An Evaluation on the Feasibility of Augmented Reality as a supplementary learning tool

A dissertation submitted in accordance with the requirements for the degree of Bachelor of Science (Honours) in Computing.

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Declaration

I hereby declare that this dissertation, entitled ‘An Evaluation on the Feasibility of Augmented Reality as a supplementary learning tool’, is entirely my own work and has never been submitted or being submitted for any other degree.

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Abstract

A range of technologies are used within educational institutions to facilitate the learning of a wide variety of subject matters. Augmented reality is increasingly becoming a technology with major research focus, as potential applications for it in different facets of society are explored. One research emphasis is placed upon the benefits it provides in visualising information and how this can tie into an educational context, particularly as a supplementary tool that can be added to teacher’s repertoires. This study utilises a combination of research conducted by other authors alongside primary data collected from university staff and student populations to determine the feasibility of AR implementation in this sector. The principal findings generated from this indicate a willingness and desire for AR tools to be available on university courses by both groups; engineering, medical/sport, art, science and computer-based courses specifically. There are also indications that AR can provide support to those with disabilities due to its visualisation capability. However, this implementation is constrained by several feasibility factors. These include providing explicitly defined uses for AR within those courses, providing training in how to use them, ensuring comfortable integration with existing tools and building a support network around them. Ultimately, if these feasibility constraints are considered and solved, AR can find success as an educational tool.

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I don’t need to name any of these people because, let’s face it, the acknowledgements within here don’t mean anything. I’m only doing this for a degree.

Rather, they can read this one simple thing. They can read it and know I am thinking of them. They can read it and have the firmest knowledge that I am eternally and incomprehensibly thankful that they think I am worth their effort –

“I am glad you exist”.

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1. Introduction

The educational environment utilises a wide range of technologies to effectively teach material. With the rapidly evolving nature of technologies, educational institutions have to consider factors such as cost, reliability, applicability, etc. prior to adopting a new tool or resource for their own purposes; implementation requires questions regarding feasibility. Computer technologies are increasingly involved in these environments via internet-based systems/virtual learning environments such as Moodle or Blackboard, video sharing, the introduction of tablet computers/mobile devices to schools (Sung et al., 2016) and so on. One such technology that is being studied for potential educational applications is augmented reality (AR) with its ability to digitally represent objects, text, images, etc. (referred to as ‘visualisation’) opening potential for new, varied learning tools that can be applied throughout many subjects.

There are a variety of definitions regarding AR so it is imperative that a clarification is made as to the meaning used in this research. Milgram et al. (1995) use a sliding scale they referred to as the Reality-Virtual Continuum (see Figure 1) to differentiate AR from virtual reality (VR), which is a distinctly separate technology but still contains overlap with AR. Using this sliding scale, AR can be defined as any technology that overlays virtual elements over a real world setting in a supplementary manner (Azuma et al., 2001), as opposed to a predominately virtual representation.

![Figure 1: Illustration of Reality-Virtual Continuum (Milgram et al., 1985)]
Due to the relatively ‘early stage’ nature of AR technology the rate of adoption and usage is severely limited, both within the educational context of this research focus and others. Regardless, the ubiquitous nature of computer systems within society, technology firms such as Google and Microsoft developing AR projects (Glass and HoloLens) and small-scale use of AR in mobile applications is indicative of the burgeoning interest in the field. As a result, the notion that AR implementation may occur is far greater currently than in comparison to the past.

With these considerations, research that helps in determining the likelihood of AR adoption within education is significant as the technology has only recently stated undergoing major development. As with all technological areas, investigations must be conducted on the viability of potential applications otherwise any developments made risk being redundant if users disregard or are unwilling to adopt them. Stone et al. (2009) identify that researchers often eschew evaluating the overall nature of educational AR in studies and instead directly critique the technology they have chosen to test. Ascertaining both the uses of and opinions on AR as a learning tool therefore serves to help identify whether it is worthwhile to pursue educational AR as a concept. Further to this, it is necessary to establish if AR visualisation is an effective method through which to enhance the learning experience.

1.1 Problem Statement
The following statement encapsulates the main problem that this research project aims to tackle -

‘There are many theorised applications for augmented reality technology as a learning tool. However, these potentialities are reliant on perceivable feasibility/usefulness if they are to be actualised and integrated into educational environments’.

