, all the processes involved in it. If it’s just showing a clip of a How It’s Made video, or a clip of a documentary about the subject that you are learning. Whether you are learning something that’s really boring and you’re shown, “this is how this bridge has been constructed as well”, and you’ve been doing all the boring calculations, it sort of puts it into context”.

Many wanted their lecturers to use videos as a way of supplementing and enhancing their taught subject. It was clear that most students, particularly the Masters level students, would spend the time looking at videos and supplementary material as they saw it as being beneficial to their learning.
“When lecturers are enthusiastic about their subject they’ll say, “oh yeah, there was this really good video on it.” If they can provide the links for you to go and look at it in your own time and things like that, that’s quite good”.

Videos were seen as a good mechanism to communicate complex information, during the discussion many examples were mentioned including very basic video creations that had substantial educational impact.

“Obviously there’s going to be a lot of boring calculation behind stuff like that, that you probably would need to know, but you can get quite complex information across. A kid who is 19 in America filming himself in his bedroom with a whiteboard and pen can put all these things across”

There was a speculation from the students that current academics of a certain older generation wouldn’t produce digital content.

“I don’t think you’ll get the academics of their generation, maybe if we’re lecturers in ten years’ time we would be more in tune to it, but if you’re going to go over the Reynolds and tell these lecturers that they are going to produce all this digital content they are not going to do it”.

Students didn’t necessarily feel that the academics themselves need to create the content, but they should be aware of what was available externally that would benefit and enhance the material taught to the students. The emphasis during the focus group was continually brought back to the basics of teaching and was the student’s main concern with certain elements of their course.

5.3.4.2.7 Conclusion of focus group four

It was evident throughout the focus group that students believed the teaching of engineering would change greatly in the future. Emphasis was on new innovations in technology, particularly the use of emerging standards and
industry working practices such as BIM. The final year Masters students who had recently done a placement were aware of industry standards and often felt frustrated that the engineering educational curriculum did not completely represent working practices.

The use of technology within teaching materials and methods was discussed and emphasis was placed more on the teaching ability rather than the methods in which is distributed. All students agreed that technology should only be used when appropriate and wanted more instances of lecturers using technology to enhance or complement a subject. Many students believed that complex subjects could be more engaging and easier to understand if lecturers made it relevant to industry or actual working examples.

Self-directed learning was crucial for many students and the importance of digital literacy was debated among the group conforming with some stereotypes found in literature. Students believed that the younger generation were automatically digitally aware as it was integrated into the daily life and was therefore not something that could necessarily be taught to students. The students saw the University’s role as providing best practice and making students aware of different technologies and the impact on their learning. The digital literacy capability of academic staff was debated with most students agreeing that they did not expect their lecturers to be as digitally literate as themselves, but should be when it comes to the subject matter in which they
teach. Other students believed that it became a problem if it started to affect the students learning ability, particularly with inconsistencies experienced with obtaining learning material and lecture notes.

Students wanted academic staff to be more enthusiastic around their subject material and provide students with recommendations with further learning such as videos, to contextualise the taught material.

The next section will introduce results from the final focus group used in this research study, focus group five.
5.3.4.3 Analysis of focus group five

Focus group five consisted of ten final year undergraduate engineering students. The students had recently completed their video assessment and were the first cohort to use the integrated video resource toolkits which takes part in cycle two of the action research.

The aim of the focus group similar to focus group three, was to obtain student views on areas relating to the research and evaluate the implementation of the resource toolkit prototype used to support the design concept video assessment.

5.3.4.3.1 Results of discussions around design concept

The engineering quote given to students during focus groups one, two, and three and repeated in focus group four.

“Young’s engineering students are proficient in detailed design tools but lacking in conceptual design and ideation” (Taborda et al., 2012)

Students in this focus group debated the quote and argued that one goes with the other.

“I’d say it’s not really any, students wouldn’t be particularly lacking in conceptual design just because they are proficient in design tools as opposed to hand-drawing, things like that. I wouldn’t say it’s, you know, they are mutually exclusive”.

Students views of an engineer.
“What I find, being an engineer, you’re given a type of problem and you think of a way you can solve it, and then as soon as you’ve got an idea of how to solve it you think how you are going to manufacture it and how you are going to build it and who is going to build it and how much is it going to cost to build it? Which is obviously skipping all the stages of the conceptual design. If you have a “eureka” moment and you think, “yeah, that will work...” You immediately go on to the next stage of thinking how you can actually have it in your hands, so you can miss out on the conceptual design stage sometimes”.

One student brought in their experience with placements. The majority of the students within this focus group had been on placements and would complete their course at the end of May 2014.

“I worked in a car design studio for my placement year, so I was working with car designers and clay modellers and guys like that. I was very much an engineer, I was a student engineer, so you have the boring engineers in the next building who think about how every single screw, bolt is going to be designed, on that level, but we’re looking at the whole car level and things like that, and I found it hard to not think about – I could put an idea forward and not exactly know how it was going to work, because it was such a concept level that I didn’t need to, that would be someone else’s job to worry about that. But as an engineer I struggled to switch off thinking, “oh, I haven’t actually designed that all the way through and gone into all the details.” It was quite hard to be an engineer in the concept stage only concerned about concept design and ideation and things like that, and not having to worry about it being engineered all the way through. There is definitely, I think if you’re an engineer, you’re trying to find out how things are going to work and to do that you want to know all the stage and you can go through the whole process”.

Students again believe that conceptual design was a skill that was learnt from experience and working with other people’s designs.

“I’d say a lot of what we do about conceptual design, managing the designs that we come up with, I think actually the conceptual designs themselves is something that’s more self-taught in terms of your own experience, or other designs you’ve seen, that kind of thing”.
This focus group debated this quote quite intensively and believed the role of engineering in industry was so varied. The role of an architect and the role of an engineer in a project were compared.

“You don’t necessarily have to have concept skills yourself, but if you appreciate that the person you are working with might be the creative guy, and you give them the freedom to do something creative, or, if you have the creativity yourself. So, you can have it yourself, or just know that there isn’t just someone wasting hours and hours filling out a sketchbook, that’s their job and you will learn things from them”.

The debate between the two roles was probed further and students were asked if they thought it was the role of an architect to come up with an actual design concept for a project or the engineer.

Students felt that it depended on the type of design and the importance of working in an interdisciplinary group was mentioned again referring to one of the soft skills currently emphasised in engineering literature.

“For a building project, yeah, perhaps, but for mechanical we don’t really deal with buildings that much, we deal with like a table, for example, which an architect wouldn’t ever really design I wouldn’t have thought, so it depends on the product”.

“I think it’s important to have that aspect of group work, having the engineering to keep hold of reality, whereas the architects kind of put their thoughts on paper and to work as a group to say, “oh, that’s very good, however if we changed it slightly, it would work”, or “that’s not possible at all.” Yes, I think it’s important to have that balance between the two, so it’s not necessarily anyone’s certain task, but it’s important to work together”.

The general consensus of the group was that a combined approach to a project using the skills of both an engineer and an architect was the most effective.
“I think an integrated approach and brain-storm is probably best, and we start with outer limits, without boundaries, so we throw out all the extreme ideas and put them all up on the boards and work out what, then you start to think about the boundaries of whether it’s possible or not, but actually getting all the crazy ideas up on the board, actually approaching them rather than just rejecting them straight off the bat. It’s always best”.

“I think it’s important to have that aspect of group work, having the engineering to keep hold of reality, whereas the architects kind of put their thoughts on paper and to work as a group to say, “oh, that’s very good, however if we changed it slightly, it would work”, or “that’s not possible at all.” Yes, I think it’s important to have that balance between the two, so it’s not necessarily anyone’s certain task, but it’s important to work together”.

The discussion naturally moved on to their definition of the term ‘design concept skills’. In this focus group students brought in other factors that they believed were important within the design concept process including time management.

“I think it’s better to definitely invest more time, time management is quite important with conception, you have to put in the time at the start to make sure it’s a fully fleshed out concept rather than jumping straight in like someone said before”.

Students were without realising, referring to the ‘soft skills’ that have more recently been discussed within Engineering Education literature (Rao, 2014).

5.3.4.3.2 Use of virtual reality in design concepts

When discussing the use of virtual reality walk-throughs in a design concept project-based students were vocal about their effectiveness. The use of the VR walk-throughs as a communication mechanism was frequently mentioned with
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students stating that they were able to convey their design concept better through the use of a walk-through.

“We’ve all learned from IDDP\(^4\) this year that it’s kind of, a picture paints a thousand words, that there’s only so much that I can tell you about what we’ve designed. We found this last week when we had a meeting with our lecturer. We were trying to explain to him what we were doing with our building, but then as soon as we put it up on the screen they were like, “oh, okay that’s what you mean.”

“I think if you can run someone through a 50,000 word report describing your building perfectly in ten minutes in a walk-through, just the level of learning from going like two or three hours, as many hours as it takes to go through that report, and you could just show it to them in a video”.

In addition to discussions around communication, students felt that the use of VR walk-throughs enables the non-technical public to understand and visualise a proposed project or programme.

“The stakeholder that you are trying to convince to give you the money, or the yes, who is probably a managing director or CEO, if they’ve probably been out of university 25 years and are probably out of touch with using probably the terms that you would use in a report, getting them to see it visually, or touch it, that’s all they need to know. That communication on a non-technical level”.

Advantages of virtual reality walk-throughs in legal terms for engineering were also mentioned and it was perceived that having something visual to refer to would limit the ambiguity within specifications in engineering.

Students were then asked what gives a better idea of a design concept, a physical model, a VR walk-through or a combination of the both. The view

\(^4\) IDDP – Interdisciplinary Design Project
between the group was split, half the students believed a combination of both was required dependent on need.

“I think you need both, don’t you? If you had a physical model of a building on the table now at a certain scale, you can see how it looks, so that building is designed in context to the surrounding area. It’s a full scale, when you are looking at it through your eyes it looks full-scale to you and it looks like you are actually immersed in it. I don’t think one or the other are better on their own. I think you probably need a combination”.

Other students discussed the limitations of physical models and how digital technology can help share ideas and designs when geographical limitations occurring working practice.

“I suppose the limitations of the physical one is, we could all look around it here, but your managing director in Germany wouldn’t be able to look at this model, but you could send him the digital file of the virtual reality walk-through, or the digital file, and he could view it”.

The government move to BIM was also discussed in this context and one student commented that they would be required to work in this way when they go out to industry.

“The government are obviously seeing this as the future, because they are integrated BIM now aren’t they, into the contracts from 2015? So you are going to have to physically show that, instead of providing just drawings now, the government are requiring you to show them 3D visual effects. They’ve just written it in as BIM so far, so that could be literally like a sketch on a piece of paper, but they are hoping that it will get taken further, so it’s conceptual design. We are going to have to start using this pretty much as soon as we come out anyway”.

All students in the group spoke highly of the use of modelling and VR walk-throughs.
“In terms of modelling and visualising the 3D environment it’s just sensational. I think it’s such a powerful tool for an engineer to have. Whereas it was just a creative tool, it’s now moved into an engineering environment”.

Students were very supportive and positive about the use of the virtual reality and CAD techniques in engineering.

5.3.4.3.3 Reflections on views on the interdisciplinary design project work

When reflecting on the work they had recently completed on the interdisciplinary design project (IDDP) work. Students generally enjoyed learning new skills and pieces of software particularly with the reference the software used in industry such as Revit.

“Well I personally, we both worked on the CAD for ours. We started doing a video and I think we all quite enjoyed learning the new piece of software. We used Revit, and we quite enjoyed just teaching ourselves to use that really. It was quite interesting”.

Frustrations were felt over the lack of computing power required to render their videos which was similarly seen across all focus groups despite upgrades implemented after action research cycle one.

Students spent time self-teaching software relevant the video project.

“I taught myself to use Premiere Pro for the video, and whilst it’s got thousands and thousands of different functions that you can use, it takes longer to use, but it’s so much more flexible than iMovie and things like that, that I was almost quicker because I could do the things I wanted and not have to fiddle about on iMovie trying to get something where I want it, but I can’t because it can only go in that box or something”.

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Throughout the discussion around the design concept video it was evident that students utilised online video tutorials and searched for answers to their problems using search engine such as Google.

“I didn’t ask anyone for help, but there’s so many things on You Tube. There’s kids that are like nine years old in America that show you how to use Premiere Pro on You Tube”.

To further probe skills that the students had learned as a result of creating the design concept video, students were asked if they felt that the skills learnt during this process were transferable into an industry scenario. The majority of the students believed they would use the skills and industry in conjunction with VR walk-throughs.

“With the virtual reality walk-through, if you’re able to put something like that together, chances are you’re going to be putting the final videos together through a program like Premiere”.

One student questioned whether an engineer would be required to make a video.

“I do question, I had a big argument about this yesterday, whether really highly paid engineers, I mean we’ve got ***** ***** 5 from Babcock working with us on our project, and the guy’s seconded to the Navy to design warships. I don’t believe for a moment he spends any time, and I’ll ask him the next time I see him, making videos”.

When asked to comment on areas they found more challenging, issues surrounding access to powerful computers was reiterated several times.

5 Name removed for anonymity
“I think we were limited by the computing powers within the university. They are not incredible, some of the rendering takes ages and we had to put it on”.

As with all of the focus groups that discussed the work around the design concept video, students spoke about the issues with rendering their CAD modelling into a VR walk-through. Despite some investment in upgrading computers following the first cycle of action research, students still experience slow rendering rates which left them feeling frustrated. They further questioned the computer specifications and whilst the machines and laboratories and open computer rooms were high spec than the computers students may have at home, due to university mapping software it meant that the machines did not run at the full capacity.

They also spoke about difficulties in locating rooms for working in which mirrors concerns in literature that universities are struggling to maintain facilities and learning spaces for students (Balamuralithara & Woods, 2009b). This also included the ability to support students who wanted to work in a suitable environment with their own device.

“You just need space where you know you are not going to get kicked out. That space is free. I’m not asking for any equipment, just to sit with a table and chair”.

Recently in literature, researchers have found that many students are now starting to bring in their own device and that universities should seek to explore learning spaces instead of shelling out money on high spec equipment (Thomson, 2012).
When asked how they would solve the problem of having a suitable space in which to work, one student mentioned having rooms specific for each year stage of the course. The same student then dismissed his own idea due to the scalability of that request. During this conversation in particular, it was evident that students were fully aware of limitations on physical space, resources and financial constraints that Higher Education Institutions face.

Flexible working and study was discussed several times during this focus group and it became evident that students themselves face problems in juggling study and work. These factors meant that students would often study outside of normal core lecturing hours with many students demanding 24/7 access to buildings and rooms so that they can work undisturbed.

“We were rendering the video, somebody stayed until two o’clock in the morning and then they got kicked out by security”.

Students felt very frustrated and believed that they should have more of a voice when it came to room availability out of hours. This reinforces increasingly literature both within Engineering Education research and educational studies that students see themselves as stakeholders and clients, particularly with the increase in student fees (Cardoso, Carvalho & Santiago, 2011; Woodall, Hiller & Resnick, 2012).

5.3.4.3.4 Transferability and impact of video to industry for recruitment

Students felt that the design concept video work had considerable impact on their employability. One student group had sent their video to a local firm and
had received extremely positive feedback and had been asked to send in his CV following the viewing of the video.

“We sent our video to a professional afterwards who were doing some of the projects of ours in Plymouth Dockyards, and he was really impressed with our video. He asked one of the guys to send his CV to the head recruitment with a recommendation”.

Other students had experienced the use of videos with practitioners in industry.

“On another note, we were given a lecture by a guy from a coastal engineering company, and they had to turn around a design and video in two weeks as a concept idea, and the fact that they had someone in the office already who knew how to turn a model into a video within like half a week, a couple of days”.

“It was just the fact that you were able to do that and present your ideas. I think it’s important that there is something in the house who is able to do that. If you are able to do that, it’s an extra advantage to your CV, isn’t it?”.

Students are aware of the need to be multi-skilled due to changes in financial investment in construction and engineering businesses. They felt that the role of the traditional engineer was changing and they must become more flexible in how they work. This is also reflected in engineering literature where engineers are becoming more like project managers and must be able to work in different disciplines (Fuchs, 2012; Picon, 2004).

“I worked at Babcock for three months this summer, and I worked in a car design studio for 12 months. You would make videos and virtual reality walk-throughs in the car studio, in Babcock I was there and I was writing 50 page reports, boring as anything, but they want a fat report. The more pages the better in their eyes. They are not all old guys, there’s some young guys there, but it’s very much a paper report-based deliverable that everything is in, because there’s no ambiguity in writing like a 10,000 page report. If they want to know something, you write a report on it, whereas in the car studio there would be guys who would
just make a video for fun, because that’s how they knew their boss likes to see their work being produced”.

While students didn’t feel they need to know how to produce videos or CAD models as effectively as other disciplines, they believed it was vital that they understood the processes behind the work to be able to work effectively with others by understanding what that work entails.

“I think even if you don’t use the skills yourself, like I said earlier, if you appreciate that someone can use those skills. So the fact that we’ve gone through the process and may have made a good video, or a crap video, when it’s probably not going to be you doing the video, but when the person who is doing the video, you know that you are not going to give him ten minutes to put a video together, you are going to give him probably half a week to put a video together, something like that. You can appreciate what goes into it”.

5.3.4.3.5 Results on production of the design concept video

During the focus group students fed back to the work video, students enjoyed the variety of the assessment and felt that it was a positive addition to their skills base.

Students had looked the online resources such as YouTube to teach them how to do tasks and activities within software programs such as Revit and Adobe Premiere Pro.

Students only used Microsoft PowerPoint to create animations as they felt it was an easy way to illustrate points within their design concept.

“We used PowerPoint to do some of the animation, because it’s quick and easy”
One of the main differences observed this year was the extra length students went to in order to make their video stand out and different to previous years. Some of the students within the group shared some of the techniques they had use within their video including video overlays using green backgrounds. This was not included in the toolkit and students had researched and implemented this technique themselves.

“If you put a green background, do all your animation and then bring it into video editing and look at it as a green screen thing, you can get rid of the green”.

Other students joined in the conversation mentioned using additional software that had not been included as part of the toolkit including Adobe Photoshop for image creation.

“Yeah, it’s like knowing how to do it, because instead of doing that, for example, I used Photoshop as well, so if I wanted something that was on its own, I could just import that as an image, delete background and save as a GIF”.

During the question it was evident that students had used a variety of software and techniques outside of the recommended ‘easy’options. When asked why they had chosen to use the more complex pieces of software, students joked and said they like a challenge and wanted to produce a video of high quality even if that meant spending extra time learning how to use a piece of software.

The conversation moved onto the use of the toolkit, with most students finding it useful to have all the information collated together in one place as well as summaries of each individual piece of software.
“Yeah, I did look at it. It was useful to have all the information collated”.

“I found it quite useful just to go on and see, where I can download it from, where the tutorials are and all the things like that, and also just at the start we had no idea what to use basically, so it was good to be able to see just an overview of each program as well”.

All of the students within the focus group had used the toolkit in the creation of the video and agreed that it provided a starting point for the students to work on without dictating what software to use and given them complete creative freedom.

When asked what could have been improved upon, the students felt that more specific guides could have been included on the use of Revit, AutoCAD and Solidworks. However, the students did not expect academics to write the guides that make use of existing material on the Internet and reference it accordingly.

“You could write guides. I’m not saying you do, because I don’t think it’s an efficient use of anyone’s time to rewrite – there’s things like Adobe Help, I don’t know what it’s called and things like that, and Solidworks Help and Ansys Help, which someone, not just yourself, but I couldn’t do a better job of rewriting and covering everything that’s out there. But like I said yesterday, I think, there’s no point in getting the lecturers to make their own information for what you were talking about yesterday, because there is people on the internet that do it and all the products generally have their own help, and then there’s people out there who show you step by step how to do it and record their screen”.

