Can Technology Enhanced Learning improve students' performance and learning experience, as part of a blended learning environment

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Abstract

The use of a blended learning approach to complement traditional face to face learning in higher education is continuing to evolve as an emerging trend. A blended learning teaching pedagogy can enhance the teaching and learning experience of both students and teachers. This study investigates the use of Technology Enhanced Learning (TEL) that supports instruction as part of blended learning approach in the delivery of CadCam. This module is delivered to an undergraduate Mechanical Engineering degree cohort of students in their second year. A mixed methods approach was adopted to gather data and to provide for a holistic evaluation into the effectiveness of using TEL to complement the learning process. The study compared the learning experience of the same group of students over two semesters; semester one used a blended learning approach and the other a traditional learning approach. The study took place over the academic year 2019/2020 and involved fourteen participants. There was no statistical difference in mean overall grades for the cohort of students that used blended learning. Results from this study showed that the average mean grade obtained in semester one was 61.8% using TEL, while the average result obtained in semester two was 66.1% that used traditional face to face instruction. This represents an overall mean average gain of 6.96% over semester one results using traditional teaching methods. Using a two sample Paired T-test (2-tailed) to statistically analyse the results showed that the null hypothesis can be rejected as the probability value (P) =0.1976 >0.05. The difference between the two mean grades are not statistically significant. Therefore, no teaching method can be found to yield better results in students' grades.

However qualitative data obtain during the research revealed that students prefer a blended learning approach instead of traditional face to face instruction. Thematic analysis of the data indicated students' preference to employ a flipped classroom approach as part of the blended learning paradigm. Participants of this study also highlighted that the use of TEL and blended learning should be employed to complement and supplement traditional teaching practices and not to replace them, a view that is consistent with the literature.

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1.1. Overview.

Technology in the classroom has provided both educators and students with new tools to enhance the learning environment. Before the rapid growth of the technology sector, the typical classroom involved the teacher imparting knowledge from the front of the class with the aid of merely an overhead projector, blackboard, and textbooks. Today's classroom involves the use of an intricate web of resources that helps breakdown student learning barriers and allows students to learn at a pace that they are more secure with. The evolution of technology as a teaching aid has changed the face of education by giving educators in Higher Education Institutes (HEI's) the opportunity to explore a wide and varied teaching pedagogy. Technology Enhanced learning can also complement distance learning by making it more accessible to students in different demographics.

Distance learning allows learners to learn at a pace and location that suits them. Most distance learners are in fact mature students who are in full time employment. This delivery mode allows them the opportunity to upskill while still being engaged in the workplace. Companies actively support the personal development and lifelong learning opportunities of their employees and often offer these courses to their employees to help promote their career.

According to the Expert Group on Future Skills Needs (EGFSN) the EU aims to have 15% of 25-64 year old in lifelong learning by 2020 ('EGFSN_lifelong_learning_report' 2016). The report also outlines the current rate of participation in lifelong learning in Ireland is at only 7.3% i.e. 181,000. This value of 7.3% engagement is well below the EU norm and is under half the targeted benchmark of 15%. To achieve these ambitious targets, we must first evaluate our current teaching models and identify how we can make lifelong learning more accessible to greater demographics.

James Morrison (1996) describes how the use of technology, software and being able to connect together with the world wide web eliminates walls and boundaries that would otherwise exist to lifelong learning. The institute of technology where this research has been carried out has responded to this changing learning paradigm and the need to have more options available for both full time and distant learning courses by providing resources to achieve a dynamic and flexible learning model. There are approximately 6000 students currently studying in the college with a mix of both fulltime and part time courses offered. Traditional fulltime engineering courses in the college involve a considerable amount of hands on practical workshops.

In recent years there has been an uptake in the number of students opting to continue their education by distant online learning. The college currently offers more than 140 online courses. A major challenge of the institute was the need for students studying engineering disciplined subjects' access to specialised software and hardware. Current technology available at the time restricted the delivery method of modules to theory-based broadcasts. To achieve their mission statement, in the Engineering and Design department where there is greater influence in practical laboratory work, a solution had to be found. Out of this call the "KITE" project was formed. The KITE project was developed together with Ayr College Scotland and Northern Regional College (NRC), Northern Ireland. The project was partly funded by the EUs European Regional Development Fund. ('KITE project ITSligo' 2011).

The primary goal of the KITE project was to enhance its online programmes by delivering live online training on hardware and software equipment. It also allows online and full time students access to this equipment to further reinforce their knowledge and bridge knowledge gaps ('ITSligo' n.d).

The Connacht Ulster Alliance (CUA) which consists of the following Institutes of Technology, GMIT, IT Sligo and LYIT are actively upskilling staff and colleges in the delivery of education online. The CUA members have received a HEA (Higher Education Authority) funding of €2.84M for Innovative Opportunities Transforming Education (iNote) to further enhance digital resources and flexible learning options into the north west of Ireland ('GMIT' 2019). LYIT is leading the project. Through this funding, the CUA have developed Digital Ed. This is a website designed by GMIT's Learning office to provide support in terms of assisting staff deliver programmes online and flexile options for fulltime delivery and also providing support to staff in pedagogic design. ('Digital Ed' 2020).

Projects like iNOTE and Digital Ed provide the foundations and resources for upskilling current and future staff to deliver flexible course material online. These projects and the use of Technology Enhanced Learning in the classroom is an innovative teaching pedagogy to education delivery, that will help Ireland reach the EU targets for lifelong learning as outlined above.

1.2. **Rationale.**

The researcher was involved in the delivery of a module called CadCam. This is a second year module on the Bachelor of Engineering in Mechanical Engineering programme. The software that is used in this module has a steep learning curve and lately the researcher has found that students have some difficulties adopting with the new software.

The students on this programme have studied Design in their first year of the course. This module involves students' designing various mechanical components using SolidWorks design software. However, in their CadCam modules they are exposed to a new type of software called MasterCam. This is a CadCam software were students' design and model components and then apply machining strategies to produce the component. This software then exports the files for processing on a Computer Numerical Control (CNC) milling machine. This changing of software causes a lot of confusion and frustration for the student as different softwares have different user interfaces.

The researcher observed that students keep trying to revert to Solidworks when trying to design in Mastercam. This is no fault on the student part, as they have gotten a lot of exposure to SolidWorks through the programme in their Design module. In year one they receive three hours per week in both semester one and semester two. In year two and three they receive the same hours again in both semesters. When students present in semester one of their second year to CadCam201 they have already received a minimum of 72 instructed contact hours in class along with additional hours for assignments and exams. This could be as high as 250 hours as each module of Design in year one is worth five credits. Subject credits ('ECTS users' guide' 2019) are part of the European Credit Transfer and Accumulation System (ECTS) and were introduced as part the Bologna process (1999). Under the Bologna process, for each five-credit module a total of 125 hours of combined learning effort should take place. Table 1 shows the breakdown of hours for the Design module in year one of the course.

Table 1: Breakdown of hours in Design year one.

Subject	No. Credits	Year	Semester	Software Package	Hrs/wk.	WK's/Sem	Instructed Hr's/Sem	Total combined effort (Hr's)
Design 101	5	1	Sem 1	SolidWorks	3	12	36	125
Design 102	5	1	Sem 2	SolidWorks	3	12	36	125
				Total	6	24	72	250

With this level of learning that has already taken place it is easy to see how students can become confused and distracted when attempting to learn another Cad based software package.

My research study is centred on helping students in their CadCam module with their learning needs and to evaluate if Technology Enhanced Learning can improve students' performance and learning experience, as part of a blended learning environment.

1.3. Organisation of the Thesis

Section two of the thesis reviews the relevant literature in Technology Enhanced Learning and learning theories. It also provides a context for the research undertaken in this study.

Section three gives a detailed account of the implementation of the research. This includes the methodology for conducting the research, research techniques and the tools used to evaluate the data.

Chapter Four Analysis the results from the research data. Conclusions and recommendations for further study is also discussed.

2. Section Two: Literature Review

2.1. Introduction.

This chapter examines the relevant literature surrounding the areas of digital learning and the learning theories that are present in current teaching models. The literature review will establish a firm foundation for this investigation. According the Webster and Watson (2002) the literature review should not be a focused to one geographic location or one demographic but instead be sufficiently wide enough to capture a holistic review of the subject matter.

To be able to effectively evaluate the role that Technology enhanced learning has as part of a blended learning pedagogy, it is necessary to review the relevant literature surrounding the area of learning theories and blended learning. This will allow the researcher to establish if this new mode of learning interlinks with the existing theories. The researcher also investigates the role of Connectivism and how it impacts the way we connect with each other in the digital age. Connectivism is a theoretical framework underpinning digital learning and technology.

In this chapter also reviewed is the literature surrounding Technology enhanced learning that will form a context to this research study and to build on current trends that exist. A critique of the literature in this area is also documented to see if there are studies that do not support the use of TEL.

2.2. Learning Theories

To design an effective course that engages with the student and is both functional and meets the learning outcomes for a module it is necessary to have a thorough understanding of how our students learn. Learning theories are studies on the psychology learning effect and how students learn. They identify the key modes of learning and examine how students extract information from these learning environments. There is no singular learning theory that is universally accepted among the scholars (Shuell 1986). Learning theories is not a new concept, in fact it has existed for quite some time. According to Illeris (2018), learning theories were developed largely independent from one another and focused on languages and geographical location.

Behaviourist learning theory

Behaviourism learning theory is a psychology approach to learning whereby the learner interacts with their environment and focuses on observable and measurable behaviour rather than emotional behaviours. The behaviourist learning theory was pioneered by Watson (1913) that identified how learning interacts with their environment. Prior to Watson, early research into this field was carried out by Pavlov (1902) with his experiments of classical conditioning of his dogs and how they reacted to a stimulus of ringing a bell at food time which produced salivation in the animal. Watson went on to develop this theory further and adopted to the study of humans.

Skinner (1936) scaffolded on earlier work of Pavlov and Watson and developed the theory of Operant conditioning. This form of conditioning differs to that of Pavlov whereby the operant uses rewards or punishment to direct behaviour.

The Behaviourist learning theory has a big impact on the learning environment. A classroom setting must have an environment that is indicative to learning. Teachers should make the learning environment calm and relaxed. Teachers also offer rewards and punishments that helps stimulate the learning environment. The main drawbacks with this type of learning model is that it is seen as been very rigid in its structure. The teacher is seen to be at the centre of the learning which is contradictory to other models which suggest that student centred learning helps breaks down learning obstacles and is personalized as it addresses the various and often complex learning needs of individual student's (Seng 2014).This Teaching philosophy is focussed on the student-centred pedagogical approach to learning, teaching and assessment. The corner stone to this approach is the shift to active learning rather than the traditional passive learning model (Lea *et al.* 2003).

Cognitivism learning theory

Cognitive learning theory describes how new knowledge is learned by reflecting on prior experience and knowledge. The learning theory is credited to Piaget (1936) who suggested that learning takes place by making sense of new information and relating it to prior knowledge. The theory focuses on the thought process whereby learning builds on existing information. This is the opposite to the behaviourist learning theory that is only focused on observable behaviour that is directly measurable and not based on internal motivation factors. Cognitive learning allows learners to examine new knowledge by reflecting on past experiences (Jackson 2009). According to Ashworth *et al.* (2004) cognitivist psychology has had a large effect on higher education. It has allowed for more freedom in course design and assessment strategies.

The main criticism of the cognitive learning psychology is that it cannot be measured directly as it relies on the learners own thought process and relates to past experiences and prior knowledge. Another area for criticism is that Piaget disagreed with Watson's Behaviourist learning theory in that the learners are only influenced by their surroundings and not influenced by intrapersonal knowledge.

With the use of technology in the classroom, this provides great opportunities to both the educator and the student. This is backed up by the cognitive learning theory of multimedia in which "people learn more deeply from words and pictures than from words alone"(Mayer 2005, p.47).

Constructivism learning theory

Constructivists believe that new knowledge is constructed from their own personal experiences rather than through a process of merely memorization (Bates 2015). The main theorists behind this learning theory include, John Dewey (1859 – 1952, Lev Semyonovich Vygotsky (1896 – 1943) Jean Piaget (1896 – 1980) and Jerome Seymour Bruner (1915 – 2016) ('Constructivism' 2015). Dewey is often regarded as the founder of the modern day constructivism approach, while Bruner and Piaget are cited as being the main theorists while Vygotsky was the main social constructivist ('UCD - CTAG' 2020). Constructivist learning is a very personal experience whereby the learning takes place by relating new information to existing knowledge in a process of reflection. Constructivism learning theory is 'an approach to learning that holds that people actively construct or make their own knowledge and that reality is determined by

the experiences of the learner" (Elliott *et al.* 2000, p.256). According to Brown and King (2000), constructivism learning examples in our education system include Problem-based learning, Apprenticeships and Reciprocal teaching methods.