1.2 Research Questions
The problem statement is broken down into three sub-questions, they are -

1. What learning areas can theorised or existing AR applications be used in/suitable for?
2. Are the potential applications for AR tools applicable to a diverse range of subjects or are they constrained to small-scale uses?
3. Do students/teachers find any perceivable value in AR tools being used as learning aids?
1.3 Aim

The principal aim of this project is to perform an ‘evaluation on the feasibility of augmented reality as a supplementary learning tool’ within the context of an educational sector, specifically universities. The research seeks to identify the various applications augmented reality (AR) can be used for within this context, both potential and realised. An emphasis is placed on the core concept of visualisation that AR technology provides, that meaning the ability to generate a visual representation of something. Primary data is collected and analysed to ascertain the opinions both faculty and students hold on AR as learning tools and whether they ultimately believe there is room for AR adoption within educational institutions; identifying attitudes of feasibility.

1.4 Objectives

The aim of this research project is categorised into 4 main objectives, they are as follows -

- Review literature sources (secondary data) concerning both proposed and realised AR application methods within education alongside evaluations of those usages
- Perform primary data collection relating to learning methods used in an educational setting and their perceived effectiveness and opinions on potential AR application implementations
- Collate information gathered from both sets of data to discover if AR has a perceivable value as a learning tool and if it can aid/supplement existing methods
- Identify perceivably valuable AR tools/resources and analyse/evaluate their potential feasibility within an educational context
1.5 **Structure of Dissertation**

Firstly, this introductory segment is written to explain the research topic alongside the relevance/significance of it. Following this, a literature review is presented detailing relevant secondary sources with supporting analysis that serves to link them to the overall research aim. The methodology section outlines the philosophies underpinning this research as well as why they are appropriate. Explanations are also given on data types collected, the methods for collecting/analysing that data and ethical/risk considerations involved. Primary data is then presented with analysis that identifies and clarifies useful information. A conclusion is discussed using all acquired data in an attempt to answer the principal research aim. Finally, all references consulted are listed and the appendices stores all additional items.
2. Literature Review

2.1 Introduction
Augmented reality technologies have a large range of applications across a multitude of industries. The literature reviewed here will only concern applications comprising the scope of educational learning tools/resources with the caveat that other uses will be referenced only when they serve to aid in explaining and/or enhancing the understanding of topics covered in this research. The major areas of interest examined are the currently used AR methods, methods either proposed or in development and opinions from people regarding the effectiveness, feasibility, etc. of those uses. Of note is that as AR is an emerging technology the consulted literature largely contains method proposals and testing while there are substantially fewer sources detailing actualised uses because of the niche area AR technology was once constrained to.

2.2 Experimental nature of augmented reality technologies
Firstly, due to both the experimental and conceptual nature of most AR devices in the preceding 20-30 years, there are very few sectors where their use has been adopted in any significant capacity. This view is expressed by Regenbrecht et al. (2005) by stating ‘the real use of augmented reality (AR) is still in its infancy’. While this statement regards uses in industrial contexts, the sentiment expressed is corroborated by Medicherla et al. (2010) as they indicate the impact AR applications have on learning have only recently begun to be explored, the inference being that this area is also in relative infancy. Further to this, the timespan between these two sources and their nearness to current times serves to support the assertion made prior that AR is only just beginning to undergo developments of import.

2.3 Visualisation and sensory factors
A key focus on the topic of AR technology is on the visualisation capabilities it provides. Vision and the perception of information through objects is central to human analysis of the world, exemplified by the statement ‘The faculty of vision is our most important source of information about the world’ made in a leading text on neurology (Adams et al., 1997). Applying visualisation to educational contexts results in what are now commonplace practices such as images in textbooks, graphs to represent data, etc. with AR therefore serving as an extension of this established practice.
There is also research indicating that multi-sensory learning is more effective than single-sensory methods (Shams and Seitz, 2008), suggesting AR visualisation may have an effective role to play in this capacity. This is because the multisensory approach suits the notion of AR being a supplement to a larger group of learning tools/methods; its use as a supplement is more appropriate as congruent learning produces superior results as opposed to using a single method (Kim et al., 2008). The majority of AR uses however, focus on single sensory visualisation as multifaceted tools tend to have greater propensity for mixed results (Stone et al., 2009).

2.4 Cues and instructional aids
Lowe (2003) describes a caveat to visual learning however, that being the greater degree of complexity to it and the lower potential benefits a learner may receive due to lack of understanding/confusion of material. A resolution for this problem is via visual cueing, where basic aids are added to graphical representations such as arrows, highlights, circles, etc. An experiment conducted by Grant and Spivey (2003) where people were assigned a problem and made to solve it with and without visual cues concluded that there was an increase in correct solutions when using this technique. Research undertaken by Zhou et al. (2008) into the trends of AR development reveals that most AR works use cues to facilitate enhanced usability and user experience. The veracity of this claim can be backed by the fact the source studied premier international conferences on AR development over a decade which are likely to contain information from authoritative members of the field.