Students felt that they learnt the most by online demo tutorial videos that took you through step-by-step screen recording on how to use software. All students agreed that there was an abundance of information already available and that all teaching staff needed to do was to give some recommendations on which tutorials were most effective.
Other feedback included having examples of videos that were created in industry similar to their project work so that they had a professional level video to compare to.

“We watched through those just to get an example of what’s good and the level of standard, but I think what would be good is if there was any professional made videos from industry, just at that level. Because we were like, in our minds we were saying, “we want this to be a professional video. We don’t want this to be a university video made by four, well a couple of students. It needs to be a professional level.” So we wanted to see a professional level video. It was helpful to see all the previous years, but...”

They didn’t want their video to just be a submitted piece of university coursework, but a highly professional piece of work that they could use to demonstrate and evidence their skills.

Students also wanted an example of badly marked videos. Within the toolkit they had been exposed to videos from previous years that had received good marks and contained feedback as to the justification for the mark. However, due to data protection of student information this would not be an option.

Following further discussion, some recommendations on what would make a bad video were compromised as an option.

During the toolkit lecture, students had been advised not to start creating their videos and more professional level software such as Adobe Premiere Pro due to the steep learning curve. One student felt that this was a deterrent for students and that they would want to learn something more difficult.
“That’s a red rag to a bull when it comes to engineers. We want to do stuff that’s difficult. We are not interested in doing run of the mill stuff”.

The opinion varied among the group with others preferring to have recommendations on simplicity to ensure that the content of the work was the most important aspect of the video.

Discussions moved onto the mobile compliancy aspect of the toolkits, the majority of students did not feel that it was important that it was viewable for mobile devices such as tablets and smartphones as they would be viewing the toolkit whilst at their machine working on the project.

“No, for me, I think the reason is I prefer, I’ve got two screens at home and I prefer having a big screen so you can have several things up at once. So you can have the tool-kit and then actually use it, where you can’t do that on a mobile phone”

This was purely a personal preference option as feedback from the focus groups indicated how useful it was for the toolkit to be mobile compliant formats such as HTML 5. In other focus groups students highlighted the importance of being able to learn when commuting home and perhaps sat in front of the TV and not physically at a computer. This again refers back to different learning styles of students and how material should be supported and made available in formats that facilitate different learning styles (Lindsay & Good, 2007).

5.3.4.3.6 Teaching of engineering utilising technology

Students were asked how Higher Education Institutions could utilise technology in supporting large groups and enhancing teaching and learning practices.
The use of iPads and tablets came into frequent discussion and students felt that these mobile platforms could be used to facilitate physical experimentation by taking students away from an actual laboratory.

“I’m a student ambassador anyway, so we do quite a lot of stuff with, when the students come in. So even like, one of the guys was wanting a dissertation to teach kids how to do, like teaching first years how to do bending moments on a tablet PC. So they would be doing lectures on tablets rather than having to use pen and paper, so freeing up space for us guys on computers in our massive labs would be beneficial if they could just sit down in a room and have an iPad, like one between two, with all the stuff that’s coming up on the board. That’s the way that schools are going, so why isn’t university up there with that? Also for us guys as well, the maths, my girlfriend does maths, they get iPads so that they can do their work on them”.

Whilst the idea might appear to be difficult to achieve, the use of technology to recreate a physical laboratory has been widely discussed in Engineering Education literature for a number of years (Balamuralithara & Woods, 2009b; Nickerson et al., 2007b; Stefanovic, 2013a).

Students also discussed the idea of making iPads freely available to students to facilitate their learning. Due to the fees increases students felt a sense of entitlement as a paying customer which reflects increasing literature recurring in Higher Education around students behaving as customers rather than just consumers of knowledge (Cardoso, Carvalho & Santiago, 2011; Woodall, Hiller & Resnick, 2012).

“We do a lot of stuff where the lecturer gives us a lecture and then, he puts it on the portal as well, so it would be useful to have the lecture on your tablet and then be able to write stuff down during the lecture as well. Kind of like when students come in, why can’t we show that we’re
leading the way rather than having us guys sit here whingeing about how stuff isn’t as good. Especially when people are paying £9,000.00, a tablet that’s 230 quid plus people that we’ve got in civil engineering are so keen for BIM and using all this neural network stuff, that they can lead the way forwards for the university so why don’t they utilise that rather than just resting on what we’ve got?”

Other opinions around technology being used in teaching were based around technology such as webinars to facilitate large groups and allow the students the option of re-watching them if the academic recorded them. However, students again reiterated that teaching staff should not use technology if the quality of teaching is missing in the first instance. Many believed that using technology in bad teaching practice would emphasise the negative aspects of the delivery.

Students also discussed that each student had their own way of learning and consuming knowledge. Some students would record their lecture with consent from the lecturer and others would take pictures of the screen in a lecture room or use their iPad to make notes for later revision.

Students were generally positive and enthusiastic about the use of technology in their learning but only if it was appropriate and relevant to their subject.

5.3.4.3.7 Conclusion of focus group five

This focus group prompted a lot of discussions and debates around certain topics such as the role of an engineer and methodologies carried out to produce
the design concept video. Differing opinions among the students reconfirm literature stating that students each have their own ways of learning and not one technique can accommodate all. Instead provision should be put into place to accommodate different mediums in which students learn and work.

Students views on technology was generally positive but only wanted the implementation of technology within their learning if it was pedagogically appropriate and relevant.

Students didn’t expect staff to produce online guidance on software or other techniques but to instead utilise existing appropriate information online and explain to students why it was a good resource.

It was clear that these final year students as many of the students had recently done a placement or had industry experience as they were able to contextualise what they learnt and identify standards and techniques used in industry and query that what they were learning within their curriculum was out of date and not true representation of working practices.

The design concept video project was received positively by the students and enjoyed the variation of the assessment as it allowed them to develop skills that they would not associate with engineering.

All students agreed that this work was relevant to working practices in industry, with some students experiencing employability options as a result of the design
concept project work. Skills learnt within the project were said to have been transferable into an engineering company, or would allow the engineer to have a greater appreciation and understanding the processes behind justifying the design concept to an outside stakeholder.

The toolkit was used by all of the students within the focus group with students finding it a good starting point for their project and a point of reference for support should they need it.

Each student had their own way of learning and all had differing opinions about the importance of the toolkit being mobile compliant. However, the general consensus was that it should be in this format to be able to facilitate all types of use and scenarios.

This concludes all of the focus groups use within action research cycle two. The next section will conclude the cycle of research and provide recommendations on potential future implementations of this work.

5.3.5 Conclusion of action research cycle two

Data gathered during this cycle of the research aims to evaluate the effectiveness of the implementation of the toolkit prototype.

An online toolkit prototype was developed and implemented using Xerte online toolkits to support the students in the production of the design concept video.
The design and content of the prototype toolkit was justified by feedback and results from the first cycle of action research discussed in Section 5.2.

The prototype toolkit was embedded in the student’s module and delivered using a variety of methods including lecture, email and information hosted on the student’s virtual learning environment platform.

Students found the toolkit to be incredibly helpful and beneficial to their production of the design concept video, with the majority of student’s access in the toolkit.

Students from the focus groups that had difficulties in developing their design concept video had not seen the toolkit despite being aware of its presence.

In this cycle of the research, students, particularly in the final year group, spent considerable amounts of time and effort in making their videos of high-quality and professional.

Students discuss the relevance of the video in terms of their employability, with some students commenting that potential employers had asked to see their CV as a result of seeing their design concept video. They also felt that their skills developed during the design concept video process were transferable into industry. Students did not necessarily expect to be asked to create a video when commencing their employment, but felt that it was advantageous to have an
understanding of the processes behind creating one and how they can be an effective method of communication to existing or outside stakeholders.

This cycle of action research saw more innovative and creative uses of technology within the design concept video and students appeared to take more time in developing different ideas after viewing case studies from previous years videos.

Recommendations for future work were identified including:

- obtaining examples of industry videos used for similar communication
- expansion of online guides around the creation of VR walk-throughs and CAD models
- recommendations on what makes a bad video to allow students to avoid making mistakes
- more investment in physical resources and more importantly spaces to facilitate students bringing in their own device for their work

This concludes action research cycle two, the next section of research will summarise both of the action research cycles and introduce the final phase of the research which validates methods used within this study in the form of an industry based survey.
5.4 Summary of action research cycles

Two cycles of action research were implemented within two individual engineering courses including one final year and one first year module.

Action research is underrepresented in Engineering Education and literature has speculated that this methodology would be effective in Engineering Educational setting (Case & Light, 2011). To assess the appropriateness of the methodology, action research was used to evaluate the implementation of new assessment techniques utilising video assessments within two engineering modules and two individual cohort years.

The first cohort consisted of approximately two hundred and twenty first year engineering students and the second cohort contained approximately one hundred and ten masters level undergraduate engineering students.

Both modules were chosen due to their interdisciplinary approach inside the module curriculum which reflects the way in which engineers are increasingly being asked to work in industry (Borrego, Foster & Froyd, 2014).

Additional techniques were used within the cycles to gain further qualitative and quantitative data using focus groups and student satisfaction and skills audit survey. These techniques evaluated the implementation of new assessment techniques in video assessment creations and form recommendations for subsequent action research cycle.
The first cycle of action research discussed and evaluated how video assessment was implemented within the module. Feedback was gathered using student focus groups and recommendations were formed on creating a prototype toolkit that would further support the students in the production of the design concept video assessment.

The second cycle of action research concentrated on the implementation of the online toolkit prototype developed and created as a result of feedback from the first cycle. The prototype toolkit was delivered and embedded in module cohorts and further evaluated using three focus groups.

The cycles of action research proved to be an effective way of both evaluating current educational practices in engineering, but also implementing substantial technological change using reflective practices.

Evaluating new practices using focus groups allowed critical reflection and improvement of techniques used within this study. Students were able to reflect on the assessment and identify areas of support that were missing within the implementation of the video assessment.

Following evaluations, the prototype toolkit was implemented during cycle two and students felt the toolkit helped support them and created a starting point for their work. The majority of students within both cohorts used the toolkits and found it useful to have information collated and relevant to their work.
Whilst the toolkit was mobile compliant and worked on smart phones and tablet is due to the HTML 5 format, students had mixed opinions on whether this was needed as some students used it whilst working at a computer and other students viewed the toolkits whilst commuting home from the University or sat in front of their TV.

Discussions around areas in Engineering Education such as the use of VR, impact of technology on working practices in engineering, digital literacy, roles of engineers and teaching practices in Engineering Education provided a useful insight into the student’s views around these areas.

Data gathered during the focus groups will be compared against industry views that will be gathered as a result of the industry based survey discussed in the next chapter.

The next chapter of the thesis will introduce the industry based survey which was carried out in parallel to the action research cycles in order to validate methods used within this study against industry practices and concerns.
6 Results from Industry Based Survey

This chapter presents data from the industry based survey to validate chosen methods used during the action research cycles. Industry viewpoints obtained on key areas relating to this research will then form a comparison against student viewpoints gathered during the action research cycle stages for further discussion in the subsequent chapter.
6.1 **Industry based survey data results**

The following section discusses the results from the industry based survey carried out in parallel to the final action research cycle discussed in Chapter 5.

The aims of the survey were to gain opinions from working professionals within the disciplines of engineering and architecture who have worked with or employed engineering graduates.

The main objectives of this survey are summarised:

- gather opinions from professional representatives from industry on existing practices in engineering around the subject of design concept process.
- understand an industry perspective on the importance and place of virtual reality (VR) walkthroughs in a professional environment.
- gain an industry viewpoint of the skills of current engineering graduates in the work environment and which areas they feel students could improve on before entering the workplace.
- collect views on how Engineering Education is evolving and how technology is impacting on changes in engineering practice including speculation on future methods in teaching engineering
- Align results gathered from the survey to compare against data collected during the action research cycles implemented during this research study
Results from Industry Based Survey

- compare industry perceptions of topics surrounding Engineering Education for comparison against student data gathered during the action research cycles

Results gathered during the survey were combined with data gathered during the other stages of this research to form future recommendations on Engineering Education.

Question design of the survey contained several areas that mirrored topics and questions asked in the student focus groups during the action research cycles discussed in Chapter 5.

Engineering Education literature discusses concerns from industry that the current engineering curricula is out of date and not responding to industry needs and working practices (Haertel, Terkowsky & Jahnke, 2012). This survey aimed to understand perceptions and opinions from engineering based professionals in industry and teaching staff within engineering. The results would also be compared against student focus group data gathered during the action research cycles. This aimed to evaluate the students had an awareness of industry concerns and requirements of engineering graduates.

The assessment techniques used within the modules during the action research cycles contained strong elements of alternative technology-based assessment methods and placed strong emphasis on the use of virtual reality walk-throughs and CAD models within an interdisciplinary engineering project group.
In order to evaluate the appropriateness of these techniques within the engineering curriculum, the survey posed questions surrounding the use of these techniques and graduate capability in order to gain the opinion and thoughts of academics and industry based professionals. Results from this validated the techniques used within this project and providing recommendations for the future direction of engineering curriculums.

The next section will discuss how the survey was analysed.

6.2 **Analysis of survey data**

The survey results are divided into seven key areas based on question content:

1. sampling data on participants
2. graduate skills capability
3. virtual reality and design concept process
4. digital literacy in engineering graduates
5. future of engineering curriculum
6. impact of technology on working practices
7. opinions on the online delivery of engineering courses

The survey was created on design using SurveyMonkey and was active for a period of eight months and disseminated by various mediums including email, web advertisements and newsletters.
Results from Industry Based Survey

Questions were analysed using a combination of manual and electronic methods. Survey responses were printed out and scan read to identify and highlight key points manually. The predominant analysis of the data utilised the inbuilt analytic tools found in SurveyMonkey itself.

All individual responses were categorised under two initial themes; industry based responses and educational based responses as shown in Figure 61. Educational based responses were defined as participants who are actively working in education in Higher Education Institutions for example academics, teachers and technicians. Industry based responses were defined as participants who are actively involved in working practices outside of education for example; engineers, architects, urban planners, designers and construction workers.

![Figure 61: Categorisation of survey questions results](image-url)
6.3 **Sampling background evaluation**

The background information and data behind the respondents to the survey are outlined in the next section. The professional job title field from respondents indicated a good mix from both industry and education. A word cloud was created showing the seventeen most used words within the professional job title field from the survey and is illustrated in Figure 62.

A word cloud or ‘tag’ cloud is a visual representation for text based data and often used within qualitative data to identify frequently used words. Each word is singular and the most prominent words appear larger in font size to less used words. Within qualitative research the use of word clouds are becoming a useful tool for initial analysis over text based data (McNaught & Lam, 2010).

SurveyMonkey has its own inbuilt word cloud analytical tool similar and will be used for the text based questions in the survey as well as manual methods.
Further manual analysis from manual categorisation inbuilt in SurveyMonkey demonstrated a good representation in job roles from both engineering and architecture disciplines, including educational contexts as well as industry.

Respondent’s area of work were analysed using word clouds created within SurveyMonkey and manual categorisation within the survey software. Manual categorisation of results found sixty-six respondents (58%) working within the industrial sector and forty-seven (41%) working within the educational sector. One respondent chose to skip this question.

Figure 63 shows the word cloud showing the eleven most important words associated with this response.

![Word cloud showing top 11 words associated within field of work](image)

Respondent’s length of service varied between one year and fifty plus years demonstrating a broad spectrum of experience which will allow the potential of cross referencing across questions discussed further in the survey results.
6.4 Generalisation quote on engineering students being proficient in detailed design tools but lacking in conceptual design and ideation

The next section of the survey focused on conceptual design skills in engineering graduates to reinforce the design concept work use within the interdisciplinary design project modules used within this research.

The same quotation used in focus groups one, two, three and five which is discussed in Sections 5.3, was included in the survey to gather industry based viewpoints for later comparison against responses from the students during the discussions chapter.

"Today’s engineering students are proficient in detailed design tools but lacking in conceptual design and ideation". Taborda, Elkin, et al. "Enhancing visual thinking in a toy design course using freehand sketching." ASME international design engineering technical conferences and computers and information in engineering conference. 2012.

Responses from the survey predominately agreed with the quote stating that graduates are entering the workplace without any practical knowledge of industry based practices and are skilled in theoretical abilities but lack the conceptual skills needed within engineering design.

“I believe this is true as everyone is being taught to use software tools to carry out the thinking. There is more and more use of engineers who have come straight from university and into the office without any practical and real world experience”.

(Principal Electrical Engineer – Construction)

“Most graduates coming through have never had a good at trying design, drawing concepts etc. All their teaching is theory and most of it is no use in the workplace. It is the industries own fault as it expects technicians to
do drawing and graduate engineers to do the design, however engineers need to be able to sketch and visualise”. (Principal Engineer – Engineering)

Students in the interdisciplinary projects both in the first and final year were taught the importance of understanding the concepts behind the design process as well as being able to convey their ideas visually using software techniques and in hand drawn sketches and physical models.

The small exceptions to this view were mainly from educators, primarily engineering academics:

“I do not share that view. I believe students today are trained in a manner suited to the industry into which they are thrust after graduating”. (Lecturer - Civil Engineering)

Contradicting views from an engineering academic agreed with quote, blaming the innovation of technology both in computer games and other technologies for children and teenagers. They saw this as a hindrance to creativity and believed traditional toys like Lego and Meccano promoted innovation and creativity by practical methodologies.

“I agree and I believe that part of the difficulty arises from significant changes in pre-university development, associated with the growth of computer games and related technologies, meaning that traditional toys are less widely embraced during the formative years. In the past, toys like Meccano, Lego and Beta Builda Similar to Lego (there are many other examples) promoted creativity and innovation with practical and achievable outcomes. The same 'mind potential' is now frequently absorbed within virtual spaces with, typically, different outcomes.”
Other responses from the educational based fields were more cautionary on their response, stating that it depended on how the students were taught and how much workplace experience they had.

“It really depends on the staff teaching the students and how much industrial experience they have. Teaching from a book will produce processors with limited understanding, whilst teaching from experience is more likely to develop understanding” (Chartered Engineer – Lecturer)

Architectural educators reiterated the importance of sketching in assisting with design concepts and ideation stating that engineering graduates struggle with basic design skills.

“I have through the years in my experience found this to be true of engineering graduates and professionals, with rare exceptions. In our architectural technology and design focused course, my colleagues are for the first year moving away from technical drawing to 3D sketchup... however sketchbooks will remain a priority”. (Principal Lecturer – Architecture)

Responses on this question reiterated the importance of exposing undergraduate engineering students to creative design and innovation which is repeated in literature around Engineering Education discussed during Chapter 2. The concept of design thinking within Engineering Education has become more prominent in engineering in the last decade, however despite small encouraging signs; this is still yet to be reflected in engineering curriculum.

“Totally agree Most engineering projects are made up of systems (Mechanical, Elec/Electronic and Civi Engineering) that interact together to provide a solution to an engineering problem or scheme. Its extremely important that students gain experience in creative design and innovation and how to formulate design ideas and develop them”. (Energy Engineering Consultant/Associate Lecturer)
Most responses on this quote reinforced concerns that recent graduates and students relied on the software to ‘carry out the thinking’ for them rather than understand the reasoning behind them. There was however, a general consensus that students could only really conceptualise with experience and exposure to real life practical experimentation, both difficult to achieve within the parameters of an already pressured educational curriculum.

Figure 64 shows a word cloud representing the top twenty-six most commonly used words resulting from this question demonstrating that creativity and design are linked with experience.

Figure 64: Word cloud on views from survey quote
6.5 Graduate skill capability

The next section of results discusses viewpoints on graduate skill capabilities reported to be missing when students enter the workplace. As experience is limited for the majority of students entering the workplace after graduating, this was exempt from the choices.