According to Gilakjani *et al.* (2013) there is a positive relationship between technology in the classroom and a constructivist learning model. They also suggest that both technology and constructivist learning can complement each process. a constructivist learning environment is more student cantered and collaborative (Wilson 1995).

Constructive Alignment

Constructive alignment is a teaching pedagogy whereby the students' should be given a clear and concise roadmap of the learning outcomes for a module and how the assessments will relate to these outcomes (Biggs 1999). This give the student a clear overview of the learning that will take place and how all the assessments dovetail together to assess the required learning outcomes. Constructive alignment has two primary main components. The first of the components relates to the constructive alignment of the module and how students must construct meanings through learning activities. New knowledge is learned by relating, building, and reflecting on existing knowledge. The second component to the learning theory relates to the teacher or more importantly how the teacher relates the learning activities and links them to the desired outcomes for the module. (Biggs 2003) . When a teacher aligns their learning activities "a web of consistency optimising the likelihood that they will engage in appropriate learning activities" (Biggs 1999, p.26). This alignment is referred to as the 'Golden Triangle' as seen in Figure 1.
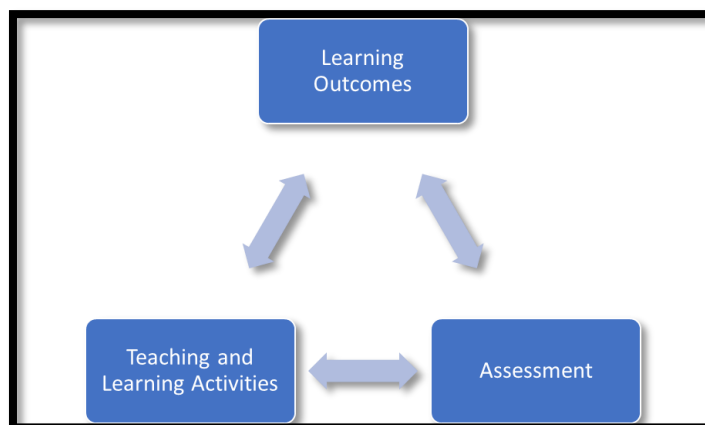

Figure 1: Constructive Alignment

Humanism learning theory

Humanism learning theory is a learning paradigm that originated in the 1960's. It was developed in contrast to Behaviourism learning theory and Operant conditioning as it was felt that there were limitations to this psychology as it did not address the human experience to learning. (Augustus 2015). According to Hunt (2001), the key values of humanism is that people act with intent and with their values. People should be viewed holistically as the sum of all our parts as opposed to single traits such as behaviour. Key theorist is this area include Carl Rodgers (1902 – 1987) and Abraham Maslow (1908 – 1970).

Maslow (1943) identified the five hierarchically needs as shown in Figure 2. This tier model identifies that people are motivated to achieve certain needs. All humans have a desire and motivation to achieve certain needs. Examples of this include students studying to get their degree. The motivational needs include self-fulfilment by bettering oneself and ultimately being more employable. The humanist perspective on learning involves the student being self-aware of their ultimate goals. Tuijnman and van der Kaffip (1992) notes that adult learners are more motivated to learn when the learning activities are relevant to their needs. This finding is also backed up by Woodbyrne and Yung (1998) who also noted that mature students have stronger motivation over younger students who enter higher education.
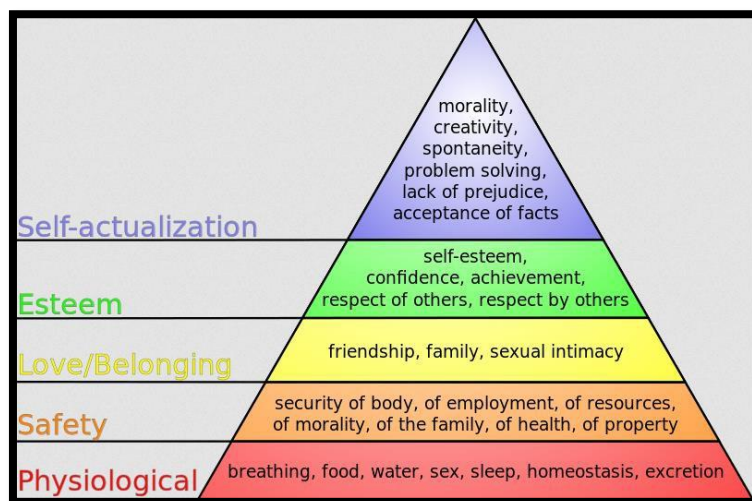
Source:(Finkelstein 2006)

Figure 2: Maslow's hierarchy of needs

Social learning theory

Social learning theory describes the significance of observing the actions and attitudes and learning from the behaviours of others. It describes the learning that takes place due to social interactions and the observing and imitating of others. Albert Bandura, (1925 – present) is considered the father of this type of observation and learning psychological and developed the Social Learning Theory (1977). Social learning theory has a major impact on how educators design their curriculum that helps integrate this learning paradigm. According to the Education Corner, ('Social Learning Theory' 2020) the flipped classroom in one method that can be integrated into the curriculum design to increase the level of Social Learning in the classroom. With learning material assigned to be completed outside of the classroom, this frees up valuable time in the classroom for higher level thinking activities and replicating what has been learned outside of class. Further reinforcing knowledge that has been learned. These finding align with the findings of this study, were the participants suggested that future recommendations for a blended learning paradigm should include a flipped classroom approach. The Education Corner also suggest that there should also be greater emphasis on peer learning as students develop key skills such as leadership, coaching, motivation, and confidence in themselves. It also allows students to replicate knowledge learned by assisting their peers.

Learning theories and blended learning approach

An understanding of the learning theories is pivotal in developing meaningful TEL tools in the classroom. Learning theories provide the foundations and underpin the fundamental modes that students engage and process new knowledge. No one learning theory accurately describes the complex thought and learning process of students. Instead it is an intricate web of all learning theories and styles combined, as present-day students come from various demographics and all have individual learning styles.

Today's classroom must cater for all learning styles to actively engage with students and to promote higher level thinking graduates. Traditional face to face instruction favours certain learning styles while a blended learning approach has the benefit of being able to cater for all learning styles (Laine *et al.* 2015). Blended learning offers educators a greater degree of flexibility in course design that allows them to be able to target students individual learning needs and support them more directly (Gulc 2006). A major benefit to that of blended learning

is that it is an extension of the classroom by using technology to enhance the learning and can therefore cater for all learning styles.

It may be difficult to implement key learning theories, when using an online teaching model. Most notably Humanism learning theory, especially when dealing with young adult learners as they often lack the self-discipline, self-motivation, self-actualisation, and determination to be able to commit to fully online programmes. This view is also supported by the University of Illinois Springfield ('Strengths and Weaknesses of Online Learning' 2020) who identify that while online course delivery can be highly beneficial for adult learners, it is not an appropriate teaching pedagogy for dependant or young learners as they often lack the necessary drive to engage with the material.

Social learning theory is another key learning theory that requires great care to implement and to design into the curriculum. Many online learning platforms attempt to often mimic this important learning theory by incorporating virtual classrooms and online communities and various collaborative tools to get the balance right while also helping with social interaction between students. Online learning itself can be viewed as social learning as the students are observing either synchronous or asynchronous online material and imitating the content. However, another element of social learning theory can involve the tangible social interaction experience that students obtain from a classroom setting that is obsolete from the online learning model.

The participants of this study were asked to reflect on their experience of using technology in the classroom as part of a blended learning model. Students' commended the use of a blended learning model, stating that this is the correct mix of face to face teaching and use of online delivery methods. As this study also took place during the Covid19 pandemic, late in the semester all classes were transitioned to online mode of delivery. The participants had time to reflect on online learning, stating that it was not the preferred mode of delivery that they would choose. They noted that they missed the social presence of the classroom and commented that it helps break down leaning barriers. The participants highlighted that blended learning should be used to complement and support their other modules in their course but stressed that it should not replace the traditional mode of delivery. This feedback from the participants aligns with the current literature and further highlights that great care and research should be taken when developing course design and delivery mechanisms. The classroom plays a significant role in the teaching and learning paradigm as it produces an environment that is indicative to learning.

2.3. Technology Enhanced Learning

Personal computing devices are now more common than before with students. Computing devices have become very powerful is the last 20 years and according to Moore's Law (cited in R. R. Schaller 1997), the processing power of computers will double every two years. These devices are now getting very powerful and portable, with smart phones being the market leader in all phones purchased today in Ireland ('Statista' 2018). This trend is set to continue with smart phones expected to have a market share of 78.59% by the year 2022. The result of this is that students now have vast amounts of information available to them in the form of both mobile and personal computing devices. This technology has changed the education model and how students' access learning material.

With technology developing at a rapid pace it is important that all facilitators of education adapt to the change and put in place measures to ensure that their classroom reflects current and latest trends in teaching pedagogy.

There has been extensive research carried out in relation to TEL. Schmid *et al.* (2014) identifies that the use of technology in the classroom can have an overall positive effect on the learning environment. This view is also echoed by Tamim *et al.* (2011). Kirkwood and Price (2013) highlighted three types of TEL interventions. Type one is simply replacing ones existing practices with TEL. the next style of intervention focuses on supplementing one's current practices with the latest technology while the final type of intervention involves transforming one's current teaching practice.

Carrington's pedagogy wheel (2016) is a valuable tool for aligning the latest apps available on both iOS and Android platforms with specific learning outcomes. The pedagogy wheel that gives the educator an up to date visual aid so that they can quickly identify useful applications that will complement their learning environment.

Atherton's (2018) book, 50 Ways to Use Technology Enhanced Learning in the Classroom, highlights the latest trends in TEL and it gives practical examples of how to use TEL in the classroom.

Blended Learning.

As technology has become more accessible for students' there is increasing research into how this technology can complement the learning process. This technology can form part of a blended learning teaching pedagogy. Blended learning is a teaching methodology that employs different technologies, techniques, and methods to enhance the overall learning environment. Graham (2006) suggests that the term "Blended Learning" can be quite vague. The most widely accepted definition of the term of Blended Learning (BL) is a mixture of traditional face to face learning together with technology assist (Graham *et al.* 2003). According to Poon (2013) the main benefit of blended learning is that it provides for greater flexibility in the course design and it gives the student access to course material away from the classroom. It allows the student to learn at a pace that suits their learning style.

Reusable Learning Object (RLO).

Reusable Learning Objects (RLO) are a teaching resource that teachers use to assist with the delivery of their curriculum. It is usually digital, and web based which gives students' ease of access. RLOs are instructional and involves breaking down material into sizable chunks that can be reused. The main benefit of RLOs is that they give greater flexibility to the student in terms studying and portable access to material. (Wharrad and Windle 2010). These learning resources should be developed to support the principle of Constructive Alignment (Biggs 1999, cited in O'Neill *et al.* 2005). This model promotes greater cohesion in mapping learning outcomes with content material. A study conducted by Windle *et al.* (2010) to determine the effectiveness of using RLOs highlighted a significant improvement in results over a traditional teaching pedagogy. One of the key advantages of using the RLOs was that students were able to learn at a pace that was more suited to their learning style.

There are different models for implementing RLOs into a course. These range from integrated videos for teaching core elements to additional resource material that complement the learning. Early adopters of RLOs were designed as a vehicle to only give feedback (Sridharan *et al.* 2010). Since then RLOs have grown organically and have developed into an on-demand teaching resource (Gee *et al.* 2014).

Connectivism

The origins of Behaviourist, Constructivist Cognitivism and Humanism learning theories have been around for quite a considerable amount of time. Since the conceptualization of these theories, there has been far reaching advances in the way we access information, both new and existing. The most notable change is the readily available technology. These overarching learning paradigms fail to address this new era. Connectivism is a new learning theory concept that bridges the gap with our original learning theories and digital communication (Siemens 2004). He suggests that the internet and associated connected technologies have created new learning opportunities with the access to the world wide web. According to Vaill (1996), learning must keep in pace with new events.

Connectivism is networked social learning. A key element of this learning theory is that much of the learning takes place online. Students can form peer communities as part of their class or connect with much larger communities that allows for the sharing of knowledge. Online communities such as Forums and Bloggs have become a large source of information both formal and informal. Siemens (2005) suggests that the connectivism learning model complements society changes. He also suggests that learning is no more an individualistic activity but part of an interconnected web of information.

Massive Open Online Course (MOOC)

The Massive Open Online Course (MOOC) are free online courses that are available online to everyone who wants to learn a desired topic. This is an example of the connectivism theory where information is readily available online between social communities. MOOCs use free open source software systems for the delivery of their courses. Traditional online courses generally consist of tuition fees and the awarding of credits ('ECTS users' guide' 2019) that go towards the awarding of programmes. MOOCs on the other hand are generally free and many are credit less while some offer professional recognition. (Pappano 2012). "A MOOC builds on the active engagement of several hundred to several thousand students who self-organize their participation according to learning goals, prior knowledge and skills, and common interests" (McAuley *et al.* 2010, p.5).