Visual cues can be expanded into providing users with hints and/or instructions via overlays as showcased in the works of White et al. (2007) and Srivastava and Yammiyavar (2016). The first work concerns how AR can represent user interactions with an object through overlaying e.g. if an object can be moved in a certain direction an overlay appears to indicate this. The study tested seven techniques for this and concluded that ‘ghosting’ and text annotations were ‘most preferred’ by testers; the study defines ghosting as the process wherein ‘an object is rendered semi-transparent to represent its past or future state’.
Srivastava and Yammiyavar (2016) have devised a system where an AR mobile/phone application is used to overlay 3D circuitry over an assembly breadboard alongside visual and audio instructions using a marker for detection purposes. While neither of the sources are industry leaders highlighting definitive applications, they are valuable examples of AR visualisation techniques. Interestingly, Zhou et al. (2008) express that marker-based methods were a first step in AR development that were quickly moved past to explore other research avenues. The paper also references the work of Zhang et al. (2002), who comparatively studied many AR marker systems and called them ‘widely used’. These points suggest marker methods are not a major focus of research anymore, but them being widely used implies a degree of feasibility that enables mass implementation; the more contemporary second source shows marker interest is persistent.

2.5 Marker and marker-less implementations

Of note is that the second system by Srivastava and Yammiyavar (2016) implements marker-based and mobile technologies. Marker-based AR is the use of small physical markers, such as small cards, that act as placeholders for software to detect and then display relevant/correct information (Johnson & Witchey, 2010). These markers display a virtual object when a corresponding AR device is directed at them. Marker-less technologies on the other hand utilise the local environment and objects within it as focus points. This type is demonstrated by Wu et al. (2016) with a system for object assembly and detection being handled by checking surfaces against a database. They also cite the work of Alvarez et al. (2011) in creating a marker-less disassembly tool using edge detection software. These systems have been developed outside of an educational context but are readily applicable for engineering disciplines where practical works/creating items may occur as part of the curriculum e.g. setting up a breadboard (Srivastava and Yammiyavar, 2016).

Kato and Billinghurst (1999) implement marker technologies into video conferencing whereby a user with a head-mounted AR display have a series of cards. These markers will display to the user other people in the video conferencing session, essentially acting as individual viewing screens. An accompanying virtual whiteboard allows the users to share annotations (text or drawings) with one another also, if applied to an educational context this would be considered collaborative learning which is ‘occurring in every discipline at every level of education.’ (Goodsell, 1992).
2.6 **Collaborative learning aid**

There are many studies that explore the role of AR to enhance this collaborative effect. AsBillinghurst (2002) explains, students work together better when their focus is drawn to a
common workspace as opposed to screen based collaborative settings. Emphasis is placed on
the benefits in behaviour that arise when a workspace is ‘a subset of the communication
space’, citing the work of Kiyokawa et al. (2002) who found shared AR setups produce a more
natural learning process.

Pemberton and Winter (2009) describe a system similar to the video conferencing experiment
of Kato and Billinghurst (1999) with emphasis on remote collaboration between students via
the display of objects during presentations. However, of detriment to both of these is the, as
Pemberton and Winter (2009) explain, “fundamental design issues’ of the required setups as
both applications need users to wear head-mounted displays (HMD) which proved
‘impractical’ in testing and, by association, would be impractical in commercial usage. Wang
(2009) also highlights a problem whereby collaboration can be stymied due to each individual
having an independent view of the AR material, thereby creating difficulty establishing a
common reference frame.

An alternative collaborative learning AR approach facilitated by mobile technology is
introduced by Lin et al. (2013). Their experiment teaches undergraduate students a scientific
concept through modelling, achieved by AR-capable mobile phones, named ‘AR Physics’, and
using multiple users to control differing sections of the model. When comparing the results
of this test with a control group using 2D models, they noticed a marked improvement in
learner understanding of the concept when using the AR Physics system. This is also
concluded by Pemberton and Winter (2009), who found AR techniques were ‘well received
and led to a deeper understanding’ of the subject matter they were testing with.
2.7 Further uses

Other subjects that have been tested with AR resources include the teaching of physics through the simulation of various forces (Buchanan et al., 2008) and geometry with the Construct3D system (Kaufmann and Dünser, 2007). In a 2005 usability evaluation on the Construct3D system, it was found that in the majority of cases student users rated the AR system more highly, in regard to factors such as usefulness, satisfaction, etc., than a traditional 2D based software. The majority of these applications point to enriched learning and understanding when using AR 3D modelling of what are traditionally text and 2D based taught concepts, indicating scientific education holds a great degree of potential AR adaptability/suitability.