Engineering graduate skills capability has come under criticism from industry, reporting that students are deficient in fundamental key skills needed within the work practice. These key skills are often referred to in literature as ‘soft skills’ which has become more prevalent in Engineering Education literature in the last two decades (Rao, 2014).

The interpretation of soft skills in engineering varies amongst practitioners, but can be summarised under the following fields:

- communication skills
- team working skills
- leadership skills

In addition to these soft skills, respondents were asked if graduate engineers were lacking in any specific skills apart from experience, when they enter the workplace.

Respondents were given the option to select multiple choices or enter their own. The results from this would later be compared against views raised in
literature to create a greater understanding of the skills gap in graduates in engineering. Figure 65 summarises results from the question on missing graduate skill capabilities in engineers when entering the workplace and Figure 66 outlines the number of participants responded to each choice.

![Figure 65: Skills missing from engineering graduates](image)
Technical knowledge, Freehand Drawing Ability, Design concept skills and time management were areas that industry deemed as lacking. The general consensus from responses was that graduates lacked the ability to transform theory learnt in education into working practice and how they should interact with different disciplines as an engineer:

"Having recently graduated and have now found employment in relevant industry, it would appear that the university course perhaps lacks in 'real world' experience. How projects actually run and how processes actually operate in order to achieve tangible results". (Architectural Assistant)

“Written, oral, presentation communication skills” (Professional Development Manager - Highways and Infrastructure)

“Most engineering courses do not cover end-user involvement in design and understanding end-user requirements. There is often only limited material on ethical issues. Therefore graduates are likely to be lacking key skills in these areas”. (Senior Lecturer – Engineering Technology)

In addition to the soft skills, responses indicated graduate engineers are insufficient in design skills and the ability to draw freehand which was repeated
during the free comments on this question. Literature on the use of design skills in engineering is increasing and has focused on the importance of having a creative engineer but also criticised the use of technology design tools such as AutoCAD to facilitate it.

Students within this study were made to work in interdisciplinary based groups to represent how 21st-century engineer should work in industry. Both Engineering Education literature and results from the survey reinforced the importance of soft skills within engineering graduates.

The survey indicated that respondents from the survey felt that technical knowledge, freehand drawing ability, design concept skills and time management were areas that industry deemed as lacking. Work within the design concept video encouraged technical skills development and was primarily focused on building design concept skills within a team environment and therefore was responsive to views from industry.

6.6 Change in graduate capability

To expand on graduate skills capability, respondents were asked if they had seen a change in graduate capability in the last ten years. This question aimed to gather qualitative data on what changes have occurred from different stakeholders involved in Engineering Education.
In order to gather themes and viewpoints from different areas in Engineering Education, responses were filtered into those from educational academic based roles and those based in professional practices such as engineers or architects.

Some of the educational responses focused on issues relating to widening participation and the fee changes creating a different type of student:

“The fee structure at the universities is creating a consumer culture and students who graduate are likely to carry forward such thinking into wider world - not good if you are trying to create thinking and responsible professionals”. (Lecturer - Architecture)

“Widening participation, by increasing the proportion of young people entering university level education, has increased the number of students who are not ready for higher level education (i.e. those who need to decide what they want for a career before choosing an arbitrary course). They should find work/experience first then enhance their qualifications”. (Reader - Mechanical Engineering)

The impact of technology within an engineer’s role was discussed by many educational based respondents. Many argued that it was engineering itself that had changed but Engineering Education has yet to adapt to these changes, a view that is repeated in Engineering Education research literature.

“Not so much "capability" as students today are just as capable as any time in the past. The change is in the nature of engineering itself - Computers have become extremely powerful and much of what an engineer did with a calculator 10yrs ago is now codified into a software programme. That results in a change in focus for engineers”. (Lecturer – Civil Engineering)

“There is a tendency towards increased computer/technical skills, accompanied by reduced maturity and professional networking skills: I offer some personal views also: The mobile technologies have created wonderful freedom and digital access (even from primary schools onwards) but these technologies have facilitated intensive peer-to-peer communication, at the expense of interaction with adults. This means
that both socially and in direct educational settings, there is much more intense interaction with peers (more comfortable also) and less interaction with adults and professionals (less comfortable). The wonderful communication abilities can actually end up stifling really vital interactions, because there is so much energy and general communication traffic being expended on the 'peer to peer channels', often to the detriment of adult interaction. School and home life are all significantly affected by this phenomenon. Peer-to-peer interaction, if too sterile, can simply reinforce aspects of immature networking at the expense of mature developmental interaction. Technology is fuelling much more here than simply a generation gap”. (Senior Lecturer & Faculty Teaching & Learning Coordinator – Computing and Engineering)

Technology was often referred to in a negative context, speculating that technology has caused a reduction in physical communication skills in a social and professional context. Students were seen as being able to communicate effectively in a virtual environment but at the expense of physical human interaction.

Skills that have been defined as ‘soft skills’ discussed in previous section are expanded upon within this question with many respondents referring to the lack of this in engineering graduates.

“Engineering courses in the UK are beginning to address professional competence - but there is a long way to go before one could say that engineering education delivers well in this direction”. (Retired Professor - Structural/Civil Engineering)

“Less organised and lacking basic communication skills. Low standards in time keeping, presentation and appearance”. (Associate Structural Engineer)

The views from industry were stronger and concerns again around the lack of practical skills surfaced and how students lacked independent learning and
thinking were echoed throughout the survey. Frustrations on the lack of change in engineering curriculum was frequently mentioned from industry responses.

"It feels like the students expect a lot more. Not necessarily teaching but to be told exactly how to the point of be shown exactly and doing the work for them, even though there is enough material available to self-teach".

“Not really because the universities haven’t changed the way the courses are run or taught”. (Architect)

Responses regarding the lack of design skills in engineers were commented on by a number of respondents.

“The push to require MEng has led to Graduates who has a lot more theoretical knowledge that is of no use in the workplace. They are generally not given projects which involve design. Most have never done any drawing when they start work. Even at my level you need to sketch your thoughts out”. (Principal Engineer – Civil Engineering)

Other themes from the survey question reinforce concerns that students are reliant on software and technology for design solutions without understanding the fundamentals behind a good design concept.

“From a structural engineering perspective, I believe that recent graduates are far too eager to try and utilise design software prior to gaining an appreciation of detailed hand calculation. This can lead to a fundamental misunderstanding of design concepts”. (Senior Structural Engineer - Engineering Consultancy)

Industry viewpoints mirror frequent discussions in literature both historically and more recently which is discussed later on in this paper. The changes in fees structuring has led many educators to see a perceived change in the attitude of students who want justification on the amount they are paying for their degree.
Literature around this is limited due to the recent fee changes, aiming but certainly indicates that this is becoming more prevalent (Allen, 2012).

Educators were more concerned with the impact of technology within engineering graduates and predominantly saw this has a negative attribute whereas students from the focus groups believe that technology had a positive impact on their studies and allowed them to contextualise their learning as well as adhere to the industry based standards such as BIM (HM Government - Department for Business, 2012).

A word cloud analysis was created on responses from this question can be seen in Figure 67.

![Figure 67: word cloud on views on the change in the graduate capability in the last ten years](image-url)
6.7 **Virtual reality in design concept process**

The use of virtual reality in engineering is becoming more popular as educators begin to appreciate the effectiveness of visualising design concept using VR models and CAD (Abulrub, Attridge & Williams, 2011). Participants in the survey were asked how useful they felt VR walk-throughs were in assisting with the design concept process. A chart visualising the response can be found in Figure 68.

![Figure 68: How useful are virtual reality (VR) walkthroughs in assisting with the design concept process for engineering designs?](image)

**Table 68: How useful are virtual reality (VR) walkthroughs in assisting with the design concept process for engineering designs?**

<table>
<thead>
<tr>
<th>How useful are virtual reality (VR) walkthroughs in assisting with the design concept process for engineering designs</th>
<th>1. Not Very Useful</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5. Very Useful</th>
<th>Total</th>
<th>Average Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.49%</td>
<td>7.69%</td>
<td>23.09%</td>
<td>30.77%</td>
<td>32.87%</td>
<td>91</td>
<td>3.78</td>
</tr>
</tbody>
</table>
The majority responses from the survey indicated a strong preference to the usefulness of VR models which reinforced justification on the use of this technique was in the design concept video process. Both the first and final year students had to produce VR models and walk-throughs of the design concept to allow their stakeholders to understand their design.

Further questions asked if they would like to see more use of this technique within students work. Only 12% of respondents selected no and the rest of responses were split between yes and don’t mind indicating that industry would like to see more use of this within the engineering curriculum.

This further reinforces the justification and validation of the production of VR models and walk-throughs in assisting the engineering design concept process for undergraduate engineers.
When asked if they would like a student proficient in building physical to scale buildings or student with proficient skills in computer-aided design (CAD) and virtual reality (VR) walkthroughs, the majority of respondents felt a combination of both would be appropriate for students learning. Figure 69 illustrates the responses from this question.
In the first year module DSGN143 used within this study, students had to produce a combination of both the evidence and visualise the design concept for their project.

![Graph showing preferences for physical skills, digital skills, combination of both, and don't mind.]

**Figure 70:** Would you rather have a student proficient in building physical to scale buildings or student with proficient skills in computer-aided design (CAD) and virtual reality (VR) walkthroughs?

Additionally, when asked what they felt give a proper understanding of the design of a building most of the respondents felt that a combination of both the physical and virtual reality model would give the greatest understanding of a design as shown in Figure 70.
6.8 Digital Literacy

Digital literacy is becoming an integral part of educational pedagogy with increasing literature discussing studies and reviews on how digital literacy affects students teaching and learning as well as employability (Greene, Yu & Copeland, 2014; Santos, Azevedo & Pedro, 2013).

The survey asked how important it is that engineering graduates are digitally literate when they enter the workplace.

Respondents from the survey felt very strongly about its importance with over 57% of participants saying it was very important and 41% felt it was important, only one participant felt it was not important. This is shown in Figure 71.

![Figure 71: How important is it that engineering graduates are digitally literate when they enter the workplace?](image)

Participants who chose to add additional comments after this survey question provided varied responses. Only a small percentage gave extra comments but there seemed to be a bias’s towards students being naturally digitally literate.
"The fact that so much of all young British lives are dominated by digital technologies means that students are invariably "literate" in the use of such media, but usually have little or no appreciation of the underlying principles, design approaches and methodologies".

(Electronics Teaching Laboratory Manager (retired))

The survey reinforces the importance of giving students access to teaching and learning that promotes the effective and pedagogically appropriate use of technology within student’s studies. The design concept video project engages students in the production of a ‘digital report presentation’ to evidence and support their work within their interdisciplinary teams.

Students used collaborative online tools and used systems such as YouTube to develop their learning by online tutorials and guides. The project facilitated students use of different digital tools and the toolkit showed them the appropriate ways in which they could use them within their work. The skills audit used within the action research cycles ensured that the students were fully supported and no speculation was made on their skills at the beginning of the project as recommended by various researchers (Helsper & Eynon, 2010; Jones et al., 2010b).

6.9 Future of engineering curricula

Engineering Education research has been discussing the future direction of engineering curriculum and education for a number of years (Felder, 2012; Galloway, 2007b; Grimson, 2002). The survey asked practitioner’s views on how they thought the future of Engineering Education may change.
Industry responses filtered into the educational category tended to focus more on the future methods of the teaching delivery utilising technology, which has been widely discussed in Engineering Education (Froyd, Wankat & Smith, 2012).

“Employers will continue to demand that graduates can deliver useful work within weeks of starting their employment. The fee-based system means students are becoming more demanding. Some of this is good, as it means more of them are actually thinking about the purpose of their course (as opposed to thinking about how to make the most of their social lives!”

(Electronics Teaching Laboratory Manager)

However, the industry based responses from those in workplaces, such as engineers and architects, focused more on the standardisation of BIM, and reflected their frustrations and lack of faith in educational curriculum, reinforcing what is needed in industry.

“I can see the education process continuing in the same direction as it is currently heading unless universities listen to the real life needs of the working practices rather than solely sticking to a curriculum”.

(Senior Architectural Technologist)

“BIM will take a further 5-10 years to become the norm and to be used to its full capabilities. It will by default give walk though capability. Teaching of engineering should encompass gaining an understanding of the potential interconnectivity of the various software packages”.

(Building Services Engineer)

Industry responses felt that the engineering curriculum was dated and out of touch with professional working practices (Claris & Riley, 2012). Literature suggests this problem has been evident for a while and despite research discussed in the introduction, educational institutions are still failing to
contextualise learning and make it relevant to industry methods (Ali & Aliyar, 2012).

Students in the focus group, particularly the final year students, reinforced their personal experiences on placement year on the importance of government standards arriving in 2016 in the use of BIM. Many students based their project designs around BIM standards to ensure that their project was closely aligned to how a project would be implemented in industry.

The toolkit prototype also contained information on the software specifically supports the use of BIM standardisation and other industry based standards to ensure that students had full awareness.

6.9.1 How they would like to see it change

To explore this further, they were then asked how they would like to see it change. Educational responses were mixed:

“Over time there will need to be a move to supporting delivery of interactive teaching using mobile/tablet devices rather than traditional passive lecture theatres and PC labs. The supporting infrastructure (physical resources and training) needs to be in place to support this together with exemplars for academic staff to become familiar (and persuaded of the merits) with such interactive teaching technology”.

(Lecturer - Civil Engineering)

Industry based responses to the question were critical towards current educational themes in engineering and sought for Universities to gain a stronger alignment with industry practices.
“It needs to be more multidisciplinary as we work in multidisciplinary teams. But as all courses have to be accredited by an institution they tend to be narrowly constricted to the institution’s discipline. BIM and design needs to be taught. People working in the industry need to come in and do lectures”.

(Principal Engineer - Civil Engineering)

The modules used within this study were predominantly based on the interdisciplinary teamwork and promoted the effectiveness of learning to work as part of the multi-disciplined team. Students were exposed to processes and standards used within industry and were required to produce reports based on the Royal Academy of Engineering standards (Lamb, 2010; Martin et al., 2005).

A word cloud of how respondents felt the teaching of Engineering Education would change in the future can be seen in Figure 72.

![Word Cloud]

**Figure 72: How do you see the teaching of engineering changing in the future?**

Respondents were asked how they would like to see it change which produced great variations across the industry based disciplines.
Educational responses were mixed:

“Over time there will need to be a move to supporting delivery of interactive teaching using mobile/tablet devices rather than traditional passive lecture theatres and PC labs. The supporting infrastructure (physical resources and training) needs to be in place to support this together with exemplars for academic staff to become familiar (and persuaded of the merits) with such interactive teaching technology”.

(Lecturer - Civil Engineering)

Industry based responses to the question were critical towards current educational themes in engineering and sought for Universities to gain a stronger alignment with industry practices.

“It needs to be more multidisciplinary as we work in multidisciplinary teams. But as all courses have to be accredited by an institution they tend to be narrowly constricted to the institutions discipline. BIM and design needs to be taught. People working in the industry need to come in and do lectures”.

(Principal Engineer - Civil Engineering)

A word cloud shown in Figure 73 was created based on the respondents views on how they would like to see Engineering Education changing the future. Key themes were again seen including design, projects, BIM, experience, technology and interpersonal skills.
Both the DSGN143 and the IDDP modules encompass all of the key themes seen in the word cloud and responses. Its unique method and assessing techniques allow the students to experience and understand how an engineer would work in industry. This was further validated by students who had recently come back from placement years working within the natural engineering firm and confirmed that the work was relevant and appropriate.

6.10 Impact of technology in working engineering practices

The impact of technology in engineering disciplines has been discussed frequently in both literature and from the student’s focus groups. Similarly to the students, participants in the survey were asked how they believe technology will impact on working practices in engineering over the next ten years.

A word cloud shown in Figure 74, was again created emphasising words such as design, BIM, software, virtual and visualisation. Staff involved in the modules
used within this study had strong industry links and were able to contextualise student learning and engage the students on how engineering practices are changing.

Industry based responses predominantly discussed the use of BIM.

“In civil engineering BIM will be standard. Most large designs will be done in 3d with teams all working on the same model. All projects will be shared in the cloud. Different file formats need to be integrated. EG word and excel documents need to talk to BIM etc”. (Principal Engineer - Civil Engineering)

“Virtual reality, 3D printing etc. is likely to have a significant impact”. (Architect)

Virtual reality and 3-D printing also featured highly within the responses. Students within the design concept video project utilise virtual reality walkthroughs to visualise and enable stakeholders to understand the design concept process. Whilst the use of 3-D printing is not currently available to students due to time and investment, students are made aware of the possibilities of this and many had discussed this during the focus group.
Educational responses repeated views from industry based personnel and believed that it would have a significant impact in the way engineering was delivered and practiced.

“In the next ten year we would be in a much better shape. The professional Institutions have all recognised and are pushing towards this goal and the technology is moving to a much faster pace. Anyone/institution resisting this will not survive”. (Associate Professor - Structural Engineering)

“Distance working will increase. Projects will become truly 24/7, with engineers collaborating across the globe - and not just in large multinational corporations. Data security, particularly in regard to intellectual property, which is already a major concern, will become a dominant issue for all engineers. Note that this is, to an extent, a driver in the opposite direction from the distance-working and globally-spread design teams noted above. The availability of cheap, precision, multi-material 3D printers will transform prototyping in education, and will allow even the smallest companies to work in ways currently only possible for the wealthiest and largest” (Electronics Teaching Laboratory Manager)

Some comments were met with caution with educators being slightly more cautious of the impact of technology and some believed it would lead to lazy students or engineers. However, the majority of views discussed how technology would facilitate group working at a distance and allow engineers to be part of the global team rather than being limited geographically.

Students on the DSGN143 and IDDP course are made aware of technologies that can facilitate online collaboration and information sharing to support their digital literacy such as Dropbox, webinars etc.
The toolkit gave them multiple platforms and reinforced the importance of making students aware of different technologies and how they can facilitate different ways of working representative of industry methods.

6.11 **Can an engineering course be taught online?**

The focus of technology impacting on education and working practices was continued and participants from the survey were asked if an engineering course could be taught online. Technology is widely discussed as a potential problem solving in Engineering Education (Rajala, 2012).

Responses from industry can be seen in Figure 75 demonstrating a large majority of just under 80% opting for the no option.

![Figure 75: Do you believe that an undergraduate Engineering course could be taught completely online?](image)
When prompted to explain their responses, survey respondents indicated that the emphasis was mainly around the perceived missing team interaction and communication that a purely online course would give.

"The fundamentals of engineering cannot be learnt utilising only online learning. A fundamental part of engineering is about successful communication and removing face to face learning would be extremely detrimental to an undergraduate’s development".

(Senior Structural Engineer)

The responses from professionals practising in education were mostly of the opinion that it was not a good idea, but the respondents that did agree agreed reluctantly and mentioned preferences in Higher Education into utilising technology in education was a factor.

"More and more courses are going online - can engineering resist this tide? I doubt it. We may drawn into willingly or otherwise". (Principal Lecturer)

A word cloud was again created of the free comments relating to the question and is shown in Figure 76. In addition to the comments it was apparent that there were fundamental reasons why they believed it could not be taught early online with words such as interaction, practical, face-to-face and skills coming up as frequently mentioned.

The survey responses were agreeable to views represented by the students in the focus group when asked the same question. Despite demonstrating positivity towards technology impacting on their studies, only one student felt
that an engineering course could be taught purely online as they believed that what they were taught at university was purely theoretical.

Figure 76: Word cloud on views of engineering courses being taught online

6.12 General analysis of survey

The results from the survey validated work undertaken within the action research cycles discussed in Chapter 5.

Industry responses highlighted the importance of the development of soft skills in engineering graduates and felt that students had little or no experience in working in their interdisciplinary based teams. The work undertaken within the modules were based on students being split into interdisciplinary teams to replicate how an engineer would work in industry.