The major benefits that MOOCs offer, is great flexibility to study at a time and place that suits the students' needs and making education more accessible to disenfranchised groups of

students. A key finding from a study on the first ever delivered MOOC in Massachusetts's Institute of Technology (MIT) noted that students who collaborated offline with another student had on average scored three points higher than a student who studied alone (Breslow *et al.* 2013). They also noted that "… it reflects what we know about on-campus instruction: that collaborating with another person, whether novice or expert, strengthens learning." (Breslow *et al.* 2013, p.20).

2.4. Critics of Technology in Education.

While the literature point's to the clear benefits of using technology to augment learning, there are some critics to this new model of learning ('15 Disadvantages of Technology in Education' 2015). There are numerous potential issues identified that the use of technology poses on today's student. Table 2 gives an overview of the main concerns and issues with using Technology as part of the teaching and learning pedagogy.

Table 2: Critics of Technology in Education

Problem	Reason
Expenditures.	Put's an eminence financial burden on both the college and the student.
Teaching pedagogy.	Due to the pressures placed on teachers to adopt to the changes in technology, they are not receiving adequate training using some of these technologies.
Time management.	Relying solely on computers for teaching fosters poor study habits. Students surf the internet to find the shortest way to answer problems.
Incompatible software.	Problems with software / computers to slow for the task can cause frustration and wasted time.
Mis information.	A lot of mis information is on the internet. Students need to be educated on how to source factful reliable information.
Source of distraction.	Social networking sites provide for major sources of distraction form course work.

Cheating and plagiarism.	Plagiarism and cheating are major issues surrounding the use of technology. Students can simply copy entire assignments with the click of a button.
Online cyber bullying.	Due to the increased possession of both mobile and personal computing devices, cyber bulling has become a major issue especially for vulnerable groups.
Performance and presentation skills.	Overuse of digital communication tools causes learners to lose core skills such as vocal and presentation skills.
Challenges for the teachers.	With software being continuously updated, and trying to keep with the latest trends, this can put pressure on teachers to keep pace with these changes.
Loss of digital material.	If students are not vigilant at backing up their work periodically, lots of data can be lost if a computer should malfunction. This is becoming less of a problem nowadays with greater access to cloud data storage facilities.
Online course motivation.	Study online requires a lot of motivation and self-direction. Students studying solely online are disadvantaged from students in traditional education. Bandura's Social Learning Theory (1977) recognised that people acquire knowledge by observation of one another, something that is missing from online learning.
Handwriting techniques.	There is now less importance on handwriting skills. The main emphases are on soft skills such as word formatting and PowerPoint.
Low to mid income groups.	Low income demographics are particularly vulnerable to the digital age as the burden of purchasing personal computing devices can put a measurable strain on these groups. The average price for a pc worldwide €573 ('Average computer price 2019' 2019).
E-books	The use of e-books does not suit every learning style. According to Kang *et al.*(2009) reading e-books caused greater eye fatigue compared to traditional books. They also noted that the reader of a traditional book had a greater comprehension of the material.

While there are numerous critics of the use of TEL in education, they only address surface problems with its implementation. When addressing the issues faced by the adoption of TEL in education University Home Work Help ('15 Disadvantages of Technology in Education' 2015) fail to address the fundamental learning theories and learning styles associated with TEL in education. Instead they focus on the superficial aspects associated with its adoption such as access to the technology and costs associated with it. While these points are relevant and do need to be considered before designing technology into the classroom, further evaluation of the benefits need to be explored. According to Hicks (2011) some members of the education community fail to realise the merits of this approach.

Ferrell and Ferrell (2002) suggest that the advantages to learning that are to be gained from the integration of technology in the classroom outweigh any disadvantages or limitations it causes. "It is imperative that we as teachers be supportive of new technology and work to integrate meaningful technology into the curriculum" (Hicks 2011, p.190).

According to the 2020 Educause report on Teaching and Learning (O'Brien 2020), there will be significant new technological trends for education in the future. The research has identified new trends in Artificial Intelligence and how it will impact on teaching and learning. The report reveals that artificial intelligence will play a significant role in future technology in the classroom. It can assist educators with student feedback and to assist students with disabilities. Artificial Intelligence also can help breakdown language barriers. Amazon is one company that is developing artificial intelligence that can be integrated in the curriculum ('Alexa in Education' 2020). Students can access critical information on demand and allows for deeper learning for students. This is a new emerging trend that is already be integrated into several higher education colleges with the trend set to continue.

2.5. Conclusion

In recent times, technology has become ever more prevalent in higher education establishments. With the increased processing power of computers, this has opened the potential for software developers to develop novel applications that can assist the classroom and make the learning experience more personalised for the students. With a wider take up of technology in the classroom many scholars suggest that this will lead to more Constructive Learning taking place (Bransford *et al.* 1999). According to Volman (2005), this shift in

learning paradigm will have an impact on the role of teachers. Teachers will support, coach, and facilitate students instead of the traditional method of broadcasting knowledge.

While there are some critics of the role of technology in education, there are clear benefits to implementing this teaching pedagogy into the curriculum. According to Donnelly & O'Rourke (2007), the use of technologies is an important challenge for teachers. They also point out that without adequate training, teachers will not be able to utilize these tools to their full advantage. According to O'Donnell and Sharp (2012), the results of a survey of over three hundred students indicated that they view technologies in education as beneficial to the teaching and learning environment. The results of the survey also revealed the while technology augments the learning process in education it will never replace the teacher who is vital to the teaching pedagogy. Sridharan et al.(2010) suggests that effective e-learning is a mixture of traditional face to face learning complemented by technology enhanced learning. Technology enhanced learning will continue to evolve with more educational establishments realising its benefits to students and educators. With the evolution of artificial intelligence, this has provided both students and educators with a new vehicle that can not only assist in the classroom but also has the potential to assist students with disabilities and students with different languages. Artificial Intelligence technology can provide a more personal learning experience for students' and can help breakdown learning barriers.

In this chapter a comprehensive review of the literature surrounding the area of technology enhanced learning and the associated learning theories that form the foundation of educational paradigm has been researched. To answer the research question, can Technology Enhanced Learning improve students' performance and learning experience, as part of a blended learning environment, extensive research on the current practice that exists in this field and critics of technology has been conducted. This research has given the researcher an overview of the current trends and potential limitations to the successful adoption and integration of technology in the classroom environment. Chapter three discusses the methodology used in the implementation and data analysis of the research study.

3. Section Three: Implementation and Evaluation

3.1.Introduction

Babbie (1998) defines research as a systematic process used to explain, predict and describe an observed phenomenon. It is a process of analysis to advance knowledge in a specified subject field. Hargreaves (1997) suggests that research in the context for that of teachers should provide guidance and evidence to teachers of what teaching pedagogy they should adopt and the merits of the approach.

The primary aim of carrying out research for this study was to evaluate the research question, can Technology Enhanced Learning improve students' performance and learning experience, as part of a blended learning environment? This research will provide relevant information for the use of technology in the classroom and will be used as a foundation to build and scaffold further interventions to improve the teaching and learning in the classroom. This will allow the researcher to hone and sharpen their learning environment and to provide a more holistic learning experience that will engage with students and remove learning obstacles.

In this section the researcher provides an insight into the objectives of the research study and methodology used during the implementation of the study. A detail analysis of the research techniques and analysis is discussed including data analysis and data collection methods.

3.2. Introduction to the research design

The research study consisted of evaluating the effectiveness of using Technology Enhanced Learning as part of a blended learning approach in the classroom. The research was based on a group of fourteen students who were studying in their second year of a Bachelor of Engineering degree in Mechanical Engineering. Students' performance was compared over two semesters. The module that this study was based on is CadCam 201 (semester one) and CadCam 202 (semester two). CadCam 202 is a follow on from CadCam 201 and builds directly from it and is ideal for comparing two different teaching and delivery models. In CadCam 201 the researcher used TEL to support the learning while in CadCam 202 traditional teaching methods were used. The study involved creating supporting learning material for the students in semester one in the form of recorded instructional videos and comparing their mean grades in

semester two that employs traditional face to face instruction. The researcher also gathered both qualitative and quantitative data to evaluate the learning experience associated with TEL.

The research study took place over the academic year 2019/2020. During the second semester the Covid19 pandemic struck which had a profound effect on the delivery of all education in Ireland. As a result of this all education establishments had to deliver their course content online with no access to the campus permitted to students. All schools and colleges were closed from 12th March 2020 ('Covid-19' 2020) and remained closed for the remainder of the term.

The hours allocated to the module in semester two were two hours per week for the duration of the semester. The researcher opted to deliver the module three hours per week over a period of eight weeks to provide additional in class time for students in setting up the CNC machines and manufacturing their components. Table 3 shows a breakdown of the scheduled delivery and the actual delivery of the module.

Table 3: Module delivery schedule

Delivery	Subject	Year	Semester	Hrs/wk.	WK's/Sem	Instructed Hr's/Sem
Scheduled delivery	CadCam 202	2	Sem 2	2	12	24
Actual delivery	CadCam 202	2	Sem 2	3	8	24

This revised delivery schedule was very fortunate for the researcher, as by the time the college closed due the Covid19 pandemic on the 12th March 2020, all the module contact hours had been delivered and all learning outcomes met. Table 4 shows the delivery timeline schedule Gantt chart for the CadCam 202 in semester two.

Table 4: Module delivery timeline

Activity	Wk	January 22/01/2020	29/01/2020	February 05/02/2020	12/02/2020	19/02/2020	26/02/2020	March 04/03/2020	11/03/2020	18/03/2020	25/03/2020	01/04/2020	April 08/04/2020	15/04/2020	22/04/2020
		1	2	3	4	5	6	7	8	9	10	11	Easter Break		12
Scheduled delivery		■	■	■	■	■	■	■	■	■	■	■			■
Actual delivery		■	■	■	■	■	■	■	■						

This research project was conducted using asynchronous instructional recorded videos that replicate in class material and bridge knowledge gaps to answer the research question 'can Technology Enhanced Learning can improve students' performance and learning experience, as part of a blended learning environment'.

Questionnaires and interviews were used to gather data and both qualitative and quantitative tools were used to thoroughly analyse the data. The data was correlated and graphed to highlight any trends / performance markers that exist.

Student interviews were done at the end of the study to capture the students' perception, feelings, and experience of the intervention. Thematic analysis approach was used to uncover themes that were present in the data.

3.3. Technologies used in the Research

The primary aim of this study was to evaluate the research question, can Technology Enhanced Learning improve students' performance and learning experience, as part of a blended learning environment? This study involved creating supporting learning material in the form of RLOs. In semester one students were given additional learning support in the form of RLOs that allowed the students to bridge gaps in their knowledge outside of class time while in semester two, traditional face to face instruction was used. The experiences and performances of the students was gathered to evaluate the effectiveness of TEL as a blended learning approach. The integration of TEL into a blended learning approach to teaching involved the use of a range of

technologies and software packages. The technology that was used for this study both directly and indirectly included that following Panopto, GoToMyPC and MasterCam.