Noll et al. (2014) have created an application that aids in dermatological education. Using a mobile device and markers that can be placed on the skin of a subject, overlays of different skin conditions corresponding to individual markers are shown with accompanying text/multimedia annotations. Another medical tool proposed by See et al. (2016) allows students to hear several types of heart murmurs through, again, a mobile AR device paired with a stethoscope. Both works suggest the use of AR can present students with diagnoses/findings that might otherwise be uncommon in real-life patient study, which results in practical teaching difficulties. Though this specifically addresses medicinal sectors an extrapolation could be made that AR may be useful for learning difficult to teach topics, for similar reasons of rarity, in other subjects.

Bauer et al. (2015) have used a commercially available Kinect sensor to overlay anatomical models on users for medical education purposes, this method is also demonstrated in other works (Bauer et al., 2014; Blum et al., 2012). The studies also hold speculative opinions that this application could also be beneficial in sporting education because of the ability to visualise things such as biomechanical movements.
White et al. (2001) broadened their research of AR in education by devising an entire teaching system directed at electronic system design. They focus on the modelling capabilities of AR with the example of creating a virtual breadboard for students to develop. They also propose a database for storing these designs as well as instructional tutorials for training on how to use the system software/hardware. They conclude by stating it is also suitable for other subject areas including architecture and sciences, as expressed and demonstrated in other works (Martin et al., 2011; Tonn et al., 2008; Wang, 2009).

2.8 Augmented reality books

Another medically focused tool makes 3D objects of human anatomy appear when a mobile device camera detects relevant pictures in a book. Juanes et al. (2014) state the widespread use of mobile devices in the medical community and universities, along with advantages of learning they provide, as reasons for creating this software. This AR book implementation is also mentioned in the work of Johnson and Witchey (2010) where they explain how a company is developing an AR compatible book for visualising geographical elements such as globes.

Dünser et al. (2012) demonstrate that the use of AR books in teaching electromagnetism concepts to students produced greater knowledge retention amongst AR users when compared against non-AR users. Thy also conclude that it is effective in teaching 3D concepts due to the interactivity afforded by them which is not available in traditional teaching methods. A variation on this book concept is shown in the research of Mackay et al. (2002) where AR is used to annotate user created text with links to other texts, online URLs, etc.; AR overlay functionality is used here rather than model visualisation.
2.9 Synergy of mobile and augmented reality technologies

The decision to use a mobile device is part of a greater research area of AR known as ‘enabling technologies’, defined by Azuma et al. (2001) as advances in any technology that ‘build compelling AR environments’. While this was defined many years before current mobile devices existed, the term can be applied to modern mobile technology i.e. smartphones as they are considered an emergent AR tool (Dunleavy, 2014; Line et al., 2013; Azuma et al., 2011). Additionally, this study identified mobile applications as a new developmental area of the time and mentions video cameras and handheld computers for potential AR integration. Extrapolating from this, the synergy of those two technologies is a smartphone considering almost all phones incorporate cameras capable of recording and have improved processing power when compared to phones from 2001.

A review of reports concerning technologies forecast for viable implementation in education, authored by Martin et al. (2011), ascertains that this type of AR application method could be applied to a variety of study areas such as arts, sciences like anatomy or any subject where modelling or simulation serves as a learning aid. Furthermore, another review by Azuma et al. (2011) declares ‘Mobile AR is one of the fastest growing research areas’ due to the saturation of smartphone technology and the computing power they possess which has allowed wide availability of AR experiences, backing the claim that it is an enabling technology. Johnson and Witchey (2010) even claim AR and mobile devices are on a convergence path and this factor signifies upcoming mainstream appeal.

2.10 Evaluations on augmented reality implementation methods

Regardless of the variety of AR techniques presented the implementation of them requires the support/motivation of both developers and users. Care must also be taken to avoid a ‘quick, unsubtle introduction’, as White et al. (2001) put it, into schools lest they overcrowd and disrupt the teaching/learning paradigm. Maclntyre et al. (2004) repeatedly refer to AR as a ‘difficult medium to work with’ although they also express the belief that ‘design exploration’ is the difficult factor rather than the creation of a finalised piece of content. They also report on the ‘immaturity of AR’ which correlates with Regenbrecht et al. (2005) discussing the lack of widespread AR deployment and concluding it is due to not reaching an appropriate ‘level of maturity’.
Another statement also relays that support for AR is not at a sufficient level for wide adoption, claiming ‘the final challenge is social acceptance’ (Azuma et al., 2001). Krevelen and Poelman (2010) assert this when saying there are a myriad of factors that need addressing before AR is socially acceptable. Together, these statements indicate the need for greater support and understanding of AR, but as the majority of sources are from roughly the same general time period where AR development experienced a lull relative to now they might not be considered overly definitive declarations.