The majority of responses from industry professionals felt that students lacked design concept knowledge and relied heavily on the use of computer aided software. Whilst the modules discussed in action research Chapter 5, utilised
software techniques around AutoCAD and Solidworks, it also took them through the design concept process and referenced industry based and is and recommendations from the Royal Academy of Engineering.

The impact of approaching BIM standardisation was frequently referred to during the survey which validated the use of software techniques using Revit and AutoCAD as well as project planning within the DSGN143 and the IDDP modules.

Students were taught how to use software and design buildings based around techniques currently used in working practices. Students reiterated this during the focus group and reflected on their own experiences whilst on placement.

Responses from engineering educators were more hesitant on the impact of technology and felt that any implementation of change should be gradual and appropriate. Industry responses contradicted this and felt the engineering curriculum was out of date and not reflecting working practices. This is also repeated in Engineering Education literature where technology is speculated to facilitate the change needed to revitalise engineering curriculum (Banday, Ahmed & Jan, 2014; Grimson, 2002; Sampaio et al., 2010).

The use of VR models to convey a design concept was evident on industry based responses. The majority of the responses indicated a strong preference from the usefulness of VR models and wanted to see more use of this with students
work. This again reconfirmed the use of these techniques within the module to give students skills that were transferable to industry practices.

In summary, the survey reinforced pedagogic choices behind the module assessment criteria and content that was used during the action research cycles. Implementing Technology Enhanced Learning gave the students valuable transferable skills that were contextualised against industry practices as well as producing students with a thorough understanding of the design concept process. Engineering soft skills were enhanced during the projects, which was identified as a major area of concern for most industry responses in the survey.

The project promoted the use of student led learning and handed over the ownership of self-development to the students which was reiterated by industry professionals who discussed graduate capability and students needing to be spoon fed information.

The survey responses validated the approach used and implemented during this study and provides further evidence that engineering curriculum is enhanced further when supplemented by the use of technology.

The next section will conclude the results section of the study before introducing the discussions section of the thesis.
6.13 **Results Summary**

The results section of the thesis introduced and evaluated data gathered using mixed methodologies in the following phases:

- preliminary research
- implementation of Technology Enhanced Learning
- industry based survey

The preliminary research stage consisted of the observation of two different undergraduate engineering modules and three semi structured interviews of teaching engineering staff. The results from this stage positioned the research against Engineering Education literature and formed recommendations for the implementation of Technology Enhanced Learning using action research methodology.

The implementation of Technology Enhanced Learning results section consisted of two cycles of action research within two individual engineering courses including one final year and one first year module. This phase of the research assessed the appropriateness of action research in evaluating the implementation of new assessment techniques utilising video assessments within two engineering modules and two individual cohort years. As part of the conclusion of the first cycle, an online toolkit prototype was developed and created as a result of feedback from the students focus groups carried out during cycle one. The prototype toolkit was delivered and embedded in module
cohorts and further evaluated using three focus groups during the second cycle of action research. Results from the action research demonstrated an increase in student performance and capability when learning is supplemented with Technology Enhanced Learning. Students engaged well with alternative assessment processes and took ownership of their learning to strengthen their employability skills.

Results from an industry based survey validated chosen methods used during the action research cycles and provided a comparison against student viewpoints for further discussion in subsequent chapters.

Data gathered during these individual phases identified a number of key themes and areas of further discussion around the following areas:

- digital literacy and its relevance within Engineering Education
- impact of technology to working practices in engineering and Engineering Education
- recommendations on the use of Technology Enhanced Learning within Engineering Education
- impact of action research in Engineering Education
- impact of work to enhance employability skills
- transferable skills to engineering industry

The next chapter in the thesis will discuss the key themes identified during the research results phase and will compare data gathered from the students,
educators and industry professionals. Student’s opinions and reflections on key themes in Engineering Education will be summarised and compared against industry needs. The impact of the work will be discussed in relation to engineering graduate employability and impact on learning and teaching will be explained.
7 Discussions

This chapter reflects on the main findings of the research in comparison to the original aims and objectives of the study. Results and key themes gathered during the study will be discussed against current Engineering Education literature. The impact of the work in relation to engineering graduate employability and impact on student learning and teaching will also be discussed as well as concluding with contribution to knowledge.
7.1 Discussion of results from research

This section will discuss the results of the research in relation to the original aims and objectives of the research and compare to current Engineering Education literature.

The aims of the research study discussed in Chapter 2 were identified as:

1. explore and evaluate the appropriateness of the implementation of Technology Enhanced Learning pedagogies and methods within an Engineering Education curriculum
2. evaluate the appropriateness of action research methods within Engineering Education
3. assess and evaluate the appropriateness of a mixed methods research methodological approach to Engineering Education
4. understand views and opinions of stakeholders involved in Engineering Education research including students, academic staff and industry based professionals and to compare against current Engineering Education research literature

The main body of the research was broken down into three phases:
1. preliminary research stage

2. implementation of technology enhanced learning using action research methodology

3. industry based survey validation of methods

Each of the phases will be summarised in relation to the results and link back into Engineering Education literature.

**7.1.1 Preliminary research phase discussions**

The preliminary research stage detailed the observation of two different undergraduate engineering modules and three semi-structured interviews of teaching engineering staff. The results from the stage positioned the results against current Engineering Education literature and formed recommendations for the implementation of Technology Enhanced Learning using action research methodology.

The semi-structured interview results were compared against the findings discussed during the literature review and findings from the observations. Results indicated that academic staff also experienced frustrations and difficulties when dealing with large student groups, particularly when delivering a practical experience. This has been repeated in Engineering Education literature where many educational institutions are struggling to deliver a practical experience to students (Bochicchio & Longo, 2009; Fabregas *et al.*, 2011).
Within the literature, the use of remote laboratories, simulations and home kits suggested alternative methods of delivering a practical experience to students. There were no suggestions on the use of Technology Enhanced Learning to supplement areas that would free up time during the laboratory to allow students to develop a deeper learning.

Pedagogies such as the ‘flipped classroom’ could have been used to set learners series of tasks and activities to complete prior to their attendance in the laboratory for example a review of health and safety practices within the laboratory or understanding the aims and objectives behind the laboratory by means of a small online test. This technique has been used in other disciplines outside of Engineering Education and has proved to be an effective way of developing critical thinking skills for students (Bishop & Verleger, 2013). Within Engineering Education, the use of the flipped classroom was only used within a lecture scenario and not implemented in a practical laboratory setting (Warter-Perez & Dong).

Whilst the use of technology was mentioned as a facilitator to either enhance or replace a practical experience within an engineering curriculum, e.g. simulations and remote laboratories, it was not referenced as a way of enhancing the learning process or saving time to concentrate on other areas in a lecture. The application of technology was referred to with caution from both academics. Both of the academics discussed the lack of effective simulations
available to an engineering discipline, with one academic saying they had only seen good pedagogic examples in the field of medicine. This is reflected in literature with medical and scientific disciplines invest in highly in alternative techniques for practical education (Boulos, Hetherington & Wheeler, 2007b; Dreher, Reiners, Dreher & Dreher, 2009).

Technology was not mentioned by any of the interviewees as a way of supplementing time spent in the laboratory to make more productive use of the time. Despite further probing, they didn’t think that it was possible to free up any time in the laboratories.

The observations and the interviews highlighted the potential to make more effective use of the time spent in either a practical laboratory or a lecture by utilising Technology Enhanced Learning. Referring back to the literature review section on Technology Enhanced Learning in Chapter 2.5, there are several ways in which the effective use of technology within the curriculum could create more time for deeper learning, and enhance the learning experience for the students (Beetham & Sharpe, 2013; Kalz & Specht, 2014).

The next section will discuss implementation of Technology Enhanced Learning using action research methodologies.
7.1.2 Implementation of Technology Enhanced Learning using action research methodology

Recent research into Technology Enhanced Learning has created recommendations on new pedagogies that are available as a result of innovations in technology in Higher Education. The adoption and delivery of these methods are still small scale within Engineering Education and are approached with extreme caution within the field (Case & Light, 2011).

In order to evaluate the appropriateness of action research and Technology Enhanced Learning, a two year cycle of action research was used within a cohort of two undergraduate engineering modules embedded into the module curriculum. Additional techniques were embedded and inside the action research cycles to gain further qualitative and quantitative data via a survey and five individual focus groups.

Module cohorts were chosen based on recommendations in literature that engineering graduates must be exposed to working in an interdisciplinary environment (Borrego, Foster & Froyd, 2014), the modules chosen had strong foundations in students working on projects in an interdisciplinary group. The modules also had assessment criteria based around project based learning and encompassed strong elements of producing a design concept purely from engineering perspective. Growing literature in Engineering Education highlights the necessity of engineering graduates to possess design skills and be creative in
their approach to problem-solving (Mills & Tregust, 2003; Solnosky, Parfitt & Holland, 2014). The work used within the chosen modules aimed to develop teambuilding and project management within engineers, these skills are referred to in literature as ‘soft skills’ and are discussed as being essential to the production of a 21st-century engineer that are able to effectively work and managed engineering project in industry (Rao, 2014).

The work produced by the students during this cycle was of high quality with the majority of students taking ownership of the projects by making their videos as professional as they could whilst demonstrating the skills they had learnt as a result of the project.

Students utilised different methods of conveying their design concept including VR walk-throughs to allow viewers the opportunity to walk through their design concept. The use of VR and CAD in Engineering Education is an emerging field with literature suggesting that the use of virtual reality models within the curriculum is on the increase (Sampaio et al., 2010). Educational institutions are beginning to realise the potential of embedding virtual reality as part of the design concept process (Daud, Taib & Shariffudin, 2012). The students were made to produce VR models and CAD drawings of their work which further aligned the work in this project to practices seen in industry (Sampaio et al., 2010).
Students were also encouraged to use software such as Revit that would allow them to share their design using BIM technology which is becoming a heavy standard in industry due to government changes in construction projects (HM Government - Department for Business, 2012).

To evaluate the impact of the implementation of the alternative assessment within the modules, additional techniques were used via two focus groups that were carried out following the submission of the students design concept videos. Focus group techniques are used as an effective way of analysing experiences and gaining qualitative data (Gill et al., 2008b).

Data gathered during focus groups identified positive feedback and opinions on the specification and implementation of an alternative assessment using video techniques. The alternative assessment was viewed favourably by the students with the majority of students finding the new form of assessment, refreshing, innovative and gave them ownership of their learning. They felt that the video assessment allowed them to convey the design concept in a more appropriate manner than a traditional presentation and felt that skills learnt during the process of creating a video which is transferable into industry.

Students particularly liked the way in which the project resembled how an engineer would work in industry and final year students contextualise the project to work they had undertaken within their placement year.
Discussions

To continue with the action research framework, feedback gathered during the first cycle of action research formed recommendations of the specification of an online toolkit prototype that would further support the students in the creation and production of the video as well as understand the processes and elements of their interdisciplinary modules.

The prototype toolkit was specified and delivered during the second cycle of action research. The second cycle of the research focused on the implementation of two online toolkit prototypes that was developed and embedded in module cohorts based on feedback gathered during cycle one.

The two prototypes were created and developed using Xerte Online Toolkits (XOT) and were aimed at supporting the students in the creation of the design concept video assessment.

The toolkit was specified and embedded in the students learning framework of the module, and evaluated using a series of three focus groups for potential future recommendations for further cycles outside of this research study.

Students were introduced to the toolkit by different methods of dissemination such as lectures and emails and were encouraged to use toolkits prior to their production of the design concept video.

The standard of student work seen during this cycle had improved considerably from the previous year. Students made more use of virtual reality models in
their work and different mechanisms of video production were seen in the submitted videos.

The students made more use of multimedia tools to visualise and illustrate areas of their design as well as using more professional standard software such as Adobe Premiere Pro to illustrate key points to their stakeholders.

To evaluate the implementation of the prototype toolkit, three focus groups were carried out to evaluate and measure the effectiveness of the toolkit and assess how it was used within their project.

Students spoke positively about the toolkit and found it to be incredibly helpful and beneficial to their production of the design concept video, with the majority of students accessing the toolkit.

Students discussed the relevance of the video assessment in terms of their employability. Some of the students commented that potential employers had asked to see their CV as a result of seeing their design concept video. Employability skills is an essential part of developing graduate capability (Morgan & O’Gorman, 2011b), by carrying out this project students were able to contextualise their learning into industry standards and also develop new skills to further broaden their skill base.

Whilst students did not necessarily expect to be asked to create a video when commencing their employment, they felt that it was advantageous to have an
understanding of the processes behind creating one and how they can be an effective method of communication to existing or outside stakeholders.

This cycle of action research saw more innovative and creative uses of technology within the design concept video and students appeared to take more time in developing different ideas after viewing case studies from previous year’s videos.

Results from both of the action research cycles demonstrated an increase in student performance and capability when learning is supplemented with Technology Enhanced Learning. Students engaged well with alternative assessment processes and took ownership of their learning to strengthen their employability skills.

The next section discusses the industry based survey and its impact within this study.

7.1.3 Industry based survey validation of methods

In order to validate chosen methods within this research study, an industry based survey was developed and created to provide a comparison against student viewpoints.

Results from the industry based survey validated chosen methods used during the action research cycles and provided a comparison against student viewpoints.
The predominant aims of the survey were to gain opinions from working professionals within the disciplines of engineering and architecture who have worked with or employed engineering graduates.

The main objectives of the survey are summarised:

- gather opinions from professional representatives from industry on existing practices in engineering around the subject of design concept process.
- understand an industry perspective on the importance and place of virtual reality (VR) walkthroughs in a professional environment.
- gain an industry viewpoint of the skills of current engineering graduates in the work environment and which areas they feel students could improve on before entering the workplace.
- collect views on how Engineering Education is evolving and how technology is impacting on changes in engineering practice including speculation on future methods in teaching engineering
- Align results gathered from the survey to compare against data collected during the action research cycles implemented during this research study
- compare industry perceptions of topics surrounding Engineering Education for comparison against student data gathered during the action research cycles
Discussions

The survey reinforced pedagogic choices behind the module assessment criteria and content that was used during the action research cycles.

General responses from engineering educators in the survey were hesitant on the impact of technology and felt that any implementation of change should be gradual and appropriate. Industry responses contradicted this and felt the engineering curriculum was out of date and not reflecting working practices which is repeated in literature where technology is speculated to facilitate the change needed to revitalise engineering curriculum (Banday, Ahmed & Jan, 2014; Grimson, 2002; Sampaio et al., 2010).

Industry responses reinforced the work undertaken on this module on developing the soft skills of the students and felt that research engineering graduates they had experienced had little or no experience in working in their interdisciplinary based teams.

The survey allowed the gathering of qualitative and quantitative data and validated the use of mixed methods within Engineering Education which was highlighted as a potential methodology to allow Engineering Education to develop and progress (Case & Light, 2011).

In the next section the aims of the research study will be broken down and discussed against findings from the results of the work. Key themes resulting from the research will also be discussed showing the relationship between the results and literature surrounding Engineering Education.
The next section will discuss the results of the research in relation to the original aims and objectives of the research.

7.2 Appropriateness of Technology Enhanced Learning pedagogies within Engineering Education

The implementation of Technology Enhanced Learning within this study gave students creative freedom in the production of their work without spoon feeding information. It allowed them to refer back to key points of their learning and facilitated large group learning by developing support materials purely online.

The students obtained valuable transferable skills relative to industry practices as well as producing students with a thorough understanding of the design concept process which is seen to be vital in the future sustainability of Engineering Education (Daud, Taib & Shariffudin, 2012; Taborda et al., 2012).

Technology was used as a facilitator to the students learning in a blended approach rather than a complete replacement. Unlike other Engineering Education research, this study used a mixed methods approach and embedded action research to assess the appropriateness of Technology Enhanced Learning within two large cohorts of study rather than small scale implementations largely seen in Engineering Education research.

Use of Technology Enhanced Learning allowed support materials and training to be delivered on a purely online format rather than attempting to locate a room.
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large enough for over two hundred students. This method is used extensively throughout literature but less used in Engineering Education. This study showed the effectiveness of using technology in different ways to support and enhance their learning. By facilitating support online, students were able to access the material as and when it was needed with many students reporting it as a flexible way for them to learn.

Traditional lectures were not replaced, but enhanced through the use of technology. This blended approach, is a frequently used pedagogy within educational disciplines (Garrison & Kanuka, 2004; Yigit et al., 2014), but again limited in literature surrounding Engineering Education.

During the evaluations students displayed different ways in which they learn and technology was able to facilitate different learning styles by providing support materials in different formats such as video, text and other multimedia methods. The focus group evaluation also identified student’s personal use of technology to facilitate their own skills development and learning. Students did not refer to themselves as being digitally literate, but felt that all students undertaking a technical course such as engineering would naturally be aware of different technologies.

The next section will discuss the assessment results before the implementation of Technology Enhanced Learning and after.
7.2.1 Validation of methods through assessment results
Assessment marks from the coursework for DSGN143 were recorded prior to the implementation of the Technology Enhanced Learning and following to validate the methods.

The first set of assessment results are from the DSGN143 module which are displayed in Table 4.

<table>
<thead>
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<th>Post Cycle Two</th>
</tr>
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<tr>
<td><strong>Overall Average Mark</strong></td>
<td>56%</td>
<td>66%</td>
<td>70%</td>
</tr>
<tr>
<td><strong>Highest Ever Pass Rate</strong></td>
<td>55%</td>
<td>97.4%</td>
<td>97.5%</td>
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</table>

Table 4 DSGN143 assessment results

The second set of assessment results are from the IDDP module shown in Table 5. This module has no pre cycle one result due to the module being led by a different member of staff with contradicting learning outcomes and objectives. Therefore, these results are from the first implementation (cycle one) of action research detailing the implementation of Technology Enhanced Learning through alternative video assessment.

<table>
<thead>
<tr>
<th></th>
<th>Pre Cycle One</th>
<th>Post Cycle One</th>
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</tr>
</thead>
<tbody>
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<td><strong>Overall Average Mark</strong></td>
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<td><strong>Highest Ever Pass Rate</strong></td>
<td>NA</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 5 IDDP assessment results

Both set of results show improvement between each implementation of the cycles of action research. Combined with the data from the student focus groups, this demonstrates improvement and satisfaction both from the
student’s viewpoint and from the physical mark associated with the assessment. The validation of techniques is proven both subjectively from data gathered in the focus groups and from the mark awarded by the module leader.

In this study, the implementation of Technology Enhanced Learning pedagogies was successfully evaluated and embedded within engineering cohorts. The results identified Technology Enhanced Learning methods as being effective in changing in the engineering curriculum to be more in line with industry standards and recommendations. Student skills were successfully expanded to include transferable skills for industry implementation.

The next section will discuss the appropriateness of action research studies within Engineering Education.

7.3 Appropriateness of action research studies within Engineering Education

Action research was underrepresented in Engineering Education and literature had speculated that this methodology would be effective in engineering educational setting (Case and Light 2011).

The use of action research was used within this study to evaluate the implementation of new assessment techniques utilising video assessments within two engineering modules and two individual cohort years.
By using this method, new assessment practices were able to be specified and implemented and the impact evaluated to understand impact on the students. Recommendations were formed and allowed additional work to be implemented in the following year to improve upon existing practices and potentially increase student results and knowledge.

Action research was proven to be an effective way of measuring success in alternative assessment practices in Engineering Education. The cycle of research allows critical reflection and improvement on existing practices.

By implementing action research, the students were able to have an impact on their learning and discuss how implemented methods affected their learning and more importantly, what can be done to improve on this.

The use of action research in other disciplines as discussed in literature frequently but the use of this in Engineering Education is limited where most educators rely on a single implementation and evaluation rather than continually assessing the practices and impact.