Panopto

To record RLOs a screencast type application software called Panopto was used. This software was chosen as it was readily available in the higher education institute where the research took place. This software is used to deliver asynchronous recorded lectures. A key feature of using Panopto screencast software is the ability to store the recordings on the cloud. This provided for greater flexibility for sharing the recordings. This feature provides for the sharing of a link that allows the student to stream the recording directly form the cloud without the need to download the file. Student are also provided with the option to be able to download it to their personal computing device thereby allowing the student to view the recordings while offline. Other screencast software that was investigated for this study did not have this option available and therefore did not provide the flexibility as aforementioned. Figure 3 shows an example of an exercise to be recorded and Figure 4 shows a recording of the exercise using Panopto software.
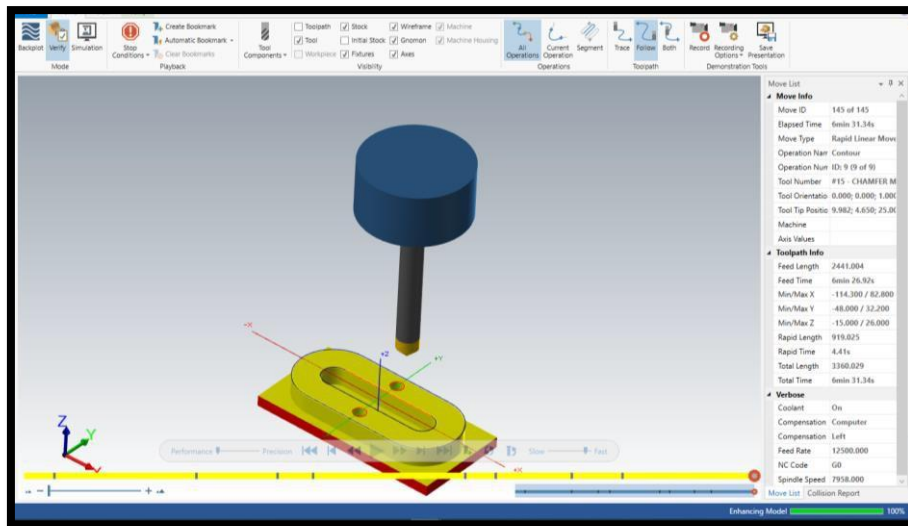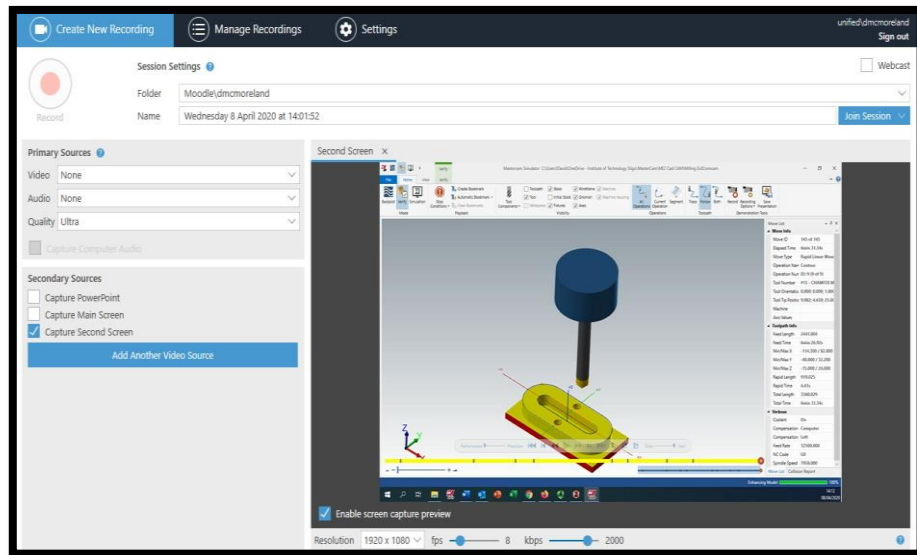

Figure 3: Application to be recorded

Figure 4: Application being recorded using Panopto

Virtual Learning Environment (VLE)

The RLOs were developed and made available to the students using a Virtual Learning Environment (VLE). VLEs are a digital online vehicle for the delivery of course material. These learning environments provide for great flexibility in course design and give the educator the tools and resources to personalise their learning environment. ('MoodleDocs' 2020). VLEs provide a repository for course information and material that includes Notes, Presentations RLOs to name but a few. The Higher Education Institute (HEI) where the study was carried out employs Moodle as their VLE software. Moodle provides an easy to use virtual platform that allows the lecturer to structure the course content that relates to the module and related RLOs. Figure 5 shows how the course was structured with the exercises to be completed and the accompanying RLOs related to each exercise.
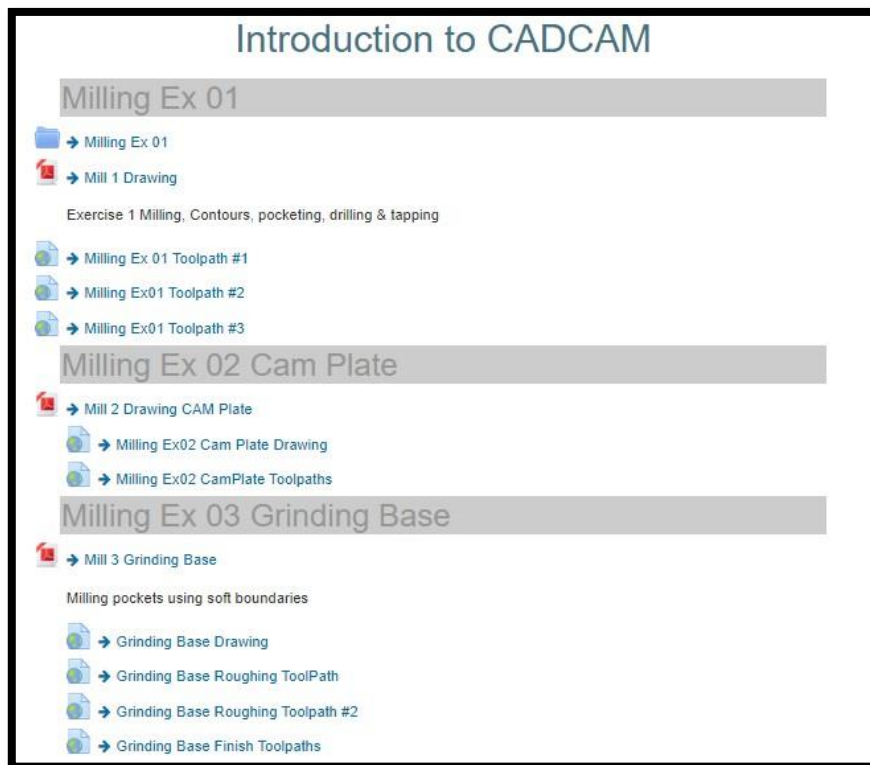
Figure 5: Moodle page layout

Remote Access to software

GoToMyPC is a computer application that allows users to remotely access pcs that has the application installed ('GoToMyPC Remote Access' 2020). This application brings the user to a virtual rack of pcs that are located on a server within the institute. Students are presented with a list of available pcs Figure 6 and they can connect to them using their student logon credentials. As seen in in the list, some pcs are unavailable when connecting. This is due to another student being remotely connected to the pc. The system also has the ability to connect to pcs in the classroom. This functionality provides greater flexibility in course design and is also the vehicle for how the remote online class take place. Cad classes for example that are delivered fully online, students connect remotely to the pcs that are present in classroom. The lecturer is then able to deliver his / her class in a similar format to that of a full time class. The lecturer has the ability to navigate the classroom and be able to see what the students are doing while also being able to talk to them.

The ability to remotely access the colleges pcs using a personal computer with an internet connection was significant in the evaluation of this study. This give students the availability to access the necessary software and hardware that was being used in the lab remotely and at a time and place that suited the user. This removes the burden on students on having to purchase any additional software or expensive computing devices that would be capable of running MasterCam as it requires a pc with a minimum hardware configuration.

Figure 6: Connecting to Rack pcs using GoToMyPC

3.4. Site Selection

The primary research site for this study took place in an Institute of Technology in the northwest of Ireland. The college originally started as a Regional Technical college (RTC) in 1970. In 1997 the college changed its name from RTC to an Institute of Technology. More recently the college is part of a consortium bid to amalgamate together with other Institutes of Technology in the west and north west of Ireland to be rebranded as part of the Connacht Ulster Alliance (CUA) ('Connacht-Ulster Alliance' 2020). In this time, it has provided fulltime and part time education for over fifty years. There are approximately 6000 students currently studying in the college with a mix of both fulltime and part time courses offered by the college.
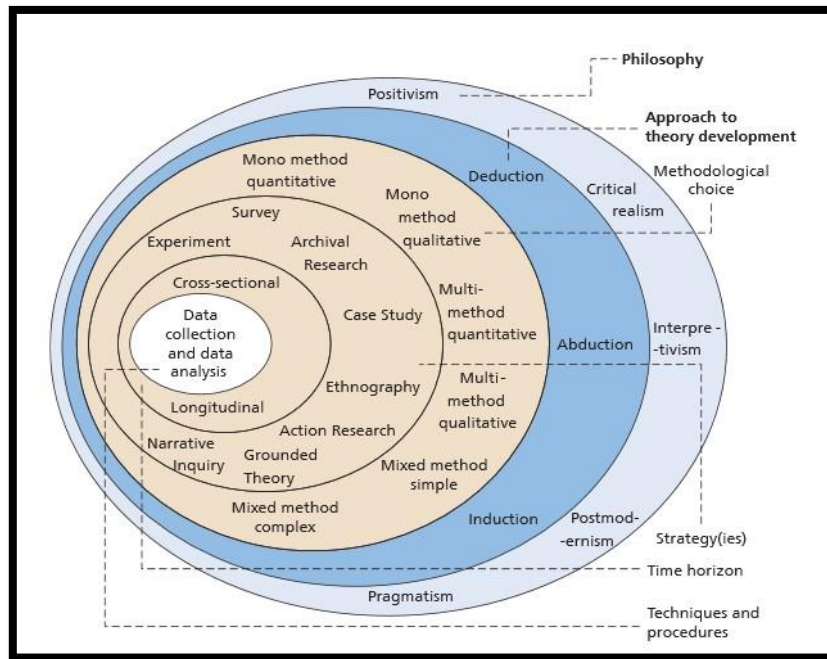
3.5. Participant Selection

All participants in this study are fulltime students' that in their second year studying for a Bachelor of Engineering in Mechanical Engineering in the faculty of Mechanical and Manufacturing Engineering. The study was performed over the course of the 2019/2020 academic year. The selection criteria for this study was to select a current module that was being taught to undergraduate engineers and to identify various methods to enhance the learning experience for the students while also making it more student centred. The primary reason for selecting this group of students was due to the fact that this was a new subject for them in terms of software exposure. This module builds upon knowledge gained in another module that is delivered in both the first and second year of the programme, "Manufacturing and Engineering Technology". This module exposes students to the fundamentals of subtractive manufacturing, giving the students hands on experience with an array of metal working machinery. The CadCam module endeavours to link this theory together with highly sophisticated CadCam software for the programming of CNC 3-aixis milling machines. The class consisted of sixteen students. All students were eligible to participate in this study however two students declined to participate. This represented a reduced capacity of 12.5%. This study included two female participants which represented 14.29% of the total participants.

3.6. Research Methodology

"Research philosophy refers to a system of beliefs and assumptions about the development of knowledge" (Saunders et al. 2019, p.130). The researcher adopted an approach to determine the research methodology for the study as proposed by Saunders research onion (Saunders *et al.* 2019), Source: Saunders et al. 2019

Figure 7. The research onion is a metaphor tool that gives guidance and direction allows to the researcher by stripping away the layers the research. In this approach it gives the researcher a paradigm on how to develop the research process.

Figure 7: Research Onion.

3.7. Data Collection and Timeline.

Data was gathered out using both Quantitative and Qualitative data collection methods. These research method tools allowed for a thorough holistic evaluation of the study. Qualitative research methods allowed the researcher to capture the participants individual experiences throughout the study and it also provided a vehicle to capture feedback and recommendations of the study. Qualitative research methods was also used to capture participants feelings, beliefs and attitudes (Pathak *et al.* 2013), something that is impossible to capture using quantitative methods alone. Figure 8 shows the data collection timeline over the duration of the study. Quantitative data was gathered in semester one that used TEL to augment the learning and in semester two that used traditional face to face instruction. The online survey which captured both qualitative and quantitative data of the students' experience was opened after completing their final class on the 11th March and remained opened until the 20th of May. The online interview took place on the 18th and 20th May respectively as not to impede with the students' exams in their other modules.

Figure 8: Data Collection Timeline

Quantitative Methods

According to Kruger (2003), Quantitative methods is useful for analysing large amounts of data. Aliaga and Gunderson (2002) describe quantitative research as collecting data that can be later analysed using statistical methods. Data can easily be compared, and comparisons made using software such as Microsoft Excel.

Data was collected using an online participant survey questionnaire, Appendix D – Participant Online End Of Year Survey Questionnaire. at the end of semester two. This survey provided mostly quantitative data relating to the effectiveness of the intervention and contained some qualitative data collection methods by way of open-ended questions. Participation in this survey was anonymous and was made up of ten questions. Students' had access to this survey online and it was made available using Microsoft Forms.

When designing the survey questions, it was important that the questions only ask questions that related to the study so that they only capture information that relates to the study. To ensure that the information sought was relevant, the survey was pre-tested amongst peer colleagues. A Likert scale was used to gather the respondent's answers to the questions. All questions were designed to accomplish three goals, It measures what it is intended to measure, It does not measure any other data and finally the wording in the survey has the same meaning to all participants (*Questionnaire Design Tip Sheet* 2007). The online student survey also included some qualitative questions that aimed to gather further investigative information of the study from the participants.

Data was also be captured by comparing students' grades from semester one to semester two. The data was analysed using three different method variables. The first variable is the independent variable, this is the use of technology to support learning in the students second semester of the subject. The next variable is the dependant variable, this measures the students' engagement with the support learning material. The final variable measures the extraneous variable, this was used to establish if there is any extraneous variables present in the data (Siegle 2015). The design of the quantitative study was experimental. Its design was crucial to the evaluation of the study and will examine cause and effect of the intervention. Experimental studies measures both before and after an event using the same sample of participants (Labaree 2019).