Beyond this, Billinghurst et al. (2009) consider a need for more research and analysis of the interaction methods these technologies use if they are to enter mainstream appeal, with users needing to be able to ‘to interact with AR content in a much more intuitive way’. HMD devices have several major drawbacks ranging from the cumbersome nature of wearing them, limited field of vision (FOV) and their intrinsic unsuitability for group use (Zhou et al., 2008) An educational institution would therefore need to acquire multiple HMD units if they were to be anything more than a novelty and users may find wearing them uncomfortable, factors that discourage their use from both a faculty and student perspective. HMD technologies have been able to be developed since the work of Sutherland (1968) and the indication that problems still persist with them after such a large time span shows research into other interaction methods is more worthwhile.

Kato and Billinghurst (1999) state, regarding one usage method in their test, ‘interaction with the real world is a little unnatural’ and another method was also described in a negative connation by saying ‘image registration requirements are a lot more challenging’ due to extremely precise HMD calibration being needed. A point to consider is that HMD AR tools seem to generate operational difficulties thereby lessening the prospect of wider use in any context, let alone an educational one.
An alternative to HMD AR is shown by Krevelen and Poelman (2010) in a survey that documents using projectors in conjunction with AR. In contrast to a HMD, they require no specialised eye-wear and have much greater FOV, covering wider areas. Projector usage is already in place across educational facilities so there is greater adaptability of this technology than HMD. The inherent limitation of indoor use still applies however, due to viewability issues i.e. uncontrollable outdoor lighting conditions may interfere with a projection. Also, calibration between the projector and marker could be disrupted if any changes to local surroundings were made.

Henrysson and Ollila (2004) state that ‘Marker-based optical tracking gives accurate results but is limited by the visibility of the marker’. This accuracy generally comes about because there is a fixed centre point for AR systems to calculate where to display objects, whereas marker-less systems must rely on environmental spaces that may be subject to change (Endsley et al., 2017). Of course, this problem could be offset through adequate instructional guidance from teaching staff to users but this does not completely remedy the issue unless a controlled environment is maintained. However, as Johnson and Witchey (2010) point out, marker-less systems have wider applicability as they are not restricted by relying on specialised equipment. Regarding markers, another problem exists wherein they could simply be misplaced/lost/damaged which is more liable to occur in busy settings such as a classroom as opposed to a testing environment used in a scientific study.

As considered by Billinghurst et al. (2009), there are limitation to mobile AR in terms of input options, resolution/graphics and processing power when compared against desktop powered or HMD devices. However, the ubiquity of mobile devices and ‘massive use’ of them by students (Juanes et al., 2014) and aforementioned current interest in mobile AR development means these limitations may not be as off-putting in comparison to those presented by HMD AR. Juanes et al. (2014) also express advantages through the lack of location restriction on mobile AR, cheapness relative to other hardware like desktops, collaboration, portability, etc. They describe caveats however, in the form of limitations of mobiles themselves such as battery life and screen sizes/resolutions and so on.
AR books are another interaction method worth consideration because essentially all universities use books in some form. Another major benefit of using books is that they do not need extensive training to use and that they may offer familiarity to students, decreasing chances of confusion in their function/use. Although, as Dünser et al. (2012) concede, the development of these books requires expert skills in programming and modelling the content which lowers the mass-market availability to a high degree. They also explain an imbalance of research where methods of creation for the books are overlooked in favour of research into their theoretical potential. This lack of research is a more generalised issue with all AR creation because of the lack of necessary hardware/software to facilitate development in the past however.

2.11 Conclusion

The reviewed literature shows that the visualisation AR provides through modelling and overlaying is effectively able to teach users in both practical experiments as well as in teaching concepts; this is applicable to a diverse array of subjects. However, the various interaction methods (HMD, mobile, etc.) used for these applications have several drawbacks that prevent adoption on a large scale and present boundaries that need to be overcome before institutions implement them. Mobile device usage however, because of their ubiquity, has less associated drawbacks and is of greater research interest.

Of particular notice is that the studies generally forgo thoroughly evaluating feasibility constraints. Instead, they focus on describing educational challenges AR can improve learning with over traditional methods. Additionally, the studies that directly ask student testers on their opinions of the technology fail to address whether they would actually like/want to use the them in their education beyond the scope of the testing environment. Teachers are likewise not consulted regarding their opinions on the tools and/or how they can modify a teaching approach. The primary research of this study therefore serves to target this gap and focus on attitudes of the various AR tools as opposed to their design and results they can produce.
3. **Methodology**

This section outlines the philosophical perspectives used throughout the research. It also details the methods of collection/analysis for primary and secondary data. Additional consideration is given to both the ethical considerations and risks of performing this study.