The next section will continue the discussion on methodologies by debating the use of mixed method research approach in this study.
7.4 Assess and evaluate the appropriateness of the mixed methods research methodology approach to Engineering Education

Engineering Education traditionally uses individual methodologies in either experimental or descriptive studies (Baillie & Douglas, 2014; Kelly & Bowe, 2011). During the study a combination of mixed research methods was used, including observations, interviews, focus groups and surveys.

The mixed methods research was used within two cycles of action research to further complement and gather data that is rich in detail and knowledge. It also provides an opportunity to evaluate the appropriateness of this methodology to Engineering Education research.

Within Engineering Education, mixed method research is limited with few literature publications reaching the wider public. Creamer and Ghoston (Creamer & Ghoston, 2013) used a mixed methods approach to analyse content from mission statements of engineering colleges. They believed that this approach enabled the detection of ideas and themes through qualitative data collection as well as validating results via quantitative approaches. However, the research was small scale and did not allow implementations of different theories to be evaluated or implemented.

Similar to their approach, this study used a variety of techniques to gather and evaluate data surrounding the implementation of Technology Enhanced
Learning. Individual techniques alone would not have provided a clear view of the impact of this work in relation to student satisfaction and learning.

Literature around mixed methods in engineering is limited and of small scale (Creamer & Ghoston, 2013; Johnson & Onwuegbuzie, 2004). This study successfully produced data results on large scale modules over two cohorts in two consecutive years. By gathering the data from these methods recommendations were able to be made for further cycles which would have been difficult using a singular method alone. The methods used within this study provides recommendations on using a mixed methods in engineering to produce sets of data that are rich in content and appropriate for the discipline.

The next section of the discussions chapter will focus on the views and opinions stakeholders involved with Engineering Education that were used within this research.

7.5 Understand views and opinions of stakeholders involved with engineering

This research took into consideration different stakeholders associated with Engineering Education including students, industry based professionals and engineering educators. The next segment will discuss each of the stakeholders individually and summarise results found from the study.
7.5.1 Generalising students views

Students within the focus group focused very much on the technology when discussing their education and learning styles. The work within the project expanded and developed their skills base not only in terms of design concept skills but also utilising technical skills and developing further awareness of the soft skills that are often referred to in engineering literature (Rao, 2014).

VR walk-throughs and CAD modelling featured highly during the conversations and students felt that more educational emphasis were needed on industry based standards such as BIM.

Working within interdisciplinary groups was an area that students felt was most effective and helped shape their design concept work and gave them an appreciation of different learning styles and methods with their peers. Working with students from different courses helped develop the students skills on problem-solving as each student had different ways of approaching the task.

Teaching methods were seen to be lecturer driven rather than the way in which it was delivered with many students feeling disengaged with traditional style lecturers which is a view mirror and engineering literature (Galloway, 2007b; Graham, 2012a). YouTube and other technology driven methods were favoured with students who wanted them to be used as an enhancement to their learning.
The final year students who participated in the focus groups had recently completed a placement year in industry and was able to contextualise their experiences to the project. They felt the project was an effective and realistic reflection of how an engineer would work in industry.

The students were more reflective and critical of their own work and discussed ways in which they would change their video and work associated with the module if they were to repeat it again.

All students in the focus group spoke favourably of using VR walk-throughs and CAD modelling to convey design concepts. In particular, they were able to refer to experiences of using such techniques whilst they have been on industry placement.

The students particularly enjoyed creating the video as part of their assessment and discussed the need for this technique to be implemented straight from the first year.

The first year students were understandably less aware of industry standards and had a linear view on the role of an engineer and what would be expected of them in the workplace.

The students felt that lecturers must ensure that teaching and learning is relevant and in a format that assist students with different learning abilities and styles to ensure they are fully engaged and motivated during the course. This
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reflects literature discussed by Felder and Silverman and ensuring the Engineering Education meets the learning styles of its students (Felder, 2012; Felder & Silverman, 1988).

It was evident throughout the focus group that students believed the teaching of engineering would change greatly in the future. Emphasis was on new innovations in technology, particularly the use of emerging standards and industry working practices such as BIM. The final year Masters students who had recently done a placement were aware of industry standards and often felt frustrated that the engineering educational curriculum did not completely represent working practices.

The use of technology within the teaching materials and methods was discussed and emphasis was placed more on the teaching ability. Technology was seen as a positive influence that students felt that lecturers should only use technology when it’s pedagogically appropriate and can enhance the understanding of a topic or engage and motivate students. They felt their engineering practices could be made more engaging if lecturers use technology as a way of contextualising the work to industry practices.

Students are aware of what’s missing in their curriculum and want more of their teaching contextualised with industry examples to enable them to apply their theoretical knowledge into real world situations. The idea of adding more real-life examples to teaching is not a new concept and in Engineering Education
Discussions

(Litzinger, Lattuca, Hadgraft & Newstetter, 2011; Machet, Lowe & Gütl, 2012) but it is clear from this research and others that work is still needed (Mulder, Segalas & Ferrer-Balas, 2012).

However, student perceptions were that more traditional engineering educators wouldn’t be keen to do so which is commonly discussed in research literature (Kukulska-Hulme, 2012).

The final year students particularly understood the importance of self-directed learning with many of them supplementing their theoretical knowledge at University with their own research.

The students saw the University’s role in digital literacy as providing best practice and making students aware of different technologies and how they can impact on their learning and skills development. The students felt that the academic teaching staff were not fully digitally literate but also did not expect them to be. They did expect their teaching staff to be the expert on the field in which they teach.

The next section will discuss industrial stakeholder views against work carried out in this study.
7.5.2 Generalising industrial view

Industry views were mainly critical of the educational curriculum for engineering and reinforced arguments that graduates lack practical knowledge which is heavily reinforced by literature (Davies & Rutherford, 2012).

They saw the importance of digital literacy in a graduate, but also noted how technology and software is transforming how students learn, which has been of huge discussion not only in Engineering Education, but many other educational disciplines (Johnson et al., 2013). They often felt that students were becoming reliant on technologies rather than understand the concept behind them.

Industry professionals called for stronger alignment between academia and industry by working together rather than in isolation in order to create employable professionals.

The development of soft skills was a key area of concern for industry professionals and they felt that students had little or no experience in working in interdisciplinary based teams or what a project in engineering actually consists of process wise.

Industry specialists wanted graduates that were able to learn for themselves without having to be told how to learn. In literature, student centred learning is becoming more prevalent with access to technology and information giving students the platform to learn more in their own environment and style (O’Neill & McMahon, 2005). They felt that technology impacted highly on both working
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practices in engineer and in the way society functions and works. As a result of this, they wanted engineering graduates to be digitally literate and able to use different platforms to convey information and communicate.

7.5.3 Generalising engineering educator views

General views from engineering educators were more hesitant on the impact of technology and felt that any implementation of change should be gradual and appropriate. Industry responses contradicted this view and felt the engineering curriculum was out of date and not reflecting working practices. This is also repeated in Engineering Education literature where technology is speculated to facilitate the change needed to revitalise engineering curriculum (Banday, Ahmed & Jan, 2014; Grimson, 2002; Sampaio et al., 2010).

Survey response, the majority of engineering educators had noticed a considerable change in engineering graduates and felt they were missing fundamental key skills such as teamwork in problem-solving and were more proficient in the use of technology rather than engineering itself.

The majority of educators agreed that technology will significantly impact and change the way in which engineering is delivered, however, this was a reluctant view by some as they felt it would affect and alter the fundamental skill set of an engineer.
7.5.4 Summary of difference between views

The questions discussed saw a strong correlation between the views of those in a professional position such as an engineer or architect, and those of the students. Students are aware of what was missing in their curriculum and wanted more of their teaching contextualised with industry examples to enable them to apply their theoretical knowledge into real world situations. Both the students and industry based professionals concentrated on the use of BIM in industry projects and both were aware of how this will impact engineering graduates.

The concept of adding more real-life examples to teaching is not a new concept in Engineering Education (Litzinger et al., 2011) but it is clear from this research and others that work is still needed (Mulder, Segalas & Ferrer-Balas, 2012).

Engineering educators were cautious around changes and felt that the standard of students was changing due to the impact of technology on speculation that the students would rely on IT systems to do the thinking for them.

This research study has validated and investigated a number of key themes that have been underrepresented in Engineering Education including:
1. the appropriateness of the implementation of Technology Enhanced Learning pedagogies and methods within an Engineering Education curriculum

2. the appropriateness of action research methods within Engineering Education

3. the appropriateness of a mixed methods research methodological approaches to Engineering Education

4. understanding views and opinions of stakeholders involved in Engineering Education

7.6 Contribution to knowledge

This research provides unique approaches to the implementation of Technology Enhanced Learning within an engineering curriculum. Engineering is a traditionally assessed discipline that has been pressured into providing alternative delivery methods of Engineering Education. Despite the pressures there has been limited reports of improvement in Engineering Education research (Stephens, 2013).

Using action research, initial concepts and use of Technology Enhanced Learning is successfully implemented into two large interdisciplinary based engineering modules. Student training and support material is provided fully online using
Discussions

Technology Enhanced Learning pedagogies to define and develop student skills support them in their video production.

The specification of video assessment methods is a unique approach to assessing students in their understanding and research in developing projects around the design concept process. It provides an inclusive alternative method of assessment with transferability into additional educational disciplines.

The research also provides evidence on the appropriateness of action research within a mixed methods study in Engineering Education. Using a combination of these two methods is unique within Engineering Education and provides recommendations of evaluating new practices and innovations in engineering curriculums.

Finally, the research provides recommendations on the unique use of Technology Enhanced Learning within Engineering Education to develop assess and evaluate engineering student’s soft skills and understanding of industry based practices by contextualising their learning.

In conclusion to the discussions chapter, the main findings of the research were reflected upon in comparison to the original aims and objectives of the study. Results and key themes gathered during the study were discussed and baselined against current Engineering Education literature. The impact of the work in relation to engineering graduate employability and impact on student learning and teaching was discussed and contribution to knowledge was evidenced.
8 Conclusion

This chapter concludes the research study discussed within this thesis. It summarises and reflects on work completed during this study. Limitations of this work are outlined and recommendations on future work are explained for continuation of knowledge transfer. The chapter concludes with the contribution of knowledge this study brings to the Engineering Education research field.
8.1 Summary of the research

This research presents investigations exploring the appropriateness and effectiveness of implementing an integrated blended learning approach using Technology Enhanced Learning practices within an Engineering Education framework.

Engineering Education is a discipline responsible for the training and development of graduate engineers and is a field that is particularly affected by influences from Higher Education. The field is experiencing turbulent changes both from government pressures on creating more spaces on Science, Technology, Engineering and Mathematics (STEM) courses and from industry demands on readdressing the requirements of graduate capability.

Despite change, literature suggest that engineering curricula still maintains its predominant pedagogic model of traditional ‘chalk and talk’ (Daun et al., 2014; Felder & Silverman, 1988) leaving students unengaged and frustrated with their learning (Kirschenman, 2011).

Industry professionals have demanded reform in the way in which Engineering Education is delivered to students to contextualise and broaden the employability skills of engineering graduates. As a result of these pressures, engineering educators are increasingly looking for pedagogies to enhance and innovate the delivery of Engineering Education to students and improve students’ employability skills (Morgan & O’gorman, 2011a).
Within this research, Technology Enhanced Learning was identified as an innovative way of delivering teaching and learning to engineering undergraduates and increase students employability skills using alternative assessment techniques. Following recommendations from literature, teaching content and delivery methods in Engineering Education were stronger aligned with educational research and pedagogy (Olds, Moskal & Miller, 2005) and contextualised against working practices in engineering industry.

The next section summarises the aims of the research.

8.2 **Aims of the research**

The main aim of the research was to explore the implementation and effectiveness of utilising Technology Enhanced Learning within an Engineering Education curriculum to enhance and develop student learning and employability.

The aims of the work were defined under the following four areas:

5. explore and evaluate the appropriateness of the implementation of Technology Enhanced Learning pedagogies and methods within an Engineering Education curriculum

6. evaluate the appropriateness of action research studies within Engineering Education

7. assess and evaluate the appropriateness of mixed methods research methodology approaches to Engineering Education
8. understand views and opinions of stakeholders involved in Engineering Education research including students, academic staff and industry based professionals and compare against current Engineering Education research literature

The next section summarises methods and results used within this study to meet the research aims and objectives.

8.3 **Summary of methods and results used within the study**

In order to achieve the aims of the research, the study was broken down into three phases:

1. preliminary research stage
2. implementation of Technology Enhanced Learning using action research methodology
3. industry based survey validation of methods

The preliminary research stage detailed the observation of two different undergraduate engineering modules and three semi structured interviews of teaching engineering staff. The results from the stage positioned the results against current Engineering Education literature and formed recommendations for the implementation of Technology Enhanced Learning using action research methodology to facilitate student learning in large groups.
The appropriateness of the implementation of Technology Enhanced Learning was assessed using two year cycles of action research methodologies within two cohorts of undergraduate engineers. Technology Enhanced Learning was implemented by creating an alternative assessment mode using video submission to assess engineering graduates design concept skills in interdisciplinary groups. The alternative video assessment was evaluated using student focus groups and a skills survey, which led to further development and the creation of an online prototype toolkit using Xerte Online Toolkits. The prototype toolkit was implemented to further support the students in their creation of their video assessment based on feedback gathered during the first cycle of research. Further focus groups were carried out after the final cycle of research to evaluate the impact of the online toolkits in relation to the student’s video production. Results found that methods used within this stage of the research was an effective way of engaging students, producing high quality work and developing both the ‘soft skills’ required by industry (Rao, 2014) and the digital literacy skills of students.

The industry based survey was developed to validate chosen methods within this research study and provided a comparison of viewpoints on key issues surrounding Engineering Education against student viewpoints. The survey gained opinions from working professionals within the disciplines of engineering and architecture who have worked with, or employed engineering graduates. The responses from the survey reinforced the appropriateness of developing
alternative assessment techniques in Engineering Education strengthened and supported by Technology Enhanced Learning.

8.4 Contribution to Engineering Education

This research provides unique approaches to the implementation of Technology Enhanced Learning within an engineering curriculum which is discussed in detail in Chapter 7. Using action research, initial concepts and use of Technology Enhanced Learning were successfully implemented into two large interdisciplinary based engineering modules. Student training and support material is provided fully online using Technology Enhanced Learning pedagogies to define and develop student skills support them in their video production.

The specification of video assessment methods is a unique approach to assessing students in their understanding and research in developing projects around the design concept process.

The research also provided evidence on the appropriateness of action research methodologies within a mixed methods study in Engineering Education. Using a combination of these two methods is unique within Engineering Education and provides recommendations of evaluating new practices and innovations in engineering curriculums.

Finally the research provides recommendations on the unique use of Technology Enhanced Learning within Engineering Education to develop, assess
and evaluate engineering student’s soft skills and understanding of industry based practices by contextualising their learning.

8.5 **Limitations of the research**

In discussing the limitations of the research, it is understood that the main body of this thesis is based on the implementation use of Technology Enhanced Learning within Engineering Education.

Due to the changing nature of technology, developments and new advancements in digital technology may provide alternative platforms in the future. Whilst the content of the research is up-to-date and valid at the point of thesis submission, the result of the research may differ if the work was undertaken again several years down the line.

Additionally, engineering class sizes and courses are continually changing due to pressures from Higher Education and funding restructuring. The study was limited to a two year cycle of action research due to the module class removing the interdisciplinary nature of the work in the year 2015. Whilst future recommendations can be made on further cycles of research, it is not possible to use within the modules used for the duration of the study and if implemented again would mean repeating the cycle from the first stage to validate results.

If the work could be undertaken again, it would be beneficial to run the implementation of technology enhanced learning using action research
methodologies to first, second and final year students to compare the results.

This study was only able to use first and final year students due to changes within the course structures that were not controllable within this study.

This research finally acknowledges limitations of data gathered during the focus groups and the survey data collection. For future large scale implementations the research results would need to be generalisable by increasing the amount of focus groups and implementations of the action research within other modules and increase the participant responses for the survey. However, the study provides valid research informed data for evaluating implemented practices within the work and recommends a blended approach to engineering education.

8.6 Future work and transferability to other disciplines

In defining potential further work, the original research aims are developed upon to include the following proposed investigations:

1. Investigate the option of creating a module purely online and removing all aspects of physical interaction whilst keeping the interdisciplinary project groups approach and allow students to collaborate purely online. This would investigate and explore potential methods and pedagogies that facilitate group working in a geographically different location within engineering. This would need significant investigation due to accreditation issues within engineering.
2. Investigate the transferability of the mixed methods utilising action research and Technology Enhanced Learning for other disciplines which have strong connections and input from industry stakeholders such as medicine discipline or scientific areas.

3. Investigate the development of a process that would allow a new member of staff to include this inclusive assessment approach into their own curriculum without any additional support. This process would enable the implementation of these methods without the need of physical resources such as a Learning Technologist. Additional support could include signposting staff to a resource utilising a range of training materials such as Lynda.com.

4. Investigate the transferability of the approach into the University’s Curriculum Enrichment Project (CEP) due for implementation in September 2015. The research technique introduces an innovative approach to inclusive assessment supported through scalable Technology Enhanced Learning resources, allowing students to develop digital literacy and employability skills.

The transferability of this work into other disciplines is associated with the video assessment technique. Within this study, the alternative video assessment technique proved highly successful, with students being fully engaged with their learning and taking ownership of their work.
By following a similar framework, other disciplines can engage their students and develop their digital literacy skills by creating new and innovative assessment techniques. Technology Enhanced Learning can facilitate and enhance existing learning practices and free up time spent in physical lectures or tutorials by changing the ownership of the learning to the students themselves. This in turn develops skills within students that are vital for employability.

Distribution of knowledge is planned in the year following submission of the thesis using a combination of research publications and conference proceedings.

In conclusion, this research and thesis introduces new innovative unique assessment techniques and use of Technology Enhanced Learning within an Engineering Education framework. Positive and successful improvements on student employability skills and student learning are evidenced.
# Appendices

## 9.1 Module Document Report for Integrated System Design (DSGN143)

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<td>CO-REQUISITE(S): None</td>
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<td>COMPENSATABLE WITHIN THIS PROGRAMME: Yes</td>
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**SHORT MODULE DESCRIPTOR**

This module helps students foster a technology-based, innovative and creative design identity. This is achieved through development of critical skills coupled with professional, multi-disciplinary teamwork. A practical focus is provided by a range of multi-facetted group design projects based upon open-ended, real-world problems.

**ELEMENTS OF ASSESSMENT:**

**COURSEWORK** 100%

Give Subject Assessment Panel Group to which module should be linked B5LEV1

Minimum pass mark for professional body accreditation ...50%.........................
MODULE AIMS:
To introduce the philosophy of engineering design. To show the
commonality in design approaches in different disciplines and activities.
To instil an appreciation of the relationships between engineering
outcomes and design input. To encourage innovative and creative
activities through group project work and case studies. To foster the
development of personal and interpersonal skills within a team work
environment. To build a portfolio of project work. To gain experience of
web-based, interactive, technology.

ASSESSED LEARNING OUTCOMES: At the end of a module the learner
will be expected to be able to:

1. Apply brainstorming skills to engineering design.

2. Discuss linkages between aspects of the design process and
   engineering outcomes.

3. Apply design techniques to a range of engineering problems.

4. Work effectively in teams.

5. Discuss causes of engineering failure.

6. Use presentation media effectively to communicate ideas.
**INDICATIVE SYLLABUS CONTENT:**

**LECTURE MATERIAL** is divided into 5 main subject areas:

The multi-faceted nature of design – design perceptions from, for example, an architect, a product designer, engineers from other disciplines.

Formulating a design envelope – requirements, constraints, criteria, iterative brain-storming.

The interaction between design, materials, processing/manufacture and service requirements.

Fostering innovation – brainstorming, looking for elegance, lessons from failures, looking for new twists to old ideas (techoptimisers).