Qualitative Methods

The design of the Qualitative study examines the effectiveness of the intervention by capturing personal experiences that would have otherwise being lost or overlooked if relying solely on quantitative data collection methods alone. A semi-structured interview was used to help participants reflect on the process (Smyth *et al.* 2012). The interview consisted of the researcher asking ten open-ended questions that were intended to press the participant for further information and experiences of the intervention Appendix C – Participant Interview Form.

> Interviewing is a qualitative research technique that involves conducting
> intensive individual interviews with a small number of respondents to
> explore their perspectives on a particular idea" (Boyce and Neale 2006, p.3).

Boyce and Neale (2006) also give detailed interview question tips. They suggest the use of open-ended questions as opposed to closed-ended questions and to ask fact-based questions before opinion-based questions. The questions for the interview were divided into three main sections. The first section asks questions relating to the participants experience of the intervention. The second sections focus on the participants use of the recorded videos while the third section focuses on recommendations that the participants feel may enhance the overall effectiveness of the intervention.

One of the downsides of using interviews for gathering data relating to the intervention is that the participants will be interviewed by the researcher. This can lead to an imbalance of power. They may feel pressured into giving false positive information about the effectiveness of the

intervention since the researcher is the person who will be grading their assignments at the end of the semester. This may affect the validity and reliability of the interview. The reliability of qualitative data, is if different techniques were used by different researchers, it would yield the same outcome (Saunders *et al.* 2009). According to Silverman (2006), the reliability of qualitative research can be aided by transparency of the data analysis and of the research design. Silverman also encourages the use of triangulation to aid the validity of the data. A Thematic analysis approach was used to uncover any themes that were present in the interview data. Thematic analysis provides for an easily accessible and flexible approach to qualitative data analysis (Braun and Clarke 2006).

Interviews

When the research study commenced it was originally intended to conduct the interviews with the participants in a room within the institute the they were familiar with. It was hoped that this approach would help relieve any anxiety that they have had as they would be in familiar surroundings. However due to the Covid19 pandemic, the institute had to close their doors to all staff and students and as such the interviews could not take place onsite. The interviews took place online. The interview was scheduled at an agreed time that was convenient to the participants. They were reminded of their right to withdraw from the study at any time and that their participation was entirely voluntary. Two participants of the study were chosen at random and were asked to voluntary participate in the interview. The two candidates were chosen to represent both genders of the study. The average length of the interviews was approximately eighteen minutes.

3.8. Validity and Reliability

The validity and reliability of the research ensures that the study measures what it has intended to measure and if it were repeated on a different cohort of participants, would be consistent and yield similar findings. This is a very generalised account of reliability and in practice the reliability is somewhat more challenging. "research with diverse paradigms, such definition of reliability is challenging" (Leung 2015, para.6). The fundamentals of reliability in research lie in the consistency of the research.

According to (Feldman 2003), validity of a research precisely reflects the topic that the study is attempting to measure. Rooney (2005) states that validity is crucial in effectual research. Cohen *et al.* (2000) notes that any research that is not valid, has no credit and the results are overall worthless.

The generalisability of a research study is the ability to transfer the findings of a study to another setting or context. Allowances and generalisations need to be made to successfully adapt a study to another setting or context. Qualitative studies are usually tailored to research a specific research question that is indictive to issues relating to a demographic or particular cohort to name but a few and the generalisability of the findings of the study is largely not expected (Leung 2015). It is felt by the researcher that in relation to this research, the study could be conducted on another cohort of students studying a different module in the Institute of Technology (IOT) would yield similar results. There would be a slight deviation in the results and the study may have to factor in changes to the demographic of the participants such as computer literacy, prior knowledge of the subject matter and age of the participants.

End of year survey and interview questionnaire design.

Ensuring the validity and reliability of the end of year survey and interview questions was of primary importance to the researcher. To ensure that they measured what they intended to measure and were clear and not ambiguous that could have led to misinformation, the researcher drafted a copy of both the end of year survey and interview questions. They were peer reviewed with a colleague in the institute and the researcher's supervisor. Prior to peer reviewing the surveys, the researcher delivered a comprehensive and detailed account of the proposed research study and what the study was attempting to measure. Peer reviewing the drafted version of the surveys revealed some ambiguous questions that was felt could have the potential to capture some misleading information. The researcher's supervisor also provided invaluable information and guidance in the drafting of the survey and in particular relation to the Likert questions, it was felt that some of the questions were ambiguous and the participants responses might not represent what was trying to be measured. The researcher took this invaluable critique of the drafted survey and interview questions onboard and redrafted both to include their recommendations. Appendix C – Participant Interview Form. Appendix D – Participant Online End Of Year Survey Questionnaire.

Ethical Considerations

Eisen and Berry (2002) suggest that the failure to research and identify ethical issues can prove to be an extremely costly mistake. Warren and Lin (2012) also echo this point and recommend self-assessing the ethical questions in the concept stage.

This research study adhered to Letterkenny Institute of Technology's (LYIT) Research Ethics Policy and Research Ethics Procedure ('Quality Assurance Handbook' 2019). Due to the nature of this study, key factor had to be addressed before it could be approved by the institute.

- Protection of research participant's information.
- Informed consent of all participants.
- No Minors under the age of 18 will be involved in the study.
- GDPR and legislation governing the use of participants data.
- Confidentially of all information.
- Anonymity of all participants involved in the study.
- Secure data storage including how long it will be stored.
- Right to withdraw consent at any time.

All participants involved in this study were required to give consent prior to involvement and had the right to withdraw consent at any time and without giving any prior notice. Only participants over the age of eighteen years were eligible to be involved in this study.

Before a participant can be considered for inclusion in this study, they must read and understand the participant information form. Appendix A - Participant Information. If a student would like to proceed with participation in the study, they are then required to fill out and sign a participant consent form. Appendix B – Participant Consent Form.

Data collection via the online survey was carried out using Microsoft Forms. This software allowed the participants to complete the survey online at a time and place that was convenient to them. All data that was collected using the online survey was anonymous. Participants were not required to download any software to complete this survey nor were they require to provide any personal information to either the researcher of the online survey application software.

The study was conducted in a separate Institute of Technology from LYIT, approval was also sought from the college's Ethical committee and from the Head of Department of Mechanical and Manufacturing Engineering where the study took place.

To comply fully with the General Data Protection Regulation (GDPR), and the Ethics committee of both LYIT and the college were the study took place, the collected data will only be retained as long as necessary and will be in accordance with the colleges data retention policy ('Data-Protection-Policy' 2018) and LYIT's data retention policy ('Quality Assurance Handbook' 2019). All collected data for this study was securely stored on a password protect file that only the principle researcher had access to. All collected data, upon completion of this study will be destroyed. In line with GDPR guidelines, the collected data for this study was only used for the purpose of this research study. It was not shared with any third party or any other members of staff. Confidentiality of all participants in this study was of upmost importance. The principle researcher was the only person who had access to the participant's identity and their data. All participants in this study will be anonymized leaving it impossible to be identified.

3.9. Analysis of the Data

"Data analysis is central to credible qualitative research" (Maguire and Delahunt 2017, p.1). This study involved a mixed method approach involving both quantitative and qualitative research methods. Braun and Clarkes (2006) six step frame work was used to evaluate the qualitative data. All data was summarised and placed into tables using Microsoft Excel. This data was then graphed to uncover thematic data. Graphs are an excellent median to communicate data as opposed to displaying data in tables (Kastellec and Leoni 2007).

Each new exercise that was covered in the module was accompanied by a range of RLOs that assisted the participants in completing their exercises. Shown in Figure 9, is a typical layout for an exercise in Moodle. The layout for an exercise starts with a pdf drawing for the exercise followed by several recordings that details how to produce the exercise. The researcher opted to break down the recordings for each exercise into bite size short recordings that deal solely with an aspect of the exercise at a time. It was felt that this approach would be more favourable as opposed to one long recording. The main benefit of subdividing the recordings was that when participants get familiar with the software, they only need to concentrate on the recordings that they need. A key finding of the study was that the number of downloads for the

recordings reduced as the participants gained more experience with the software. The number of recordings varied per exercise, depending on the level of complexity of the exercise.
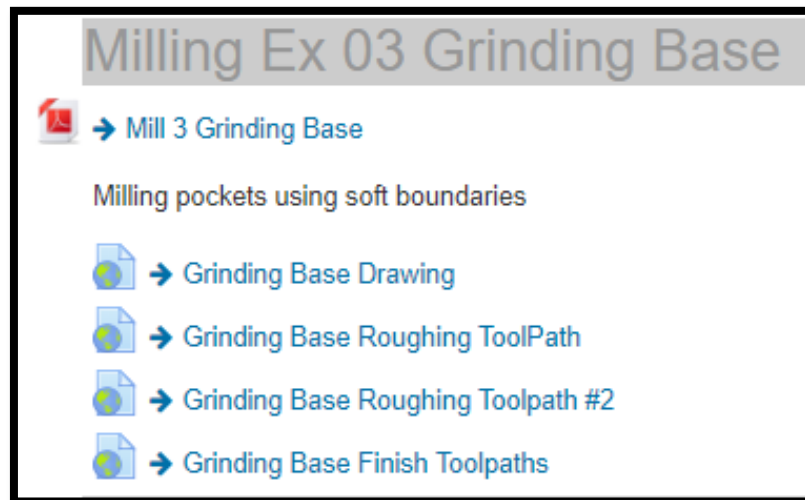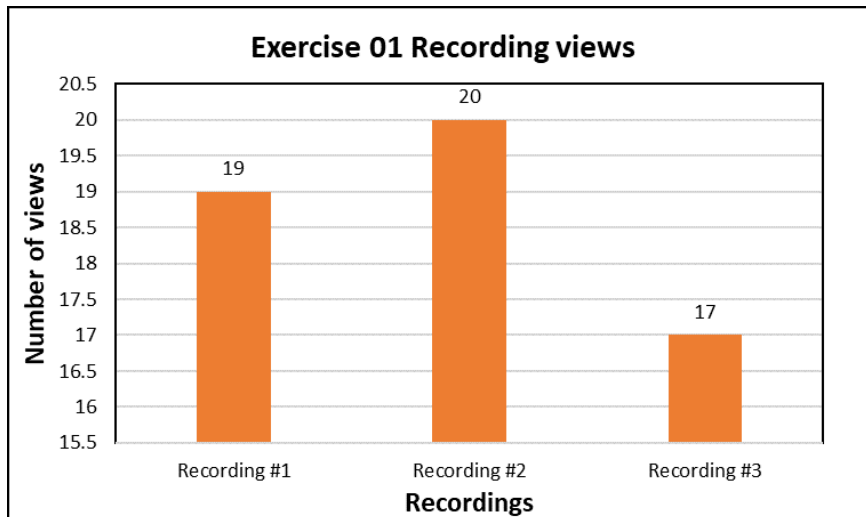

Figure 9: Exercise Layout in Moodle

Analysis of RLOs for Exercise One

Shown in Figure 10 is the total number of views relating to the recordings in exercise one. Each of the recordings are broken down into individual topics. Recording #1 demonstrates how to model the component while recordings #2 and #3 demonstrates the correct procedure to apply toolpaths to model. While there was a total of fourteen participants involved in this study, the data shows that participants viewed the recordings more than once. The total number of views for the recordings relating to exercise one was 56. The average number of views per participant was 4.0.

Figure 10: Exercise 01 Recording views

Analysis of RLOs for Exercise Two.

Shown in Figure 11, is the total number of views relating to the recordings for exercise two. This exercise had only two recording associated with it. Similar to the structure of the recordings in exercise one, the first recording relates to modelling the component while the second recording demonstrates the application of the toolpaths to the model. The total number of views for the recordings relating to exercise two was 36. The average number of views per participant was 2.57. This represented a reduced number of views of 35.71% compared to the total views for exercise one. The engagement with the RLO for exercise two was lower than that for exercise one, the researcher felt that the main reason for this drop of was that this exercise was relatively short in comparison to exercise one and the exercise was covered in detail during class time.
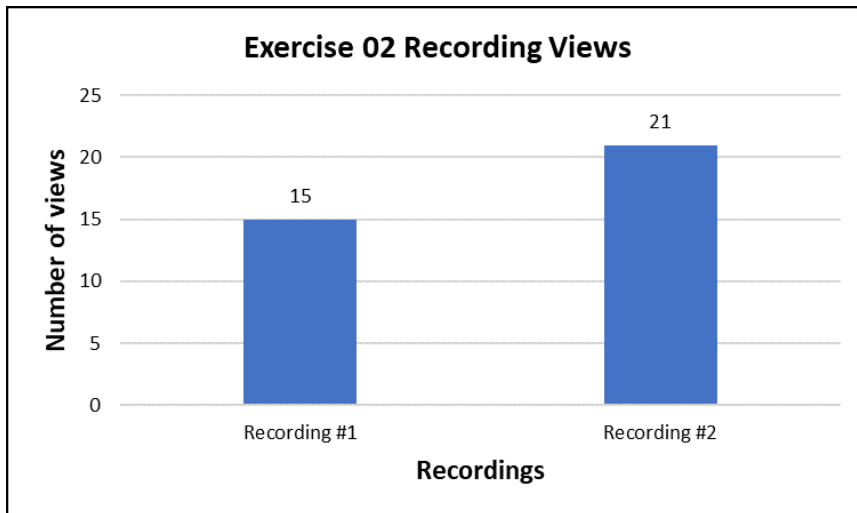
Figure 11: Exercise 02 Recording views

Analysis of RLOs for Exercise Three.