3.1 **Research Design**

The overall research philosophy this project follows is one of pragmatism, with integration of elements from ontology, epistemology and axiology also being present. As Saunders et al. (2009) point out by saying it is ‘perfectly possible to work with variations’, the pragmatic paradigm eschews favouring one particular approach over another and allows for a more adaptable/inclusive research methodology. Subjectivity and interpretivism have been borrowed from ontology and epistemology respectively as they suit the evaluative approach of this study and influence the primary data collection process. Objectivity is also applied to that collected data through the measuring and analysis of it.

Firstly, the evaluative nature of this study utilises the element of axiology wherein the researcher analyses/judges values (Hartman, 2011; Saunders et al., 2009). In this case, the value being analysed is the merits of AR educational applications. Another axiological factor of this study is that the chosen topic, collection methods and even the chosen philosophies themselves ultimately stem from what the researcher has deemed of importance/‘intrinsically worthwhile (‘Heron & Reason, 1997).

The axiological philosophy underpins a larger, more prevalent body of subjectivity. As an evaluation, there is inherent subjectivity stemming from the opinions of the evaluator, both throughout the study and especially in regard to any conclusions made. As Saunders et al. (2009) point out ‘phenomena are created from the perceptions and consequent actions of social actors’. This links directly to the purpose of the primary data gathered in this study, which is being used to determine AR feasibility (phenomena) based off of, in part, staff and student (social actors) opinions of it. Considering this, the use of an objectivist slant seems unsuitable at this stage due to that philosophy presupposing ‘an independent reality that can be grasped’ (Ratner, 2002); evaluating what people think of something is dependent.
Additionally, the process of determining an appropriate sampling demographic for this is based primarily on what the researcher believes to be the most viable/useful group in producing relevant and informative data. Choosing the correct sample requires an understanding of ‘their world from their point of view’ (Saunders et al., 2009) to gauge if they their perspectives are relevant, bringing this closer to an interpretivist mindset. Further determinations are made when performing secondary research in that sources are judged by the researcher in a largely subjective manner and the analysis of those same sources is likewise subjective/interpretive.

There are cases of objectivity concerning primary data. The collection/analysis of quantitative data via questionnaires simplifies abstract, subjective opinions into simpler to understand data by having answers that can be quantified and objectively measured through statistics. These statistics aid in discovering an independent reality (Saunders et al., 2009) exempt of subjective biases. Another area where objectivism is used is in the interview process. The researcher must maintain an objective stance while conversing with an interviewee in order to avoid/reduce bias influencing the types of answers given. Finally, using interviews and questionnaires aligns with an interpretivist approach as it concerns seeking a reality via ‘social constructions such as language, consciousness, shared meanings, and instruments’ (Myers, 2013).

A largely deductive approach is taken throughout the study as this involves attempting to confirm a hypothesis through testing (Saunders et al., 2009), in this case the theory being tested is whether AR can be an effective learning tool. The data reviewed and generated in this study is therefore used to logically deduce an answer to that initial topic i.e. does the data show it can be used as a learning tool or not? An element of inductivity is also present when analysing the data. This is because the data analysis consists of identifying and reflecting on the themes/patterns presented by it, something Saunders et al. (2009) states as inductive; the pattern recognition also incorporates inductive thinking (Arthur, 1994). This combined approach could be considered as being abductive because that approach combines inductive observations and deductive inferences (Gregory & Muntermann, 2011).
### 3.2 Data Collection

The data collection conducted for this research follows a mixed-method procedure with qualitative and quantitative datasets being gathered. Qualitative data collection consists of interviews and the quantitative collection utilises questionnaires. Using this mixed approach suits the principles of pragmatism regarding the combining of approaches, Tashakkori and Teddlie (1998) support this idea when explaining ‘the paradigm says that these ‘methods are compatible’. Saunders et al. (2009) further corroborate this mixed-methodology, claiming it is ‘possibly highly appropriate, within one study’. The collection of secondary data focuses on finding literature relevant to the topic of AR within education as well as sources beyond this scope if they can contextualize and increase understanding of that topic.

### 3.3 Primary Data

One form of primary data is collected in a qualitative manner using semi-structured interviews of faculty staff at University institutions. These interviews are audio recorded for later transcription and analysis and the participants are anonymised for confidentiality purposes.