The human dimension to design – ‘heart of darkness’ syndrome, environmental impact, ergonomics, behaviour of teams.

**GROUP DESIGN PROJECTS**

Multi-disciplinary engineering group design projects based on the theme ‘Energy and the Environment’.

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<td>(For FHSW)</td>
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<td>NAME OF SITE:</td>
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<tr>
<td>MODULE LEADER: Jasper Graham-Jones</td>
<td>Term* AY</td>
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Appendices

9.2 Module Document Report for Manufacture and Materials 1 (MFMT101)

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<td>IF LINKED, MODULE LINKED TO:N/A</td>
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<tr>
<td>SHORT MODULE DESCRIPTOR (For module catalogue. MAXIMUM four lines 9pt print):</td>
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<td>The module provides an introduction to manufacturing and materials for all BSc students. It includes primary and secondary forming processes, and introduces the concept of process-structure-property relationships in engineering materials.</td>
</tr>
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<td>ELEMENTS OF ASSESSMENT</td>
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<tr>
<td>COURSEWORK 50% EXAMINATION 50%</td>
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<td>Minimum pass mark for accreditation:</td>
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**MODULE AIMS:**

To develop students’ understanding and knowledge of basic manufacturing and materials technology, enabling them to appreciate why an understanding of the relationships between processing, structure and properties is a key element in engineering.

**LEARNING OUTCOMES:** At the end of this module students should be able to:

- Select a particular process for the manufacture of an engineering component.
- Discuss the reasons for their choice, and list its advantages and disadvantages compared to its alternatives.
- List generic types of material together with typical physical and mechanical properties.
- Describe the effects of processing on structure and properties of engineering materials.
- List and describe selected strengthening mechanisms, through the effect on structure and properties.
- Carry out a tensile test and interpret the results.
- Identify and describe features of a material’s micro- or macrostructure.

**ASSESSED SKILLS ELEMENTS:**

Analysis and Evaluation: LO 1, 2, 3, 5  
Practical: LO 1, 6, 7  
Communication LO 1 - 7
INDICATIVE SYLLABUS CONTENT:

Types of manufacturing organisation and design of facilities.

Primary forming processes (casting, rolling, forging, plastic moulding).

Secondary forming techniques, including tool life and cutting forces).

Basic metrology, including standards of length and limits and fits.

Properties of materials. Interpretation of stress-strain curves.

Qualitative description of major differences between generic classes of materials in terms of their microstructure. Influence of atomic bonding on properties. Cast structures and defects in metals. Types of polymers and additives. Polymer glass transition temperature and melting point.

Property modification techniques; relationship between structure, processing, heat treatment and properties. Metals: plastic deformation; hot and cold working; microdefects and their influence. Polymers: drawing and moulding; directionality of properties; influence of strain rate. Alloying: use of phase equilibrium diagrams in heat treatment; types of alloy. Properties, structure and uses of the plain carbon steels and the major non-ferrous alloys.

Materials testing. Strain rate effects on properties. The hardness test.

| VALIDATION: | DATE OF APPROVAL: 6/2/02 | DATE OF IMPLEMENTATION | 9/2002 |
| DATE(S) OF APPROVED CHANGE: | 18/02/09 |

| FACULTY: | DEPT: SoE | PARTNER INSTITUTION | (for IHS only) NAME OF SITE |
| Technology | | |

| MODULE LEADER: | Semester: T1 + T2 |
| Dr D Plane | | |
9.3 Ethical Clearance Documentation

Dear Rebecca,

Ethical Approval Application No: FREAC1213.22
Title: Use of CAD/VR Walkthrough Toolkit To Enhance and Understand Design Concept Processes in Engineering Education

The Faculty Research Ethical Approval Committee has considered the revised ethical approval form and is now fully satisfied that the project complies with the University of Plymouth's ethical standards for research involving human participants.

Approval is for the duration of the project. However, please resubmit your application to the committee if the information provided in the form alters or is likely to alter significantly.

We would like to wish you good luck with your research project.

Yours sincerely,

(Sent as email attachment)

Dr Syamanitak Bhattacharya
Chair
Faculty Research Ethics Approval Committee
Plymouth Business School
Dear Rebecca

Ethical Approval Application No: FREAC1213.38
Title: Use of CAD/VR Walkthrough Toolkit to Enhance and Understand Design Concept Processes in Engineering Education

The Faculty Research Ethical Approval Committee has considered the ethical approval form and is fully satisfied that the project complies with the University of Plymouth’s ethical standards for research involving human participants.

Approval is for the duration of the project. However, please resubmit your application to the committee if the information provided in the form alters or is likely to alter significantly.

We would like to wish you good luck with your research project.

Yours sincerely

(Sent as email attachment)

Dr Syamanitak Chattacharya
Chair
Faculty Research Ethics Approval Committee
Plymouth Business School
Dear Rebecca,

Ethical Approval Application No: FREAC1213.49
Title: Use of CAD/VR Walkthrough Toolkit to Enhance and Understand Design Concept Processes in Engineering Education

The Faculty Research Ethical Approval Committee has considered the ethical approval form and is fully satisfied that the project complies with Plymouth University’s ethical standards for research involving human participants. However, you are required to acknowledge the following in an email or add a sentence in section 6A of the form. “All students — in particular the undergraduate students — will be reminded that by taking part in the project or by refusing to do so, their relationship with the university will not be affected in any way”.

Approval is for the duration of the project. However, please resubmit your application to the committee if the information provided in the form alters or is likely to alter significantly.

We would like to wish you good luck with your research project.

Yours sincerely,

(Sent as email attachment)

Dr Syamantak Bhattacharya
Chair
Faculty Research Ethics Approval Committee
Faculty of Business
9.4 Survey Sampling Information
The online survey was sent out to the following:

- UK Education and Research communities email distribution list for engineering, architecture and manufacturing (engineering@jiscmail.ac.uk architecture-and-interaction@jiscmail.ac.uk)
- Members of the academic staff and technical support staff involved with laboratories in the School of Marine Science and Engineering and the School of Architecture and the Built Environment at Plymouth University
- Chief Executive for the Institute of Engineering Designers
- Royal Academy of Engineering
- UK Engineering Council
- Association Building Engineers
- Institute of Civil Engineering
- Building Design Magazine (BD)
- Architects Journal
- Higher Education Academy for Engineering Newsletter September 2013
- Local based engineering and architecture companies with direct involvement with our engineering undergraduate programs at Plymouth University.
- Plymouth Construction in Excellence Group
- Plymouth Manufacturing Group Newsletter
- Devon County Council Engineering Department
- Prysmian Group (energy and cabling solutions)
- Colas (delivering sustainable solutions for the design, building and maintenance of the UK's transport infrastructure)
### 9.5 Observation Notes for MFMT101

<table>
<thead>
<tr>
<th><strong>Date:</strong> October 2009 – MFMT101 Observation of teaching and learning materials and assessment criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Observation Notes</strong></td>
</tr>
<tr>
<td>The majority of teaching hand-outs on the virtual learning environment are Microsoft PowerPoint or PDF based. The material contains some images and links to additional information including reading lists and recommended books.</td>
</tr>
<tr>
<td>Lecture notes are uploaded after the lecture. Laboratory data was uploaded after the laboratory session.</td>
</tr>
<tr>
<td>Announcement sections are used but alert to the students are not set up and no guidance is provided on how the students can do this themselves.</td>
</tr>
<tr>
<td>Assessment practice includes a three-hour exam at the end of the spring term which equates to 50% of the final mark and the other 50% of the mark is a combination of the laboratory report and another written based assessment in the Spring term.</td>
</tr>
</tbody>
</table>
**Date:** Friday 2\textsuperscript{nd} October 2009 - MFMT101 Lecture One Observations

<table>
<thead>
<tr>
<th>Observation Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large student group, some unable to fit into the room and were standing in doorways</td>
</tr>
<tr>
<td>Students couldn’t see the lecturer or PowerPoint. This left them unengaged.</td>
</tr>
<tr>
<td>Students sat at the back became disengaged and were using their phones for use outside of their learning. One student was reading Facebook.</td>
</tr>
<tr>
<td>The room was not able to take such a large group and students were able to comfortably make notes work on their laptops etc.</td>
</tr>
<tr>
<td>Lecture was delivered using Microsoft PowerPoint with some images but mainly text based. A large slide presentation with no break in the teaching talking.</td>
</tr>
<tr>
<td>The delivery method of the modules discussed at length and laboratories mentioned briefly with students being asked to check the virtual learning environment for details of their lab groups and sessions</td>
</tr>
<tr>
<td>Some students were concerned about how to write a proper laboratory report. There was a hand-out but nothing was covered in detail either before the laboratory or in sessions after.</td>
</tr>
</tbody>
</table>
**Date:** Friday 9th October 2009 – MFMT101 Lecture Two Observations

<table>
<thead>
<tr>
<th>Observation Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large student group again, some unable to fit into the room and were standing in doorways. They left the lecture rather than go to find additional seats from another lecture room. It wasn’t a comfortable room for the students to learn in.</td>
</tr>
<tr>
<td>Students couldn’t see the lecturer or PowerPoint due to the room size and amount of students in the room.</td>
</tr>
<tr>
<td>Students sat at the back were slightly disruptive as they couldn’t hear the lecturer and didn’t speak up. Some students began checking emails and web browsing on their phones to areas not relevant to the learning.</td>
</tr>
<tr>
<td>The room was not able to take such a large group and students were able to comfortably make notes work on their laptops etc.</td>
</tr>
<tr>
<td>Large lecture PowerPoint file, text based with some images introducing materials. Some context to industry and how the students would interact with materials in their everyday practice</td>
</tr>
<tr>
<td>Laboratory was mentioned again briefly as the first laboratory was due the following Tuesday but this was only to remind students to turn up to their allocated session due to the high numbers already in the groups.</td>
</tr>
<tr>
<td>Date: Friday 16th October 2009 - MFMT101 Lecture Three Observations</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Observation Notes</strong></td>
</tr>
<tr>
<td>Large student group, some unable to fit into the room and were standing in doorways. Similar to other sessions they left rather than go to find additional seats from another lecture room.</td>
</tr>
<tr>
<td>Students couldn’t see the lecturer or PowerPoint</td>
</tr>
<tr>
<td>Students were asking about the assessment deadlines as they were unsure of when it would be due.</td>
</tr>
<tr>
<td>The room was not able to take such a large group and students were able to comfortably make notes work on their laptops etc.</td>
</tr>
<tr>
<td>Large lecture PowerPoint file, text based with some images introducing materials. It was quite content driven and difficult to engage with due to large amounts of text on the screen and the sheer volume of slides per presentation.</td>
</tr>
<tr>
<td>Laboratory was mentioned again briefly as some students didn’t turn up to their allocated session.</td>
</tr>
</tbody>
</table>
**Date:** Tuesday 13\textsuperscript{th} October 2009 – MFMT101 Laboratory One Observation

<table>
<thead>
<tr>
<th><strong>Observation Notes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>One student turned up to the wrong session</td>
</tr>
<tr>
<td>Four students had not printed laboratory sheet</td>
</tr>
<tr>
<td>Three students arrived late</td>
</tr>
<tr>
<td>A lot of time is spent at the beginning of the laboratory explaining the aims and the objectives of the session. At least thirty-five minutes was spent covering this and health and safety information.</td>
</tr>
<tr>
<td>Students had not received theory before the laboratory as the lecture covering the practical session is not scheduled until three weeks’ time</td>
</tr>
<tr>
<td>Students were unaware of what to expect from the laboratory and how it fitted into the module in general. Many of the students were quite enthusiastic to begin with but due to the large groups found it difficult to maintain the enthusiasm as they could always see the equipment. This was not due to any fault of the technician or the academic, simply due to room sized limitations being unsuitable for large groups.</td>
</tr>
<tr>
<td>Some students said they didn’t know where to obtain the laboratory hand-out or where they could find information on the submission date etc.</td>
</tr>
<tr>
<td>Equipment was difficult to fit a large group around. Some students sat at the back and appeared disengaged despite initial interest. It was at times difficult to understand what was going on unless you were in close proximity to the machine particularly when the material started to stretch and you could physically see the breaking point of the specimen. Only two or three students would have been able to witness this properly and the other students had to refer to the break of the material after rather than observe how it stretched.</td>
</tr>
<tr>
<td>First two samples did not work correctly and had to be retested, this caused a delay of approximately 5 minutes.</td>
</tr>
<tr>
<td>At one point students are left to continue with the experiment when the staff left the room. They were uncomfortable and unsure what to do despite some guidance and asked me for advice. The technician was brought back in and had to go over the concepts again. This was common in the majority of the observations of the laboratory session.</td>
</tr>
<tr>
<td>The laboratory hand-out sheet is very traditional and some students commented that this felt very school like rather than something an engineer would have to fill in? Further clarification may be needed to find out how engineers create reports around these areas. Students won’t necessarily disputing what they had to do but wanted to understand why.</td>
</tr>
<tr>
<td>A lot of time is spent with the students sketching the equipment or sample for later use in their laboratory hand-out. Some students felt frustrated that this was taken away time that they could be using the actual equipment.</td>
</tr>
<tr>
<td>The machine that defines the loads etc. didn’t always print the results.</td>
</tr>
</tbody>
</table>
**Date:** Tuesday 20\textsuperscript{th} October 2009 - MFMT101 Laboratory Two Observation Notes

<table>
<thead>
<tr>
<th>Observation Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two students turned up to the wrong session so they were added into this group making it a larger group.</td>
</tr>
<tr>
<td>Two students had not printed laboratory sheet and had to wait to get another lot printed. This delayed the start of the laboratory</td>
</tr>
<tr>
<td>One students arrived late and one didn’t turn up</td>
</tr>
<tr>
<td>A lot of time is again spent at the beginning of the laboratory explaining the aims and the objectives of the session. At least thirty-five minutes was spent covering this and health and safety information.</td>
</tr>
<tr>
<td>Students had not received theory before the laboratory as the lecture covering the practical session is not scheduled until three weeks’ time. This meant they didn’t know what the laboratory’s aims were or how it fitted into the module.</td>
</tr>
<tr>
<td>Students were unaware of what to expect from a laboratory. Some were making notes that weren’t necessary, others weren’t making the notes at points they needed to for example the results of the test or sketching the equipment specimen.</td>
</tr>
<tr>
<td>Equipment was difficult to fit a large group around. Some students sat at the back and appeared disengaged despite initial interest and enthusiasm.</td>
</tr>
<tr>
<td>The students were very shy in this group and needed a lot of prompting to do get involve. The technician was very good at giving them confidence but for many this was their first exposure to a laboratory scenario.</td>
</tr>
<tr>
<td>At one point students are left to continue with the experiment when the staff left the room for twenty minutes. They were uncomfortable and unsure what to do despite some guidance and asked me for advice. The technician was brought back in and had to go over the concepts again, by this point it was too late to do all of the test.</td>
</tr>
<tr>
<td>Students commented that they liked the practical session but it was difficult due to large group sizes to be able to get a proper hands-on experience. Some were concerned they would end up writing a bad report as a result.</td>
</tr>
<tr>
<td>A lot of time is spent with the students sketching the equipment or sample for later use in their laboratory hand-out. They were unsure of the relevance of them sketching it out as it was the same for each test.</td>
</tr>
<tr>
<td>The machine that defines the loads didn’t print again</td>
</tr>
<tr>
<td><strong>Date:</strong> Tuesday 27\textsuperscript{th} October 2009 - MFMT101 Laboratory Three Observation</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td><strong>Observation Notes</strong></td>
</tr>
<tr>
<td>One student turned up to the wrong session and was turned away as this group was particularly large.</td>
</tr>
<tr>
<td>Three students had not printed laboratory sheet which caused delay for more printing out as they need it to fill in their laboratory report.</td>
</tr>
<tr>
<td>Two students arrived late and one didn’t turn up.</td>
</tr>
<tr>
<td>A lot of time is again spent at the beginning of the laboratory explaining the aims and the objectives of the session. At least forty minutes was spent covering this and health and safety information.</td>
</tr>
<tr>
<td>Students have received the theory of the laboratory was still unclear of the objectives of the session. I asked the students what information they had and they said it was about testing materials and that’s it. They were unsure of the context and the reasoning behind them testing materials etc.</td>
</tr>
<tr>
<td>Students were still unaware of what to expect from the laboratory and how it related to their studies and engineering as a whole. It wasn’t put into context for industry based practices but they were enthusiastic about having a practical laboratory and being exposed to practical tasks as they believed it played a pivotal role in an engineer’s position. Two students who were more engaged with the laboratory left the session enjoying the idea of following it up and had arranged to come back at lunchtime to see the technician again. I asked the technician if this would be scalable across all students who could potentially ask for the same. Understandably it wasn’t, he said there was only a small percentage who asked for more access to laboratories and follow up work.</td>
</tr>
<tr>
<td>Equipment was difficult to fit a large group around. Some students sat at the back and appeared disengaged despite initial interest and it’s easier than for the laboratory.</td>
</tr>
<tr>
<td>The machine failed at one point causing delays of approximately 10 minutes.</td>
</tr>
<tr>
<td>Students commented that they liked the practical session but it was difficult due to large group sizes to be able to get a proper hands-on experience.</td>
</tr>
</tbody>
</table>
**Date:** Tuesday 3\(^{rd}\) December 2009 - MFMT101 Laboratory Four Observation

<table>
<thead>
<tr>
<th>Observation Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two additional students were in this group who had failed to turn up for previous sessions.</td>
</tr>
<tr>
<td>For students had not printed laboratory sheet.</td>
</tr>
<tr>
<td>One student arrived late.</td>
</tr>
<tr>
<td>A lot of time is again spent at the beginning of the laboratory explaining the aims and the objectives of the session. At least thirty minutes was spent covering this and health and safety information.</td>
</tr>
<tr>
<td>It was clear that students were still unsure about the laboratory or the assessment deadline for their report.</td>
</tr>
<tr>
<td>When speaking to the students, they were unsure how relevant this test was to an engineer in practice.</td>
</tr>
<tr>
<td>Equipment was again difficult to fit the large groups around and many students sat towards the back and began to use their phones for personal use and not learning.</td>
</tr>
<tr>
<td>Students commented that they liked the practical session but it was difficult due to large group sizes to be able to get a proper hands-on experience. One student asked if they could come back and attend another session.</td>
</tr>
</tbody>
</table>
9.6 Observation Notes for DSGN143

<table>
<thead>
<tr>
<th>Date:</th>
<th>October 2011 – DSGN143 Observation of teaching and learning materials and assessment criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation Notes</td>
<td>The majority of teaching hand-outs on the virtual learning environment are Microsoft PowerPoint or PDF based. The material contains visual images, links to industry standards and recommendations on using Royal Academy of Engineering references and guidance</td>
</tr>
<tr>
<td>Lecture notes are uploaded after the lecture. Module leader and teaching staff are proactive in their use of the virtual learning environment as a way of disseminating information to the students. Announcement sections are used extensively and alerts set up to the students.</td>
<td></td>
</tr>
<tr>
<td>Assessment practice is summarised:</td>
<td></td>
</tr>
<tr>
<td><strong>Assignment</strong></td>
<td><strong>Percentage of Final Module Mark</strong></td>
</tr>
<tr>
<td>Term 1: In-course test (On-line multiple choice test)</td>
<td>10</td>
</tr>
<tr>
<td>Term 1: Design Concept Presentation</td>
<td>15</td>
</tr>
<tr>
<td>Term 2: Design Project Report (includes a percentage of peer assessment)</td>
<td>50</td>
</tr>
<tr>
<td>Term 2: Project presentation day (group viva/Poster/Model/CAD)</td>
<td>25</td>
</tr>
<tr>
<td>Virtual learning environment is full of information and often difficult to navigate. However, this is predominantly due to the restrictions of the system itself.</td>
<td></td>
</tr>
<tr>
<td>A collaborative area was set up within the virtual learning environment for students to use. However many students to make use of this which took up valuable time to setup and create. Students used Facebook or email to collaborate and share their work.</td>
<td></td>
</tr>
<tr>
<td>Date:</td>
<td>October 2011 – DSGN143 Lecture One Observation</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td><strong>Observation Notes</strong></td>
<td></td>
</tr>
<tr>
<td>Extremely large module size of over three hundred students.</td>
<td></td>
</tr>
<tr>
<td>There was a lot of structure and limitations of the lecture due to the large module size. Any late students interrupted the process.</td>
<td></td>
</tr>
<tr>
<td>Students appeared to be slightly overwhelmed by the large size of the module particularly when they first walked into the room.</td>
<td></td>
</tr>
<tr>
<td>It was difficult to hear at times due to background talking and the large nature of the room.</td>
<td></td>
</tr>
<tr>
<td>Students were motivated by the idea of working in interdisciplinary groups and asked questions around the relevance to the project to engineering industry.</td>
<td></td>
</tr>
<tr>
<td>The academic staff was enthusiastic about the module and used case studies that were believable to working practices in industry.</td>
<td></td>
</tr>
<tr>
<td>A lots of examples were used within the lecture and the layout and structure of the module was made very clear to its complexity and multiple assessment forms.</td>
<td></td>
</tr>
</tbody>
</table>
**Date:** October 2011 – DSGN143 Lecture Two Observation