Shown in Figure 12, is the total number of views relating to the recordings for exercise three. This exercise had four recordings associated with it. Similarly, the structure of the recordings followed the same format as the previous. The total number of views for the recordings relating to exercise three was 89. The average number of views per participant was 6.36. This represented an increase of 58.93% of views compared to the total views for exercise one. The engagement with the RLO for this exercise was significantly higher than that of the previous two exercises. The primary reason for the higher engagement with the RLOs for this exercise was due to the introduction of a range of new concepts relating to the exercise. The exercise introduced the participants to a range of new concepts and there were a significant number of steps associated with the exercise.
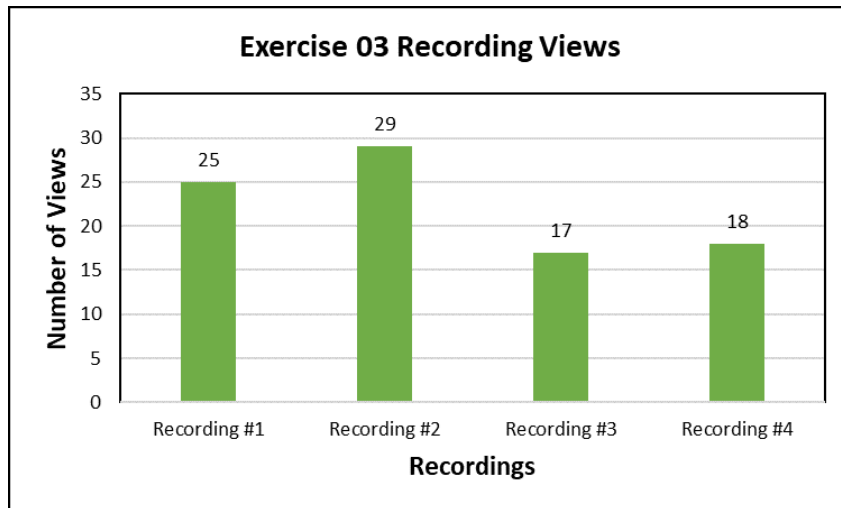
Figure 12: Exercise 03 Recording views

Analysis of RLOs for Exercise Four.

Figure 13 shows the total number of views for exercise four. As with the previous exercises the exercise was broken down into smaller recordings so that participants could focus on areas that they were struggling with. This was the final RLO to be used and presented a significant lower engagement level than the previous exercise recordings. There was a total of 27 views of the recordings for exercise four. The average number of views per participant was 1.93. This resulted in the lowest engagement of all the recordings and represented a reduced number of views of 51.79% compared to the total views for exercise one.
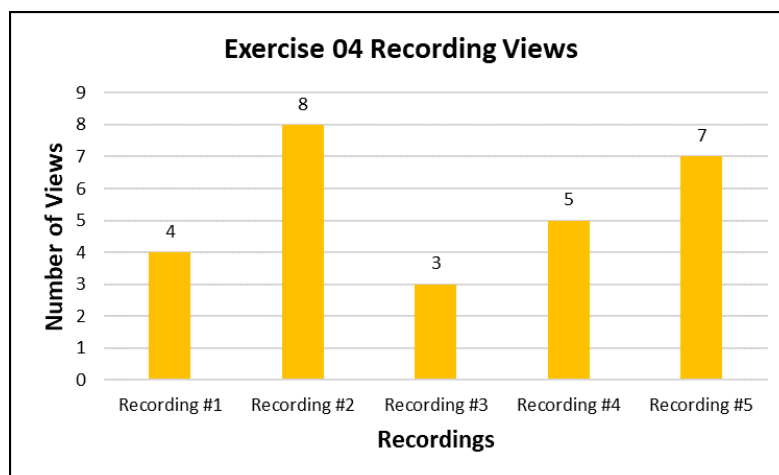

Figure 13: Exercise 04 Recording views

Analysis of RLOs summary

Overall, there was excellent engagement with the RLOs. It was not compulsory to view the RLOs, participants could choose what sections they needed to bridge knowledge gaps in. This is evident from the data above on the number of views per exercise that the students' accessed the RLOs on numerous occasions. The use of the RLOs was of significant benefit to the students that needed access to them, and the data shows that the students were able to take charge of their learning.

The data obtained shows a clear drop off in the number of views for exercise four of 51.79% compared to the total views for exercise one. The main reason for this drop off in the number of views is that this exercise was scaffolded on the previous exercises in terms of new content. Students had a firm foundation of the key concepts of using MasterCam for this exercise and therefore several students did not require additional help by reverting to the recordings. The research shows that the use of RLOs is extremely beneficial for plugging gaps in knowledge and may not be required by every student for every exercise. A repository of recordings was beneficial for students learning material in this module as it allowed students to individualise their learning. Figure 14 shows the breakdown of student engagement with the RLOs for each exercise.
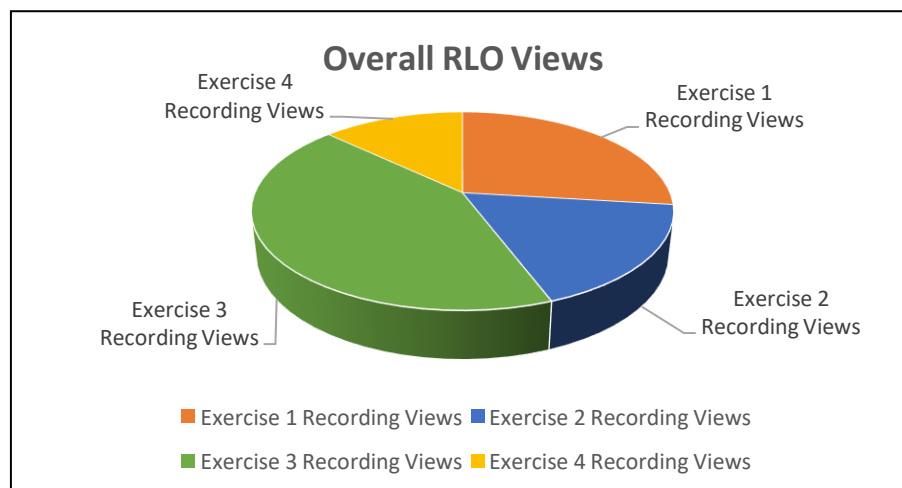

Figure 14: Overall RLO Views

3.10. Analysis of online survey questionnaire

An online survey was distributed to the participants in the study using Microsoft Forms. Thirteen participants took part in the survey with one participant abstaining. The online survey consisted of six questions. Questions 1-3 were designed as closed ended questions using a Likert scale while questions 4-6 were open ended questions designed to gather holistic feedback on the intervention. Appendix D – Participant Online End Of Year Survey Questionnaire.

Q1. Instructional Videos

Question one was broken into two sub questions. Participants were asked to choose their response to the questions using a Likert scale. The participant could choose one of the following responses depending on how they agreed with the statement, Strongly Disagree, Disagree, Neutral, Agree or Strongly Agree. Figure 15 shows the responses to question 1.A. Out of thirteen responses (38%) strongly agreed while (62%) agreed that the content of the videos was relevant.
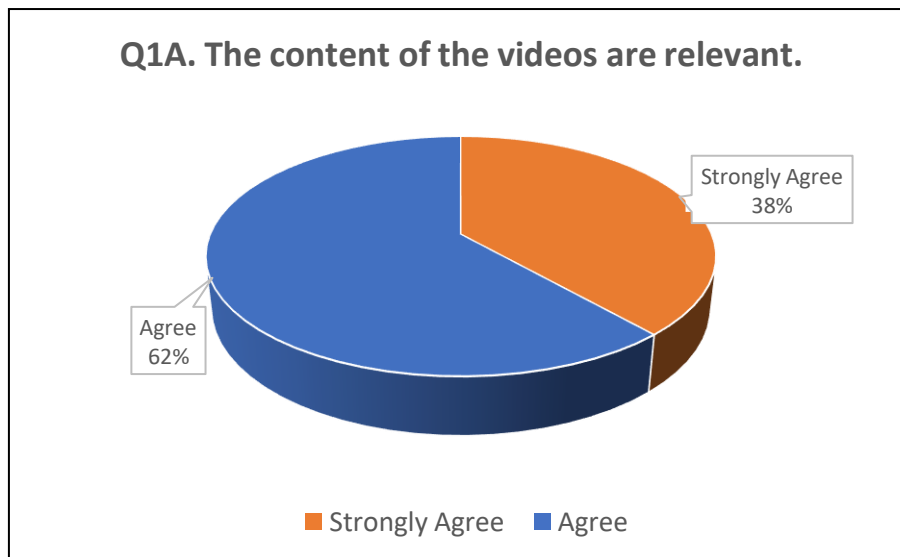

Figure 15: Responses to survey question 1.A

Figure 16 shows the responses to question 1.B. this question focused on the benefits of using instructional videos. Most of the participants (61%) strongly agreed with this statement followed by (31%) that agreed with the statement. (8%) of the participants had a neutral view of this statement. The data shows that the majority of the participants 92% stated that they either agreed or strongly agreed that the videos were beneficial to learning this module.
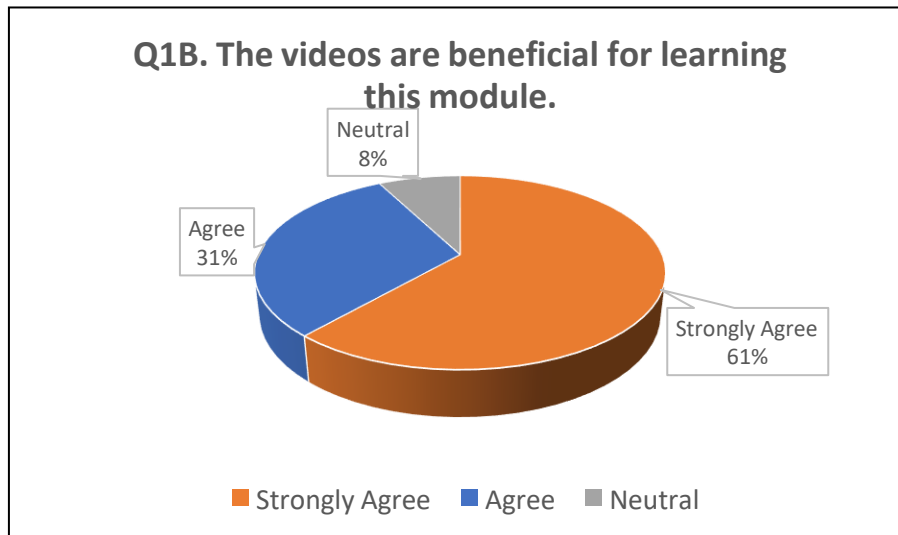

Figure 16: Responses to survey question 1.B

Q.2 The use of Technology Enhanced learning

Question two was subdivided into two parts and focuses on the use of technology enhanced learning. Similarly, to question one, participants choose a statement that reflected their views using a Likert scale. Participants could choose one of the following statements, Strongly Disagree, Disagree, Neutral, Agree or Strongly Agree. Figure 17 shows the responses to question 2.A "I like using the recorded videos for studying". Most participants (61%) recorded that they agree with this statement, while (23%) recorded that they strongly agree, (8%) were neutral and the finally (8%) recorded that they disagreed with this statement. The data shows that the majority of the participants favour this mode of delivery.
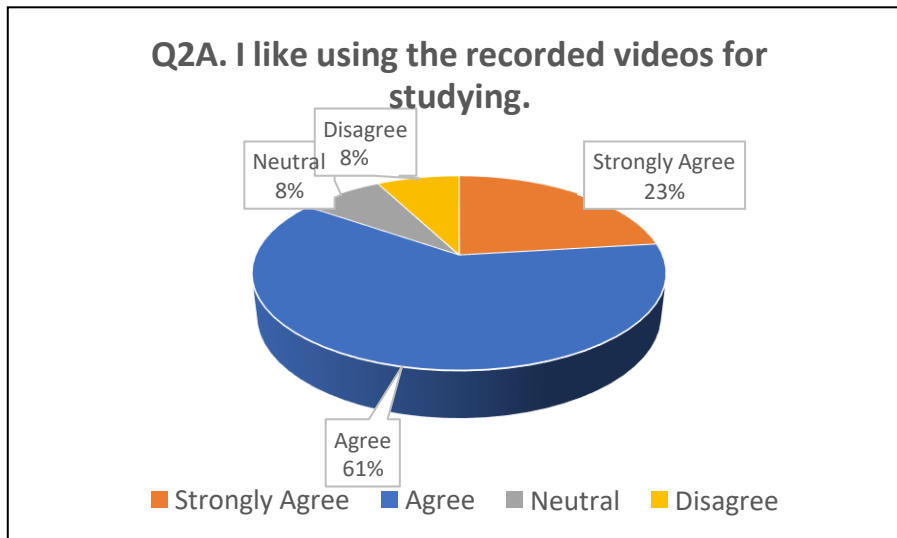
Figure 17: Responses to survey question 2.A