Interviews have been used as they are considered a leading primary research method (Doody & Noonan, 2013; Schultze & Avital, 2011). They are also useful for ‘generating situated accounts of people’s experiences’ (Schultze & Avital, 2011) which is highly appropriate for the purposes of conducting staff interviews; they are aimed at generating data from faculty attitudes based off of their experiences. The semi-structured approach also allows for flexibility in questions and topics to better generate useful data i.e. the loose structure allows for more free-flowing conversation and can open up new discussion topics not covered in the pre-prepared questions.

Upon fully transcribing each interview they will be analysed in the style of thematic content analysis which is focused on identifying trends, patterns and themes within the dataset, combining the separate approaches of thematic and content analysis (Vaismoradi et al., 2013). These trends and/or points shall be further analysed to determine what specific reasonings are behind them. Additionally, unique answers will be highlighted if they offer salient information; only utilising trend analysis would inherently restrict potential results. This analysis is presented in a narrative style i.e. a theme/point is discussed and then another point until all identified information has been discussed.
Non-probability purposive sampling, where people are targeted because of ‘the qualities the informant possesses’ (Tongco, 2007), has been used for this. As the research concerns the areas of both education and AR it is appropriate to consult with university staff specialising in the computer science/information systems field. Consulting university staff is also more ideal as, broadly speaking, they are likely to have more industry knowledge and experience than someone from the same field teaching at, for example, a secondary school. While staff in other fields may hold knowledge/experience of educational AR, and if so they are a viable sample member, computer science staff have a greater likelihood of having relevant information. The sample size therefore, is set between 3-10 people because of the smaller population with the specialised knowledge being sought.

Interviews are conducted in a face-to-face manner as opposed to a telephone interview. Travel costs were inconsequential in regard to the interviewer because the interviewees were consulted in the same general geographic area; face-to-face was a matter of convenience. Another factor is that telephone interviews may increase the chance of technical or ‘unanticipated problems’ (Stephens, 2007) and potentially be shorter than face-to-face interviews (Irvine, 2011); shorter interviews may lead to less data being gathered. Finally, as the subject topic is relatively uncontroversial there is less likelihood of respondents being uncomfortable with expressing their opinions in person.

Quantitative data through the use of questionnaires is also incorporated into the primary research. These are likewise anonymous and target the student demographic. The justification for questionnaires over interviews is that a presumption can be made that students will generally have less in-depth knowledge on the topic field in comparison to faculty. Another, more relevant reason is that the questionnaires serve to provide statistical data that either does or does not show support for AR implementation based on student attitudes of its various potential applications, this type of data is far easier to quantify through a questionnaire.
The results from this gathered data will be collated together and the answers for each question are calculated to give a percentage. This is done to all answers of categorical and ranked/Likert scale data types which are then analysed similarly to numerical data (Sauders et al., 2009). These totals are then converted into statistical graphs to better display the various responses and more easily identify any potential trends in the data. Open-ended questions, due to the lack of predefined answers, cannot be displayed graphically and will instead be analysed by identifying any key points/trends or answers with noteworthy insight into the topic. If there are groups of respondents from several courses then a sub-analysis of each will be performed. This is done to detect any similarities in answers within those groups and differences to others i.e. do students from course ‘X’ answer differently to students in course ‘Y’?

As with the interviews, purposive sampling has been used through the targeting of students within a university setting. There is also an element of convenience sampling in that, like university faculty, these students are readily accessible to the researcher. The sample size being used for this is between 30-40 respondents as this level provides sufficient data to identify trends/general sentiments among the demographic; larger quantities than this are ideal but are less realistically achievable i.e. hundreds of responses generates better results but that high of a response rate is unlikely to occur. The large sample size also serves as justification for choosing students, in addition to the educational context of the study, as the number of responses needed is likely to be obtained considering the large student population; questionnaires rely on the principle of ‘take what you can get’ (Bernard, 2017).

A small pilot test of the questionnaires is conducted to ensure it ‘measures what it claims to measure’ (Boynton & Greenhalgh, 2004). An initial questionnaire was created and given to an external entity as a test to determine the suitability of questions. Analysis/feedback given by the reviewer allowed for an updated questionnaire with more appropriate questioning and, by extension, answers fitting closer into the scope of this research.
3.4 Secondary Data

To provide an informed context/foundation for the topic and organise several concepts within AR research (Rowley & Slack, 2004; Okoli & Schabram, 2010) a literature review of relevant secondary sources is conducted using a ‘multiple-source secondary data’ approach, as Saunders et al. (2009) refer to it. Multiple-source research incorporates both standard documents such as journals along with survey-based data. This research focuses largely on different AR tools in conceptual, tested and realised stages and evaluations of them. These may only be taken from institutionally approved sources and come in the form of reports, journal articles, conference proceedings, etc. and can include written and non-written information. These are used as they maintain a standard of professionalism and industry/academic credibility as opposed to information taken from, for example, a website page without peer review.