<table>
<thead>
<tr>
<th>Observation Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large module group of over 300 students struggled to fit the students in the lecture room.</td>
</tr>
<tr>
<td>One student hand at five minutes late and the only space available was at the front which caused further disruption to the students.</td>
</tr>
<tr>
<td>Timetabling issues meant that some of the lecture time was scheduled during the sports activities afternoon which was meant to be lecture free but for this module had to run then due to time tabling clashes.</td>
</tr>
<tr>
<td>Students were introduced to the case studies that would be made available to them later. The academic made it clear on how the students could choose the case study they wanted to research.</td>
</tr>
<tr>
<td>Students seemed to be very motivated and asked questions relative to the assessment etc.</td>
</tr>
<tr>
<td>It was difficult to see the screen, however the academic mentioned that the material would be uploaded to the virtual learning environment.</td>
</tr>
<tr>
<td>Due to the large size of the module it was difficult to fully engage the students during the lecture time and only a limited amount of questions could be asked during the session.</td>
</tr>
</tbody>
</table>
**Date:** October 2011 – DSGN143 Student’s Presentation Observation

<table>
<thead>
<tr>
<th>Observation Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large module group of over 300 students. Students had to load their presentation onto the machine and due to the volume of groups took a couple of minutes depending on file size of the presentation.</td>
</tr>
<tr>
<td>Difficult to hear students present, particularly if nervous. The large group meant there was a lot of background noise.</td>
</tr>
<tr>
<td>It was difficult to observe the presentation and images were of low resolution and couldn’t see detail</td>
</tr>
<tr>
<td>Students that were late disrupted the presentations.</td>
</tr>
<tr>
<td>Students in the audience listening to their peers became disengaged after the first few.</td>
</tr>
<tr>
<td>It was difficult to understand the design concept from the PowerPoint alone. Difficult to visualise their idea although some groups attempted to embed video but this was slow to play in the lecture room and difficult to view.</td>
</tr>
<tr>
<td>Students obviously spent a lot of time working on their project that the Microsoft PowerPoint presentation did not do it justice and didn’t convey the design concept due to the linear nature of PowerPoint.</td>
</tr>
<tr>
<td>PowerPoint did not allow much creativity and the presentations took similar formats from group to group.</td>
</tr>
</tbody>
</table>
9.7 Interview One – Transcript Notes

Background Introductory Questions

1. How many years have you been involved in engineering laboratories? 30 years

2. Please give a brief introduction to your role within the engineering laboratories. Lecturer; the lab session is an opportunity to teach students in a practical environment, to point out features and issues we will cover or have covered in the classroom, to make them aware of a range of test equipment (strain gauges in the case of the beam bending), to show them how difficult it sometimes is to get practical results, to give them a feel for real engineering accuracy, to give them practice at recording and processing practical results and to critically analyse them.

Observations from Last Few Years?

1. What have been the changes in the last few years in providing practical engineering labs within the university? Pressure on both staff time and space leading to a reduction of the amount of lab work in the course. Also a need for all lab work to be directly assessed – otherwise some students just don’t engage with it.

2. In your opinion how do larger student group numbers affect the way laboratories are structured? More lab groups, demanding either more concentrated effort from the staff member, or spreading the sessions over more weeks, which make them more remote from the point at which the material was taught.

3. Have you ever had any distance learning students involved in engineering labs or courses, if so how did the university facilitate this? No.

Tensile Test

1. How important is the use of this equipment/test in engineering labs? Very – for reasons in Q1.2 above.

2. If time could be freed up in the laboratory using the tensile test as an example how would you best use this time? Not sure what you mean – I would
rather have other time freed up from admin so I could spend more time in the
lab with students!

Virtual Laboratories

1. What are your views on the use of virtual laboratories in engineering?
   Mixed feelings. A particularly good simulation may be able to emulate what
could not be experienced otherwise (eg the Navigation Simulator, or a ship’s
engine room control panel), but these are very expensive. Other more simple
examples can aid student learning, but if too simple they can be trivial (beam
bending falls into this category – one independent variable, one dependant and
a linear relationship between them – the benefit of actually doing the lab is in
experiencing the physical situation and practical difficulties; I suspect this would
not be recreated in a virtual lab).

2. What is your definition of a virtual laboratory? A simulation (usually a
   computer one) of a real laboratory experiment in which students can change
variables and record results.

3. Have you seen any simulations used in any engineering laboratories? If so
   how effective were they? One or two in engineering, and generally they were in
the “too trivial” category. Some excellent medical ones, but they have the
money & resources to develop them.

Future of Engineering Laboratories

1. What role do you see new technology playing in the future of
   engineering laboratories? As long as it is a support for real, physical, hands-on,
then it has the capacity to enhance learning. If it becomes a complete
substitute, with physical laboratories sacrificed on the altar of efficiency, it
would be a backwards step.

2. Do you think we will see any changes in the way engineering laboratories
   are taught in the next 5 years? Pressure to reduce space, reduce staff time and
reduce physical assets used for undergraduate teaching.
9.8 Interview Two – Transcript Notes

Background Introductory Questions

How many years have you been involved in engineering laboratories?

At Plymouth, 9 years; at University of Brighton, 3 years; at University of Bristol (as a demonstrator) about 5 years.

Please give a brief introduction to your role within the engineering laboratories

As lecturer, I undertake the following tasks in connection to lab sessions:

- Identify which laboratory available is relevant and at what point in the course it would be most appropriate
- Prepare the lab sheets – instructions for carrying out the lab, readings to be taken, guidelines on the analysis to be undertaken.
- Divide the class into suitably sized groups to undertake the lab
- Liaise with the technical staff to ensure that all the equipment is working and the lab space is available (it should normally be timetabled on both my and the technician’s timetable)
- Supervise the lab class, ensuring students understand what the purpose of the lab is, how it fits in with the rest of the course, that they get some meaningful results, and discuss these with them.

Observations from Last Few Years?

What have been the changes in the last few years in providing practical engineering labs within the university?

Generally changes for the better, with some new equipment being added. In some labs. However (engines and fluids labs) some of the equipment is now aging, and results can be spurious. There are more computers in the labs too, and while this can be very useful, it can sometimes detract from the hands-on tasks required. Students who are not particularly comfortable with computers tend to let others take control. With more competition for lab space they need to be organised well in advance. It is difficult to carry out any impromptu demonstrations.
In your opinion how do larger student group numbers affect the way laboratories are structured?

Larger groups make structuring the labs much more difficult. Due to time constraints, it means you can do fewer labs since you have more groups. It also means that synchronising the topics studied in the labs and in the lectures becomes much more difficult, with some students doing the practical work before the topic is taught in lectures and others the other way around.

Have you ever had any distance learning students involved in engineering labs or courses, if so how did the university facilitate this?

I have taught the BSc MDM Distance Learners. The University did not really facilitate this, in that students were required to come down to the University to carry out the lab work. The only concession we made was to allow them to undertake more than one lab on one day. So if there were 2 or more labs associated with a module they would do as many as possible on the one day. In MECH228, however, there are many more labs (about 8, I think), so the distance learners were not able to do all of them. They had to read about those they did not do themselves.

Tensile Test

How important is the use of this equipment/test in engineering labs?

Very important. It gives a good deal of information about the mechanical properties of a material, including its strength, stiffness, ductility, and the way it fails in tension. Since all mechanical and civil engineers use materials to build components or structures an understanding of how materials behave is a fundamental requirement for engineering graduates.

If time could be freed up in the laboratory using the tensile test as an example how would you best use this time?

Probably to carry out additional lab classes.

Virtual Laboratories

What are your views on the use of virtual laboratories in engineering?

They have their merits but cannot completely replace the experience of actually operating machinery, measuring, using tools, etc and seeing how things go wrong.
What is your definition of a virtual laboratory?

I understand a virtual laboratory to be one in which the experiment is simulated, either by using video or, more likely, a computer. Perhaps a combination of the two. The student might interact by controlling the speed, say, or the load added to the structure, or the flow speed, and then would be able to observe the effects of their actions.

Have you seen any simulations used in any engineering laboratories? If so how effective were they?

No, I haven’t seen any.

Future of Engineering Laboratories

What role do you see new technology playing in the future of engineering laboratories?

I see new technology as contributing to the availability of different types of sensor, and different types of control systems, as well as data collection and management. More “table top” equipment may become available.

Do you think we will see any changes in the way engineering laboratories are taught in the next 5 years?

My fear is that we will see less being taught in the laboratories, due to the expense of their upkeep and maintenance. I hope not, because in a practical subject like engineering I think they are invaluable, even if they sometimes seem to be boring, just sitting there taking readings. On most of the feedback from ****228, the thing they liked best about the module was the large amount of practical work.
9.9 Interview Three – Full Transcription

How many years have you been involved with engineering laboratories?

Thirty five years plus. I say that because I’m not exactly sure, but 35 years plus. Approximately 20-odd years here and the rest were in industry.

Q: Can you just give me a brief introduction about what your role is within engineering laboratories, specifically within the University?

Well, they call me a materials engineering officer, but to you and I it’s a technician [laughs] with some experience. Basically, you look upon yourself more or less as a facilitator, if that is such a word.

Q: Yes, it is indeed.

Because what you do is you actually provide the academic staff, so they can use the laboratory, you provide for the students so they can work safely, and work with the equipment in the laboratory you are providing, and you work with the researchers and the professors, so their work is done safely within the laboratory. So it’s really running the laboratory, but you’re covering all areas. We also do a certain amount of consultancy. So you’re facilitators for all those areas.

Q: Just as an off question to that, how many different types of equipment do you normally have to look after in the lab, as a rough idea?

In here? There must be, I would hate to guess really, 15, 20 different types, and that’s main types of equipment. So you’re going from photo-elasticity, to microscopy, to mechanical testing, photography, chemical analysis…

Q: So lots?

Lots, yes, yes.

Q: I just wanted to pick up on some of your observations from your experience over the last few years, what have been the changes in the last few years in providing a practical engineering lab within the University, what changes have you noticed?
Investment, investment in equipment. In the last, shall we say five, maybe a bit longer years, there’s been a good investment in equipment, mainly because of the people further up the change, the heads of school and the deans, have actually invested in the laboratories in terms of equipment. And more recently there’s been some good investment in the infrastructure, the laboratories, you know? ***** at the end, the labs the other side have been done out to take on the laser-cutting equipment. This area has been done to a small extent, but it needs, it’s the last area that’s not been done yet.

**Q:** And in terms of staff, have they increased the amount of staff to facilitate the new equipment, or is..?

The staff went down several years ago, but has since started to build back up. We’ve got a couple of extra technicians now that are being familiarised as we speak on the equipment that we’ve got. We’ve had a lot of investment this year as well.

**Q:** In your opinion, how do larger student groups tend to affect, if they do affect, the way laboratories are structured? And if possible, I’d like to concentrate on the use of the tensile test, for example, in MFMT101.

If you mean, do large groups function well within the laboratory, then the answer is no, because the equipment that they use, I take the approach that students are here to use the equipment, so I let them get hands-on. Now, hands-on means that you can only have a couple of people on the machine at one time with a few watching, so if you have groups larger than four or five, then the rest are not actually paying that much attention. We find that with students.

**Q:** And have you found that, say from this year compared to maybe two or three years ago, have the students groups been increasing every year?

Student groups vary from year to year. Last year and this year, we’ve taken on the Civils groups, and the Civils have quite large classes. So at the moment we have large classes come through, and the classes actually, generally the classes have gone upwards, the numbers have gone up.
Q: And if we look at the tensile test, how do you find that works with, or doesn’t work with the larger student groups then?

How does it work? Larger groups, as I said just now, is very good if they actually concentrate. But if they don’t concentrate and you actually don’t get students concentrating on the experiment, the larger groups, 60 per cent don’t see what’s going on. Now, sorry, I was going to say, we have now got an overhead projector screen at the back so that actually the group can look at the screen. I don’t know if that was on when you came on last time.

Q: I believe it was for some parts of it on the software I think, but not necessarily for the...

But I’m not in favour of large groups. Overall I like to see small groups, because I think small groups get more benefit from the experiments.

Q: This might not be relevant, but have you actually had any distance learning students involved in engineering labs? If so, how did the university facilitate it?

I looked at this earlier on and said “no, I’m not sure if I have or haven’t.” We’ve not done any distance learning with showing videos online for students.

Q: Do you think that’s just because it hasn’t happened, or do you think it’s because there’s a lot of resource involved in facilitating distance learning in engineering?

I think it’s both. I think it’s just not happened and it does take a lot of resources. I think with the manpower that we’ve had up to recently, we probably would find it difficult to cope.

Q: I’d just like to concentrate more on the actual tensile test now. How important is the piece of equipment and the use of it in engineering labs in the university?

Essential.

Q: It’s essential?

In a nutshell. It’s the backbone of the laboratory really. Students get so much information from the data that they get from the tensile test, but that is in conjunction with all other parts of the equipment. What happens is
the tensile testing is just one part of like a jig-saw puzzle. So when you are doing materials characterisation you do a hardness test, you do microscopy, you do a tensile test, you do some x-ray analysis, you've got the electron microscope. Basically all those bits of information fit into a jig-saw puzzle, and then with what you’re taught in your class, you then are able to get an overall picture, but it is a big part of that jig-saw puzzle.

Q: And is that used across all years in degree programs first to final years?

Yes, yes.

Q: And in research?

Research, final year projects, consultancy…

Q: So it’s basically a very integral piece of equipment to you?

It’s a very integral piece of equipment, yeah.

Q: If time could be freed up specifically with the tensile lab – I'm talking about the MFMT101 – if you could have more time, how would you use the tensile test to further get the students engaged with it? What other sort of things could you do with tensile tests if you had more time with students?

Specifically with tensile test?

Q: Specifically with the tensile test.

Well, it depends what the actual students would want to do. If it's a tensile test, you wouldn’t do a great deal else. You perhaps would go deeper into the analytical side of the information you get off it, but a tensile test is fundamentally a specimen which you put in and pull apart. Now you can do compression tests, you could do fatigue testing, but in MFMT it’s a fundamental tensile test, modulus TS.

Q: Because I know at the end of the tensile test if they have time, with the plastic samples, they can then go and identify the plastics.

Yes.

Q: Is there anything else that could be expanded on there? Are there other samples they could use that would help them, or..?
They do a range of samples. They do plastics which are ductile, plastics which are brittle. They do steels, they do aluminium I think in some cases now as well, some groups do. In all of those they can do further work, but it wouldn’t be on the tensile tester. For instance, they would come in a look at the fracture surfaces.

**Q: So you are utilising other equipment?**

You would utilise other equipment. Like I said just now, it’s like a jig-saw puzzle. You don’t get all the information from one piece of equipment. If you did a tensile test, and what I believe you saw was the steel tensile test, you’d see how it necks down, or doesn’t neck down in the facture, and then you look at the fracture surface to see whether it was a brittle fracture, or ductile fracture.

**Q: So do you think that would be, if the initial work on the tensile test then was sped up, if you like, than if they could then carry on and do the next piece of equipment, would that be beneficial to that module, or..?**

I believe they do it anyway. I believe they do, they could do more in the time they are given to do the tensile test, if the tensile test were speeded up. I don’t think you could speed it up a great deal more, to be honest. I think if the students are prepared and it’s done sensibly, the information that they get is quite, is very valuable and critical. Then the other time they could come in, they could cut a sample off and they could look under the microscopes, look at the fracture surface – they do actually, in another session, come and look at the microscopy side of it. Did you see that?

**Q: No, I haven’t seen that one, no, just the tensile test.**

Well they do, I’m sure they do. Trouble is, a lot of the courses overlap and I might be wrong, but ***** changed some of the stuff because ***** ***** used to do the – ***** changed some of the stuff and I’m sure they did go in with ***** afterwards on another occasion, and look at the micro structures of the materials. So like I say, it’s all of those things come together. They do the micro structure, they do the tensile test, they do the hardness test, so...
Q: And I guess the fundamental thing is the students coming in prepared, knowing what they are doing to be doing with the lab and..?

Yes, yes. But the other thing is that we actually, although the tensile tester, and we’ve got one tensile tester, you can get several, we only have a couple of microscopes in next door. There again, when you get large groups, we have got a monitor, so they are actually taught and only a few, one person uses the microscope at a time, so the rest are looking at the screen, and they are actually told they can come in there other times to use the equipment.

Q: In their own time?

In their own time, yeah. They’ve got to fit in around.

Q: And do students do that?

Yes, the keen ones do.

Q: The keen ones do?

But you always get the ones that don’t want to do anything.

Q: Could you give a rough percentage of how many keen students you get out of a group that wants to take things further?

It varies from year to year, but you could say 30 per cent. I wouldn’t say it’s an accurate figure.

Q: Which is probably quite good [laughs].

But about 30 per cent, yeah.

Q: As a rough idea, yeah. I’m going to move on to the ideas behind virtual laboratories now. In general terms, what are your initial views on the use of virtual laboratories and engineering?

I think they can be very good, they can be very good, but in my own personal opinion they’ll never replace the actual hands-on, and the actual work experience of doing a real test, because you don’t get that experience from watching a film. I remember being at school, we were
shown steel-works and stuff like that, steel being made, but it’s no substitute for actually doing it. There’s no substitute for actually putting the specimen in, loading up, putting on the extension, making sure that everything’s correct, finished. You don’t get that. You get the idea, the fundamental idea of doing a tensile test, but you don’t get that experience of the correct way of doing it.

**Q: The actual way of doing it. What would you definition of a virtual laboratory be?**

My definition?

**Q: There’s no right or wrong [laughs].**

A virtual laboratory, where in fact they don’t actually do anything as such? Perhaps just sit in front of your computer, look at the screen and change varying parameters, like the size of the specimen, *0:12:25.9* type of material.

**Q: So more in terms of simulation on a software simulation?**

Yes, yeah that kind of thing.

**Q: I mean there’s no right or wrong answer on that one, it’s interesting what people’s perceptions of virtual laboratories are.**

No, I don’t, well yeah, virtual. Well to be virtual is not real, if it’s not real the only way of not doing a real rest is to look at a screen.

**Q: What examples have you seen in engineering laboratories of simulations, if so how effective do you believe they were?**

Again, it’s down to looking on programs that are shown on, I mean a lot of the equipment we’ve got will actually show you a simulation of a test, or how to do a particular operation on a machine. To me, that’s a simulated, virtual reality set-up. Then you actually have to adapt that to meet your own criteria of the test that you want to do. So fundamentally, they are showing you the basic way to do a test and to get information, and save that information, but they don’t give you all the details you need for your particular way of doing it, or the route you want to go down.