Figure 18 shows the participants responses to question 2.B "I would recommend the use of Technology Enhanced Learning in other modules". The results showed that most of the participants (69%) either agreed or strongly agreed with this statement. (31%) recorded that they were neutral to the statement. The researcher feels that the students who recorded a neutral statement to this question prefer to do their learning in class when they have access to their lecturer. This response is also evident in question five that asked respondents to list the weakness of using RLOs. Students recorded that the main weakness associated with this model of learning is that you 'cannot ask questions' and it is 'hard to watch and design at the same time'. Another respondent also recorded in question four that they 'did not use this, prefer to learn in class when I can ask questions.' The results show that there is a high recommendation regarding the use of TEL in other modules.
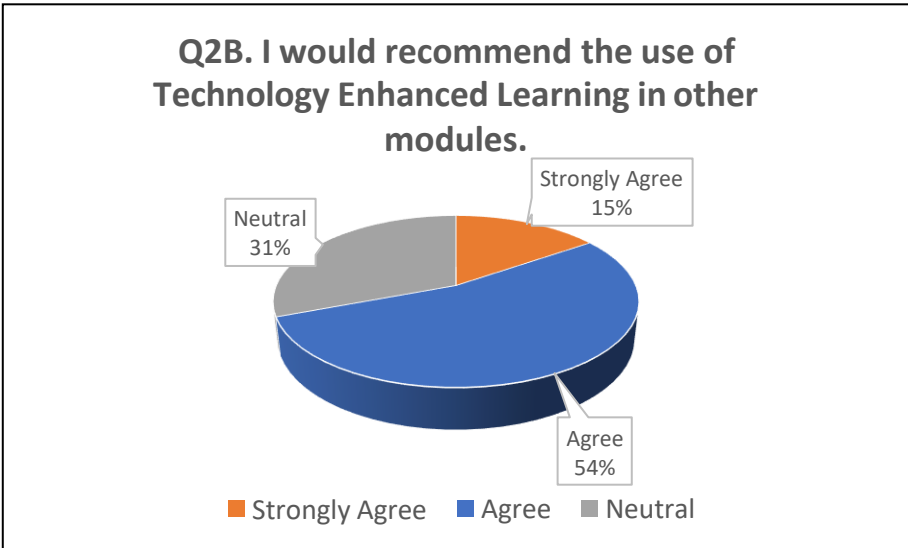
Figure 18: Responses to survey question 2.B

Q3. Length of the Recordings

Question three recorded the participants view on the length of the recordings. Participants could choose one of the following responses depending on how they agreed with the statement, Too Short, Short, Adequate, Long, Too Long. Figure 19 shows the results recorded. Out of thirteen participants, (92%) recorded that the length of the recordings was adequate while (8%) of the participants recorded that the videos were short.
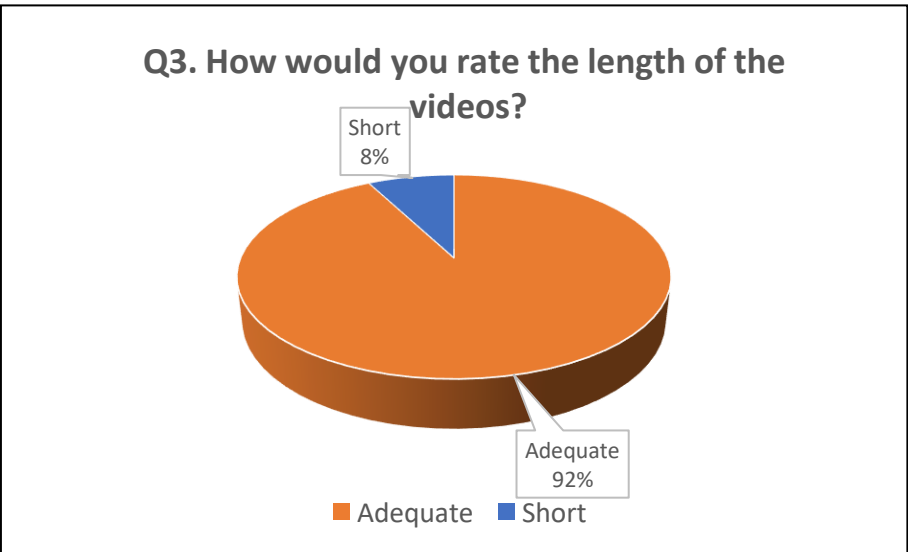

Figure 19: Responses to survey question 3.

Q4. Please list what you regard as the strengths of this intervention.

Question four was an open-ended question that captured qualitative feedback concerning the strengths of the intervention. An open-ended question was favoured as it provided for a more holistic analysis of the data and a vehicle for thematic analysis of the data. Table 5: Responses to survey question four. Out of thirteen participants, eleven (84.6%) completed question four while two recorded non-applicable.

Table 5: Responses to survey question four

Q4. Please list what you regard as the strengths of this intervention:
Ability to see step by step procedure
Easy to follow
I did not use this, prefer to learn in class when I can ask questions. But would be useful for when you are stuck on a particular thing.
You can re watch easily and at your own pace
Very helpful in terms of if I did not understand how to do a certain aspect on Mastercam, I would refer to the videos on Moodle as they were very helpful.
Step by step guide See exactly what is going on Can pause and go back at any point
Good range of answers
Strengths are the content videos they really help.
Help showcase difficult parts of Mastercam or other software along with new features that need to be learned
Ability to pause and catch up on steps in the design process. Being able to see exactly what is being done. Revision for exams.
Pick up information that may be overlooked in class

Q5. Please list what you regard as the weaknesses of this intervention

Question five endeavoured to capture the weakness with this type of intervention. There was low response to this question. The researcher feels that the reason for a low response was that the participants could not identify with any major weakness with the RLO as they were used to complement the classroom activities. A common theme emerged, highlighting that the main area of weakness is the inability to not ask questions. One participant recorded that the main weakness for them was the difficulty in watching a recording while attempting to design simultaneously. Table 6 shows the key areas that participants found as the weakness of this intervention.

Table 6: Responses to survey question five

Q5. Please list what you regard as the weaknesses of this intervention:
Cannot ask questions
You cannot ask questions as easy or if there is a problem it is a lot harder to solve
Some videos can be long
Hard to watch and design at the same time

Q6. General comments and suggestions for improvements

Question six provided the participants an opportunity to voice general comments and any suggestions for improvements. Table lists the main responses to the question. Overall, participants recorded that the use of recorded instructional videos was very beneficial for the learning of the module. A key theme that emerged for the findings was the recommendation to provide the videos in advance of the class, in essence, flipping the classroom. This type of model involves providing the students with new material content outside of class time which opens in class time for additional activities and other forms of learning and teaching. Flipping the classroom can provide for a favourable teaching pedagogy when designed and implemented effectively (van Alten *et al.* 2019).

Table 7: Responses to survey question six

Q6. General comments and suggestions for improvements:
Introduction videos to Mastercam should have to be watched as homework to speed up productivity during class time.
Helps students adapt to different ways of learning. It is also very helpful for students who have their own pace of learning. CAD/CAM videos were also very helpful throughout the year.
very beneficial
Very good and helpful videos overall
Send videos to be watched before classes to speed up productivity in class time.

3.11. Data analysis – Interviews

A semi structured interview was conducted online with two participants chosen at random. One male and one female participant was chosen that would give a gender-neutral balance to the interview. Both participants declined to be recorded as they felt that this would add to their anxiety. The interview involved ten open ended questions and was broken into three main sections. Section one focused on their experience of using TEL in the module. Section two focused on their usage and finally section three looked at any recommendations. The interviews helped uncover thematic themes that would have been otherwise overlooked if relying on the online surveys alone.

The consensus was that the use of TEL in the classroom promotes the learning and enhances the learning environment. "*very handy to recheck what you are doing*" (Student A1).

When asked if they would recommend the use of this type of intervention, (student B1) "*would like this model of teaching to be used in other modules*". This is similar to findings by Moyle and Wijngaards (2012) who found that over 90% of surveyed students agreed that the use the Technology enhanced learning has a positive effect on their studying. They also noted that students expect TEL to be used in higher level education.

When asked about recommendations for improvement, (student A1) "*recordings should be broken up into smaller sections so that you do not necessarily have to watch the entire video and only need to focus on the section that you are stuck on*".

Both participants suggested that the use of TEL should not be confined to complementing the work done in class but to flip the classroom that will make additional time available in class for the setting up of practical sessions. This finding corresponds to findings in similar studies that highlights the benefit of flipping the classroom, it provides greater opportunities to promote a higher level learning paradigm (O'Flaherty and Phillips 2015).

When asked if they thought that this mode of delivery should replace traditional face to face classroom, both participants said "no". In response to this question student (A1) described that that the main reason for not recommending replacing face to face learning was the "*ability to ask questions in class if you are stuck on a topic*". The participants had first-hand experience of attending fulltime education online as the interview took place after the participants had completed several weeks online study due to the Covid19 pandemic. Both participants noted that they did not like a fulltime mode of delivery online but had a significant preference to a blended learning model. The researcher pressed the participants further to better understand the learning complexities for online learning. Both participants noted that the main reason for not favouring fulltime online learning using assisted technologies was the removal of the human interaction and social presence. They also felt that peer learning element in the traditional classroom was something that greatly aids students learning. While virtual learning environments such as Moodle have made great advances to facilitate the virtual classroom and cater for peer learning, there is still no substitute for the traditional classroom that is augmented with technology. Peer learning helps students develop key skills in teamwork, communication, and organising skills. It also helps reinforce their knowledge by explaining and coaching their peers (Boud 2001).

3.12. Findings

The assessment criteria for this module was made up of a combination of continuous assignments and an exam in both semesters. Semester one used TEL while in semester two traditional instruction was used in the delivery of the module. The average mean result for semester one was 61.8% while the average mean result for semester two was 66.1%. This represents an overall mean average gain of 6.96% in semester two over semester one results.

Figure 20 shows the profile of results obtained in semester 1 and semester 2 for each participant. While the results showed that the mean average grade was lower using TEL

compared to the average result obtained in semester two using traditional instruction, further analysis of the data using descriptive statistics method was employed.
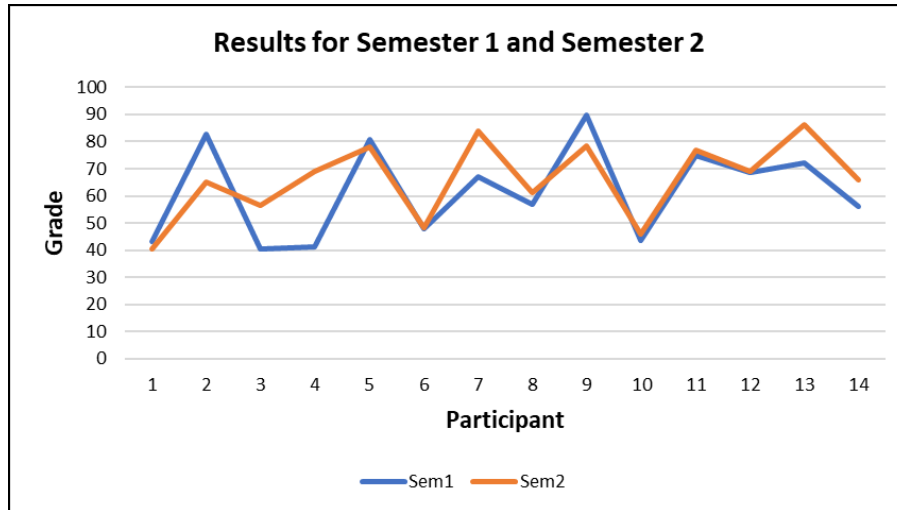

Figure 20: Results for Semester 1 & Semester 2

Table 8 and Table 9 show the results using a two sample Paired T-test (2-tailed) to statistically analyse the results. The results of this test show that the null hypothesis can be rejected as the probability value (P) =0.1976 >0.05. The difference between the two mean grades are not statistically significant. Therefore, no method can be found to yield better results in students' grades.