**Q: Just to bring it to a close on this, what role do you see any new technology playing in the future of engineering laboratories?**
What role technology?

Q: How do you think that technology that’s current being developed, be that of virtual laboratories, simulation software, what role do you see new technology playing in the future of engineering laboratories?

Well, you’d be able to do more complicated things easier, because technology is good at number-crunching. Number-crunching, as we all know, is the fundamental basis of doing lots of technical, getting lots of technical information and I can see that’s going to be the way it will go.

Q: And do you think that the university here would be adopting new technologies within the engineering laboratory?

I think providing we have the people at the top that actually sees the value of engineering technology, yeah, but if you lose those people, and we’ve spoken about one person now, I shan’t mention names, but if you lose that person’s keenness, then in fact it’s quite easy for things to die. At the moment, from my experience, we’ve got quite a good grounding in technical staff who are quite keen in all their areas. If you lose some of those, and I’ve seen it happen, even in our little area, you lose a person, an academic, or a technical person in that area and that area then dies, because no one else has got the time to develop it.

Q: Do you think we are going to see any changes in the way engineering laboratories are taught in the next five years?

Any changes? I think more technical imput will be at the forefront. I think the technical staff would start taking the laboratories away from the academic staff. Not away from the academic, but freeing up the academic staff to teach, and leaving the technical side to the technical staff within the laboratories, who after all use the equipment day in and day out.

Q: Do you think we are going to see any changes in student numbers?

Student numbers will fluctuate. It all depends on external forces. You know and I know that they’ve just changed the rules again for student numbers at the university, so it really depends on that. You can only do so much. You’ve got a pot of students and then there’s a university and
they’ve got a choice of university to go to, we can only sell ourselves as best as we can sell ourselves.

Q: Do you think if there is a reduction, or if, in fact there is a gain in students, do you think that that could mean that some labs are actually merged together and form even larger student groups? Is that a feasibility?

I think it would be a good thing if labs merged together, because in engineering really we’ve been fragmented over man years, and we are only just now starting to come back together. When I first came here civil and mechanical engineering was one, and because student numbers grew, they split. Now students numbers have shrunk back down again, they’ve started, and space is an issue, we’ve come back together, but a lot of the areas overlap. If you had specialist areas with specialist laboratories, you could make a big difference. I say that with, I mean I have microscopy stuff, science has microscopy stuff, *****, up in the electron-microscopy has microscopy stuff. We overlap to a certain extent. I’ve got light microscopes there and this laser microscope, **** got the x-ray and scanning microscopes up there.
### Appendices

#### 9.10 NVivo Nodes

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<tr>
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<td>RV</td>
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</table>
9.11 Video Production Resource Toolkit
Available online:
https://xerte.plymouth.ac.uk/play_html5.php?template_id=1025#
Video Production Resource
Design Concept Video

This video provides background to the production of videos in your studies and provides you with key information to enable you to produce your own high quality Design Concept Video, using a resource that has been produced with input from your fellow students specifically to support you in doing so.

It has been produced to help you understand the framework of your design project, the importance of the Design Concept Video and what you need to include in it.

Most importantly this video clarifies the role that the resources play in giving you the support and information you need to produce your Design Concept Video.

Please watch the video and then use the resources – it is essential that you do so.

This video launches in YouTube, to change the quality of the video (for example to HD) please click on the wheel icon situated at the bottom right hand side of the video screen and then change the quality from the pop up menu. This may vary depending on the internet speed at the time.

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Video Production Resource
Project Concept Diagram

Please note all of the components listed here are part of the Final Year MEng Interdisciplinary Design Project (IDDP). First year DSGN143 students do not necessarily have to produce a Personal Reflective Log, a presentation of project choice, a project specification, or a Project Execution Plan but you should review the descriptions.

To look at the specific elements of the module (including the design concept video project) please click on the relevant boxes on the diagram to the left.

**Project Report**

The Project Report is produced to document the outcome of your research and detailed design activities as identified in the Project Specification and Project Execution Plan. It is a very comprehensive document. It will contain detailed descriptions and fully scaled drawings of all of your designs (including integrated systems) with supporting proposals for implementation including full costing, risk assessments, health and safety plans, plans (gantt charts) for building your proposed solution etc. The document will also contain a business plan which you've developed in order to sell your project to investors in order to gain finance to build it. Guidance notes for production of the Project Report and Business Plans can be found [here](link).

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Staff Audit

Please take a couple of minutes to respond to this simple survey. The survey helps us to gauge what support maybe required from the video concept project and to adapt support materials where needed.

The members of the group responsible for creating the video are required to complete the survey with as much detail as possible.

Click here to go to the skills audit

Video Skills Audit 2014

If you are experiencing trouble viewing the whole of this form please use the arrow keys on your keyboard or select and hold to scroll the page down on your device.

* Required

Please enter your name :

Please enter your group number :

Please select which stage you are in :

Do you have any experience in video production i.e. filming using video cameras/flip-cams etc.?

Yes

No

Do you have any experience in video editing i.e. editing using software such as Adobe Premiere, Final Cut Pro, ae.cine, Windows Live Movie Maker?

Yes

No

Appendices

Video Production Resource

Help in Using the Resource

Both of the resources have been created to provide a one stop shop for all the resources you will need to create your video projects in both the DSGN 143 and the final year MEng modules.

In order to help you navigate and locate a specific resource a [tree view diagram PDF guide](http://example.com) has been created for your use as well as a PDF guide on how the interface to the resources work in HTML5 and how you are able to manipulate and change how the resource looks to provide an accessible view to all.

Video Production Resource

This resource (which you are currently in) introduces the video design concept project and reinforces it aims and objectives as well as help you plan your video project as well as show examples of previous students work.

Video Support Materials Resource

This resource provides links and other support materials for you to use to produce your project, from which software to use down to locating PC access and equipment. This resource is available online in HTML5 – [http://example.com](http://example.com).
Appendices

What is a storyboard?
A storyboard is a visual aid that makes it easier for you to share and explain your idea for your video with others. With a storyboard, you can show people exactly how your video is going to be mapped out and what it will look like. This makes it easier for colleagues in your group to understand your idea.

Why use a storyboard?
There may be an initial time investment to creating your storyboard, but in the long run it will save you time.

How to create a storyboard?
The first step in creating a storyboard is to use a series of squares on a piece of paper.

Some templates for you to print have been created, either a small version of boxes or a large version.

Video Production Resource
Previous Video Examples

A Replacement for Brunel Building

We’ve included this first year video as it relates to a building that all students at Plymouth University are familiar with. This video was one of four videos produced in our original pilot programme. The students addressed designing a modern building that not only incorporates all of the existing functionality but also addresses some facilities that are in short supply on the existing campus. The video is constantly moving using different types of displays and animation to keep the attention of the viewer. The design and functionality are very logically presented – all decisions are clearly identified and suitably justified. Some innovative energy saving initiatives are proposed which fit well within the innovative layout proposed. The presentation of project plans to date and for the work to be completed in the second term provide a clear picture of the process carried out by the students in completing their project.

The video can be viewed here via YouTube.

Student Village

This first year video provides a complete picture of the process followed and the design conclusions that the students reached in developing their design concept – it is a near perfect template for implementing DSGN143 projects. The group had made excellent progress during term one having completed their design concept and, even though their project contained several different and interacting buildings, had already commenced with their detailed designs that are described very well with some excellent (and detailed) supportive 3D drawings. At the end of term one it is extremely rare for students to have addressed the major systems that make their buildings safe, secure and comfortable but there are described well with some useful flow diagrams. The Project Management proposals are well presented and provide a very clear picture of the work for term 2. It is hardly surprising that this group went on to produce an exceptional project report.

The video can be viewed here via YouTube.
9.12 Video Support Materials Resource Toolkit

Available online:
http://xerte.plymouth.ac.uk/play_html5.php?template_id=1018
Video Support Materials Resource
SolidWorks Support

What is SolidWorks?
"SolidWorks is a suite of 3D software tools that let you create, simulate, publish, and manage your data. SolidWorks products are easy to learn and use, and work together to help you design products better, faster, and more cost-effectively. The SolidWorks focus on ease-of-use allows more engineers, designers and other technology professionals than ever before to take advantage of 3D in bringing their designs to life."

(Taken from http://www.solidworks.co.uk/)

Online Support
There are lots of help and support both online but also here on the Plymouth University portal courtesy of academic and professional members of staff.

A large website area of support tutorials and guides can be found here:
- http://www.tech.plymouth.ac.uk/dmmr/cad/SCL_CAD/

How to Download
Information on how to download Solidworks can be seen here:

University Support Person
There is a dedicated support person who can help advise on certain aspects on a variety of software such as Revit, Solidworks and Autocad.

Mr Lee Martin lee.martin@plymouth.ac.uk
Smeaton Building Room 106

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Video Support Materials Resource
Revit Support

What is REVIT?
"Autodesk® Revit® software is specifically built for Building Information Modelling (BIM), empowering design and construction professionals to bring ideas from concept to construction with a coordinated and consistent model-based approach."

(Taken from http://www.autodesk.com)

Online Support
There are lots of help and support both online but also here on the Plymouth University portal courtesy of academic and professional members of staff.

Selections of these are listed below:
- A PDF document containing a list of YouTube Revit tutorials has been put together which we strongly recommend you take the time to view.

How to Download
The following REVIT products are freely available to students to download via the Autodesk website.

Autodesk Revit
Autodesk Revit Architecture
Autodesk Revit MEP
Autodesk Revit Structure

University Support Person
There is a dedicated support person who can help advise on certain aspects on a variety of software such as Revit, Solidworks and Autocad.

Mr Lee Martin lee.martin@plymouth.ac.uk
Smeaton Building Room 106

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**Video Support Materials Resource**

**Windows Live Movie Maker**

**What is Windows Live Movie Maker**
Windows Live Movie Maker is essentially a simple, easy-to-use video editor that helps you put together photos, videos, music and special effects to create an eye-catching presentation in a few easy steps.

This version only works in Windows Vista and Windows 7.

Windows Live Movie Maker is the software that we recommend you use for Windows based editing if you are not used to video editing. It is readily available and free to use.

**Help and Support**
There is a huge range of online help resources as well as help within the software itself. Some key help areas are highlighted below.

**Importing Videos in Windows Live Movie Maker**
Windows Live Movie Maker allows the following video formats to be imported into the software:
- asf, avi, dvr-ms, m1v, mp2, mp2v, mpe, mpeg, mpg, mpeg2, wmv and wmv

To import a video file:
1. Click **File**, and click **Import Media Files**
2. Navigate to where your video file is stored and then click **Import**

A full guide to importing videos can be found on the Windows Movie Maker website.

**Importing Photos in Windows Live Movie Maker**
Windows Live Movie Maker allows the following picture formats to be imported into the software:
- bmp, dib, emf, gif, jif, jpe, jpeg, jpg, png, tif, tiff and wmf

You can easily add images and photos into your video project. In Windows Live Movie Maker go to **Home** tab in the **Add group** and click **Add video and photos.** Then open the folder where your photos are and click **Open**.

**Video Support Materials Resource**

**Final Cut Pro**

**What is Final Cut Pro?**
Final Cut Pro is an Apple based video editing package which is more high-end video editing program than iMovie and is aimed at more experienced users.

**Help and Support**
Whilst Final Cut Pro is more technical, there are a range of online help resources and tutorials that will help you get going. However, as previously mentioned iMovie is the MAC based video editing software that we would recommended for beginners.

Final Cut Pro resources, downloadable guides and video tutorials are available on their website support area.

**How do I access Final Cut Pro?**
Final Cut Pro is quite expensive to buy for personal use, if you do choose to purchase this you can do so via the Apple website Final Cut Pro page.

However, there are a number of MACs on campus that has this installed. For further information on this please visit the PC Access and Location of Specialist Software section of the toolkit.

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Video Support Materials Resource

iMovie Support

What is iMovie?
iMovie is a MAC based video editing software which is also available in a more limited format on the iPad, for the Mac and iOS (iPhone, iPad, iPad mini and iPod touch).

iMovie allows you to import video footage to the Mac either from firewire or from material on your harddrive such as video and photo files. The user can edit the photos and video clips as well as adding in titles, music, and effects to make a professional looking video project.

Help and Support
There are lots of inbuilt help in the software. To access this within iMovie choose Help and then iMovie Help.

Alternatively, there is an online iMovie support area on their website along with a range of online video tutorials.

Where can I access iMovie?
iMovie is unfortunately not available on University machines at present. However, if you have a MAC at home and wish to purchase iMovie you can download it onto your MAC from the Mac App Store for £10.49 each.

For further information visit the iMovie website.

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Video Support Materials Resource

Adobe Premiere Support

What is Adobe Premiere?
Adobe Premiere Pro is a timeline-based video editing software that is used by multimedia professional developers such as the BBC. It is a complex piece of software and only recommended to those that have previous editing experience of the software.

Adobe Premiere is part of the Adobe Creative Suite, which is a suite of graphic design, video editing and web development programs.

Help and Support
Although Premiere is complicated there is a good resource available on the Adobe website including guidance on getting started and what’s new in the latest feature.

There is also a free download manual in .pdf format that you can download.

As with most things, if you search on YouTube there are some good short video guides on specific areas in Premiere.

How can I access Adobe Premiere?
Adobe Premiere isn’t currently available on the University fleet machines. However, it is on the video editing machines in the library which you can book out via the library media counter on ground zero.

For further information on this please visit the 'Where can I book Equipment' page.

You can also download a free 30 day trial from the Adobe website.

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Appendices

Video Support Materials Resource

Where to Book Equipment

We understand that many students may wish to use their own equipment but for those that may not have any or wish to try something new we have some options for you.

As mentioned before it is important to plan any bookings as equipment is based on first come first serve. So please do not leave your booking until the last minute in case you are unable to access anything.

Library Based Cameras

There is a fleet of cameras in the library including 6 non HD cameras and 4 HD cameras that can be that can be hired out to any students as well as tripods and MP3 recorders.

To book the equipment you need to go to Level 0 in the library to the media counter desk. Please try and plan your booking as this is a first come first serve basis.

Video Editing Suite

There is also an editing suite of four high spec video editing machines that can be booked out at the media counter. These machines contain Adobe Premiere which is for the advanced user and again you will need to plan your booking.

Toshiba Camileo BW10 Sportcam

There is a number of handheld Toshiba Camileo BW10 Sportcams that you can hire out that have been purchased within the School of Marine Science and Engineering. These cameras are ideal if you want to do some up close recordings or if you’re out and about on location.

These cameras are similar to Flip Cam’s and export to an .mp4 format and chargeable via a USB cable. A full PDF user guide to these has been created and is downloadable here.

If you wish to hire one out please contact:
Dr Jasper Graham-Jones (Associate Professor in Mechanical and Marine Engineering).
Email: jasper.graham-jones@plymouth.ac.uk

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Video Support Materials Resource

Specialist Software Location and PC Access

We understand that you may need a combination of specialist software and access to faster machines for processing power. Based on student feedback from 2013 this area has been created to give you the most up to date information on where you can access specialist software such as Google Earth and Adobe Premiere as well as locate faster processing machines running 64bit.

Google Earth Pro

Currently available on all Student Systems (approximately 1760 PC’s).

Google Sketchup Pro

Currently available in:
- Brunel W1C
- RLB 211
- RLB 212
- RLB 213

Total of 24 machines.

AutoCAD

Currently available in:
- Babbage 105
- Babbage 106
- Babbage 107
- Brunel 006
- Brunel W1C
- Fitzroy 307
- RLB 201
- RLB 202
- RLB 211
- RLB 213

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Video Support Materials Resource
Managing Time Effectively

We are all busy, we all have to produce lots of assignments, lots of deadlines and almost certainly have lots of other things to do.

If we are going to manage our time we first have to plan it.

That will frequently involve looking at all the things that we have to do and planning to complete all of them – planning one assignment in isolation to all the others is not likely to result in completing them all. Indeed planning all your assignments in isolation from other commitments you have is not likely to result in completing them all either.

There are lots of potential solutions to managing our time – advice commonly includes producing an initial a top level to do list that includes all of the assignments that you have to produce and identifies dates for completion – you should include in this list any other personal commitments which would affect your ability to deliver your assignments.

Listing assignments in order that they have to be delivered might help

Next take an assignment (the first due to be delivered?) from your to do list and produce a gantt chart including the major activities that you have to perform in order to deliver the assignment – include start and finish times for each activity (be realistic in your estimates).

Repeat the exercise for all of the items in your to do list and incorporate the results into a single gantt chart – this makes it much easier to identify all the conflicting demands on your time and then devise a plan to manage them.

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Video Support Materials Resource
Online Storage and Collaboration

What is Dropbox?
Dropbox is a free service that can be used on your PC/MAC/Phone or tablet that lets you save your photos, docs, and videos anywhere and share them easily with friends and family.

Dropbox initially gives the user 2GB but for every successful referral you make to Dropbox that increases by 500MB with a maximum free limit of 18GB

Help and Support with Dropbox
A great overview of the features and help in Dropbox can be seen here.

How can I access Dropbox?
Dropbox can be downloaded here.

What is Box?
Box is another free collaboration tool which allows online sharing of files. Users are given 5GB of space free and can create and share folders and manipulate permissions for sharing purposes in group work.

Help and Support with Box
Help files and information on Box are available on their resource section of the website.

How can I access Box?
Box can be downloaded here.
Appendices

Video Support Materials Resource

Video Conversion

There are various video formatting conversion software out on the market. Below you will see a list of some software you may wish to investigate further. Before installing any free software please bear in mind the following:

- Most try to get you to install web browser search bars and all sorts of add-ons to your browsers you don't actually want!
- Check what your agreeing to in terms of check boxes. They aren't all related to the software,

**Please note the University is not responsible for software downloaded to your PC**

PC Based

Format Factory

Format Factory is a multifunctional media converter.
Provides functions below:
- MP4/3GP/MPEG/AVI/WMV/FLV/SWF
- MP3/WMA/AMR/OGG/OGP/AAC/WAV
- JPG/BMP/PNG/TIFF/ICO/GIF/TGA

Format Factory's Feature:
- 1 support converting all popular video, audio, picture formats to others.
- 2 Repair damaged video and audio file.
- 3 Reducing Multimedia file size.

Download information here...

MAC Based

Handbrake

Handbrake (Mac or PC version) can process most common multimedia files and any DVD or BluRay sources that do not contain.

Video Support Materials Resource

Do's and Don'ts of Filming

Audio Techniques

Audio in a video is just as important (if not more) than the picture and there are a few factors to take into consideration when filming to help create a crisp clear professional video.

Be aware of External Sound

External noise will be picked up in your video unless you’re using an external microphone and even then there is a possibility of noise interference. Try to check your environment in which you’re filming for example:

- Are there cars moving past?
- Are people talking in the background.
- Is there a hum of a PC in the background.

Monitor the Sound

Monitor the sound on your recording, if you can plug headphones in to play back your recording to see how your audio is sounding.

Create a Voice Over

You may wish to record a video and then create a voice over later to talk about something you have filmed. You can do this with an external MP3 recorder (information on where to buy one of these can be found on the booking equipment page) and import as a standalone audio file to your video. Alternatively some PC’s etc. have a good enough mic as part of the machine and the ability to take a USB powered microphone.

Lighting Techniques

Always consider your lighting when you’re recording and take into consideration the environment around you. These simple tips can make a huge difference to your final video.

Shoot with the Light!

Shoot with the light and not against it. If you film with light behind you (i.e. in front of a window, main light or direct sun) your subject will appear dark and difficult to make out.

Of course there are instances where it’s nearly impossible to change the lighting (e.g. filming outdoors with the sun as your light source). If this is the case try filming in different conditions or use reflector boards to send more light into the direction of what your.
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