Qualitative data gathered, highlighted that the use of TEL was beneficial in student learning and engagement. The results are inclusive regarding the use of TEL to enhance student's performance.

Table 8: Paired T-Test mean grades

Paired T-Test Sample Statics				
	Mean	N	Std. Deviation	Std. Error Mean
TEL (sem1)	61.8	14	16.9831	4.5389
Traditional (sem2)	66.107	14	14.3285	3.8295

Table 9: Paired T-Test Results

	Paired T-Test Differences						
			Std. Error Mea	95% Confidence Interval of the Di			
	Mean	Std. Deviation					
TEL(sem1)-Traditional (sem	-4.307	11.86					

3.13. Summary

Overall students that participated in this TEL research study viewed it as a positive improvement over traditional face to face instruction. The findings are similar to studies carried out by Cortizo *et al.* (2010) who in their study highlighted that the use of blended learning technologies resulted in an increased level of knowledge of the student. The use of RLOs allowed the students to study at a pace that they were comfortable with and reinforce their understanding of topics delivered outside of class time. The findings of this study are similar to a study carried out by Bath-Hextall *et al.* (2011), they discovered that the use of RLOs had a positive effect on the students understanding of material delivered in the study. They also describe how the students used the RLOs to effectively fill the gaps that they had in their knowledge.

A theme that was uncovered during the interviews and the online survey was the recommendation for improvements. Students expressed interest in flipping the classroom together with a blended learning teaching paradigm. This approach would allow for deeper learning activities in class along with additional time spent on practical lab sessions and would also give them the resources to study and reflect on material in their own time. This view is back up by a study by Danker (2015, p.171) who's results of a study found "flipped classrooms had promising impact for student learning and achievement".

The students also recommended that blended learning should replace traditional face to face instruction in the classroom. They highlighted the importance of social presence and peer learning. They felt that the environment indicative to learning that is present in the classroom promotes learning. This view is also echoed by Bath-Hextall *et al.* (2011) who noted that feedback from a study on the effectiveness of RLOs showed that the use of RLOs should be used as a supplement to complement the learning activities of the classroom and not to replace it.

4. Section four: Conclusion.

4.1. Conclusion.

This paper explored the comparison of using Technology Enhanced learning to supplement and complement traditional face to face instruction on a cohort of students over traditional instruction methods alone. This study evaluated if Technology Enhanced Learning improve students' performance and learning experience, as part of a blended learning environment in an undergraduate Mechanical Engineering degree module. This study focused on the use of RLOs as part of a blended learning approach to assist students in the learning of their CadCam module in semester one while also endeavouring to break down learning barriers associated with new subject modules. These results were then compared to their results obtained in semester two of the module.

The findings of this study align with the literature and recent studies regarding the potential benefits to both students and teachers of integrating a blended learning approach to curriculum design and delivery. The results of this study have shown no statistical evidence in mean grades of the participants of this study. The average result obtained for the fourteen participants of the study in semester one was 61.8% while the average result obtained in semester two was 66.1%. This represents an overall mean average gain of 6.96% over semester one results.

The results of this small scale study are inconclusive. Using a two sample Paired T-test (2-tailed) to statistically analyse the results showed that the null hypothesis can be rejected as the probability value (P) $=0.1976 >0.05$. The difference between the two mean grades are not statistically significant. Therefore, no teaching method can be found to yield better results in students' grades.

The main benefit of using TEL in semester one, was that it allowed them to familiarize themselves with the software in an accelerated time frame. It was felt by the researcher that if this approach were not taken, there would have been numerous learning barriers for the students to overcome. The main barrier for students was adopting to the new cad software that is used in the CadCam module. This is primarily due to students being exposed to two different types of Cad based computer packages. Students have already completed two semesters of classes in SolidWorks design and continue this subject into year two. This aids to the frustration that some students encounter when being exposed to a new cad based software package.

However further in-depth holistic analysis of all the data suggests that there is evidence of the benefits of using TEL in the classroom in terms of student engagement and the ability to take control of one's learning. The findings of this study also found that there is significant support from the participants for adopting the use TEL in their other modules as part of their undergraduate degree in Mechanical Engineering.

The study also highlighted the students' attitude towards the use of TEL in the classroom. The students reported that the use of TEL in the classroom had a positive and contributing effect on their studies. They also stressed that it should be used to supplement and complement the traditional face to face learning practice and not to replace it.

4.2. Research Limitations.

This study was limited in its size and confined to a single geographical location. The study was confined to second year students studying for an undergraduate degree in Mechanical engineering in the North West of Ireland. The class size that was considered for this study was a class of sixteen students however two students declined to participate in the study. This represented in a reduced capacity of 12.5%. This small sample size may represent limitations in the generalisation of the data and may also have an impact on the ability to uncover holistic thematic themes in the data. The researcher also acknowledges that student demographics could have had an effect in the study. This includes students' gender, students' age and students' varying cultural and ethnic backgrounds. This study included two female participants which represented 14.29% of the total participants. This study may have also benefited in comparing the results over different years to help identify any significant markers and trends in the data.

4.3. Recommendations

This study has highlighted the significant positive attributes associated with the adoption of TEL as part of a blended learning classroom. The researcher felt that while this study showed promising results, the following recommendations would provide for a holistic evaluation of the suitability and effectiveness of this style of teaching pedagogy.

It may be advantageous in conducting the same research to different cohorts of students' and different sites to evaluate weather student demographics affected the result of this study. This would also give the opportunity to improve the design of the RLOs and to assess the suitability of using additional TEL resources to enhance the learning experience for students.

Areas of improvement include the adoption of improvements identified by the students. The online survey and the interviews highlighted a common recommendation to redesign the course content that would flip the classroom thereby free up critical in class time to focus on higher level thinking activities. Further research may benefit from a detailed analysis into this teaching paradigm and to access its suitability for adoption into this module.

Students' identified with this mode of learning and highlighted the benefits of its adoption into the course design. They also recommended the adoption of this teaching paradigm across their entire modules. While the use of TEL did not show any statistically significant gain in the average grades obtained, it significantly broke down learning barriers and allowed students to learn at their own pace. Similar studies could be conducted using the TEL on the other modules of their course and to compare the findings of those studies with the findings of this study.

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6. Appendix A - Participant Information.

PARTICIPANT INFORMATION

Title of Study: Can Technology Enhanced Learning improve students' performance and learning experience, as part of a blended learning environment?

Name of Principal Researcher: David Mc Moreland. Lecturer in the Department of Mechanical & Manufacturing Engineering.

1. Aim of the study.

I, David Mc Moreland am currently doing a research project as part of my Master of Arts in Learning and Teaching in Letterkenny Institute of Technology (LYIT). This research project involves the investigation of the effectiveness of Technology Enhanced Learning as part of a blended learning approach in the classroom improve students' performance and learning experience.

2. Description of the study.

This research will focus on examining the effectiveness of using Technology Enhanced learning to improve students' performance and learning experience. I will be focusing this study on CadCam201 (semester one) and CadCam 202 (semester two). CadCam201 will be the control group while the second group, CadCam 202 will form the research group. My study will involve creating supporting learning material for the research group by way of recorded instructional videos, interactive virtual learning environment and the use of digital assessment tools. The data will be correlated and graphed to highlight any trends / performance markers that exist between the two groups. I will be looking at various patterns that exist between the two groups, namely student performance and learning experience, engagement with the material and their need for additional material from the lecturer to effectively evaluate the intervention.

3. Age of Consent.

Only persons over the age of 18 will be able to participate in this study. You will still be able to access all the material.

4. What benefits are there for participating in this study?

Participants do not receive any benefits or money contribution. This study will help develop a better teaching model that will benefit future students.

5. Can I refuse to participate?

Yes. Participation in this study is entirely voluntary.

6. Confidentiality.

All names will be kept anonymous. You will not be able to be identified throughout the study or in the Thesis. No information relating to the identity of the participants will be disclosed.

7. What will happen to the information which you give?

The data and results recorded for this study will be kept confidential and stored securely for the duration of the study and destroyed afterwards.

8. Data Retention.

The data collected will only be retained as long as necessary and will be in line with the Institute's Data Retention policy.

9. Has this study been reviewed by an Ethics committee?

Yes. Letterkenny Institute of Technology's, Research Ethics committee at have reviewed this study.

10. Further Information.

If you require any further information or need clarification as to the nature and purpose of this study, please contact;

David Mc Moreland XXXXXX

7. Appendix B – Participant Consent Form.

Participant Consent Form

	YES	NO
Project Title: Can Technology Enhanced Learning improve students' performance and learning experience, as part of a blended learning environment?		
Principal Researcher: David Mc Moreland		
Participant Declaration: Please read and complete this form carefully. If you agree to participate in this study, please sign and date the declaration. *Tick Yes or No as appropriate:*	YES	NO
1. I confirm that I have received a copy of the information sheet for this study. The information contained within is clearly explained and I fully comprehend it.	☐	☐
2. I understand what this research will involve. The scope and reason, for the study have been clearly explained to me.	☐	☐
3. I have had enough time to consider whether I will take part in this study and I have not been unduly pressurised into participating in this study.	☐	☐
4. I understand that I can withdraw my consent at any time without it affecting my performance.	☐	☐
5. I give consent to be part of this study.	☐	☐
6. I understand that the data obtained will only be retained as long as necessary and will be in line with the Institute's Data Retention policy.	☐	☐

Participant (Blank)   *Researcher (Blank)*

Date:_____   **Date:**_____

Signature of the Participant: **Signature of the Researcher:**

_____   _____

8. Appendix C – Participant Interview Form.

PARTICIPANT INTERVIEW FORM

Title of the Study: Can Technology Enhanced Learning improve students' performance and learning experience, as part of a blended learning environment?

Principal Researcher: David Mc Moreland, Assistant Lecturer in the Department of Mechanical & Manufacturing Engineering.

Experience

1. How did you find this blended learning approach? Please explain.

2. Did the use of Technology Enhanced Learning have any effect on your studies? Please explain.

3. What worked well with this intervention?

4. What didn't work well with this intervention?

Usage

5. Did you find the content of the instructional videos was at a suitable level? Please explain.

6. Did you think that the design of the instructional videos was appropriate? Please explain.

7. Was the duration of the videos to an acceptable level? Please explain.

Recommendations

8. Would you recommend the use of this intervention? Please explain.

9. Have you any recommendations for improvement?

10. In your opinion, do you think this mode of delivery should replace traditional face-to-face classroom? Please explain.

9. Appendix D – Participant Online End Of Year Survey Questionnaire.

Bachelor of Engineering in Mechanical Engineering Y2 CadCam 202 End of Year Survey

Thank you for taking part in this important end of year survey. It will be used as part of my Research Masters in LYIT to determine your experiences of the use of Technology Enhanced Learning. It will only take 5-10 minutes to complete. The survey is completely anonymous. Participation is voluntary.

Required

1.Instructional Videos

Please indicate if you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The content of the videos are relevant.	○	○	○	○	○
The videos are beneficial for learning this module.	○	○	○	○	○

2.The use of Technology Enhanced learning

Please indicate if you agree or disagree with the following statements.
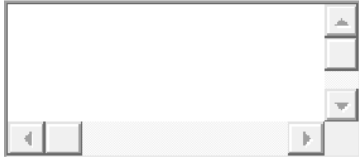
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I like using the recorded videos for studying.	○	○	○	○	○
I would recommend the use of Technology Enhanced Learning in other modules.	○	○	○	○	○

3.Length of the Recordings
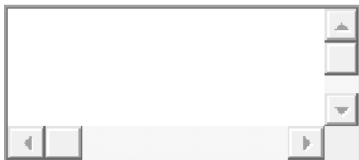
Please indicate your preference with the following statement.

	Too Short	Short	Adequate	Long	Too Long
How would you rate the length of the videos?	○	○	○	○	○

4.Please list what you regard as the strengths of this intervention:

5.Please list what you regard as the weaknesses of this intervention:

6.General comments and suggestions for improvements:

10. Appendix D – List of abbreviations used

BL   Blended Learning

CAD   Computer Aided Design

CAM   Computer Aided Manufacture

CNC   Computer Numerical Control

CUA   Connacht Ulster Alliance

ECTS   European Credit Transfer and Accumulation System

EU   European Union

GDPR   General Data Protection Regulation

GMIT   Galway-Mayo Institute of Technology

HEA   Higher Education Authority

HEI   Higher Education Institution

iNote   Opportunities Transforming Education

IOT   Institute of Technology

ITSligo   Institute of Technology Sligo

KITE   Knowledge and Innovation Transfer in Engineering

LYIT   Letterkenny Institute of Technology

MIT   Massachusetts Institute of Technology

MOOC   Massive Open Online Course

Pc   Personal Computer

RLO   Reusable Learning Object

RTC   Regional Technical College

TEL   Technology Enhanced Learning

VLE   Virtual Learning Environment