Any and all information used from these will be explained and analysed appropriately. This analysis consists of firstly, explaining what AR research area the source is involved in and then describing relevant information within it. This information consists of detailing uses of educational AR and any evaluations of those uses. The sources are also corroborated with one another in an effort to increase understanding of any points they make.

Correct referencing practices are used throughout, Harvard style in this case, to provide acknowledgment and further reading material. Referenced material is indicated alongside the text analysing/quoting the source and can be found in a bibliography. The information is incorporated into the work through a combination of direct quoting, paraphrasing and summarisation. All material that is directly quoted is indicated to prevent plagiarism. Any non-written text, such as an image, used is appropriately labelled as a figure and cited both in the study body as well as sourced in a separate figures section.
3.5 Ethical Considerations

To effectively perform this research numerous considerations must be taken into account, especially relating to primary research. Firstly, all participants must be given a full briefing as to the extent of their involvement in this project along with what the project itself entails along with a declaration stating their voluntary acceptance. This is achieved through the use of information sheets and consent forms (see Appendix 6.2 Participant Information Sheet & 6.3 Participant Consent Form) that facilitate informed consent, which is imperative in research involving participants (Steane, 2004).

Adding to this is to allow any participant the ability to request any data collected from them be removed for any reason. Any and all data concerning the participants must also be stored safely and kept private to ensure anonymity and work in accordance with laws/regulations such as the Data Protection Act 1998 (hereafter referred to as DPA). The use of participant anonymity is done to ultimately respect the right to privacy an individual has as they may not want their opinions being revealed publicly (Behi & Nolan, 1995). In this case, all data collected will only ever be reviewed by the researcher and any data that is shared will only be done so through the findings presented in the study itself without identifying individuals, in accordance with their consent.

All secondary sources referenced in any section of the study must be sourced, using Harvard style referencing, so as to avoid instances of plagiarism and give correct acknowledgement to the author(s) of those works.

Furthermore, transparency/honesty regarding the content of the study must be ensured, that meaning exaggerations or fabrication are to be completely avoided. This extends to the research practices as aforementioned which is achieved through information sheets and consent/acknowledgements. Biases on the part of the researcher must also be avoided as much as is possible; subjectivity is ever present as part of an evaluative study but explicit bias such as ignoring unfavourable findings should be avoided.

Finally, this study has been approved by and identified with the ethical reference 2016D5650.
3.6 **Study Risks**

This study contains several small-scale risks associated with it; small-scale in the sense that highly sensitive data is not being gathered and physical dangers from hazardous environments or people are extremely unlikely to occur. Regardless, precautions such as conducting interviews in public spaces and pre-arranging times, along with informing others when/where they will take place are taken for the reassurance of both interviewer and interviewees.

Additionally, care must be taken to ensure all data collection, handling and storage/use follows established laws, like the DPA, and organisational guidelines. Confidentiality of all participants from both datasets must also be maintained throughout the duration of the study as well as after. The first point can be mitigated by simply consulting and adhering to laws/regulations and the second can be resolved by not disclosing personally identifiable information to anyone and keeping it securely protected.

Another risk potentiality is that data may be lost and/or corrupted which greatly impedes the progress of the study. The collected data itself may also not be adequate for research purposes and be unreliable as can secondary sources used which may contain inaccurate/misleading information and/or come from an unapproved source. To prevent these, backup copies of work will be stored and secured and all sources consulted will be checked for professional standards e.g. peer reviewed, recognised publisher(s), etc.

4. **Primary Data Analysis**

4.1 **Interviews**

The first piece of analysis concerns 7 interviews conducted with faculty of a university. The following excerpts are taken from interviews that can be found, fully transcribed, within the appendix of this work. Several common themes have been discovered through analysis of them.
4.1.1 Relative Inexperience in using AR
Firstly, of interviewed faculty a prevailing finding is that they have only used AR tools in a limited fashion. Some have only experienced “the odd demo” (Interviewee 6, Line 93), simplistic tools or AR for entertainment purposes (Interviewee 1, Line 128; Interviewee 4, Line 46). Others used mobile AR (Interviewee 1, Line 134; Interviewee 3, Line 61), with mixed opinion, as one person evaluated it as “a bit basic” (Interviewee 3, Line 59) and another said it was of interest (Interviewee 1, Line 135) in comparison to a Google Glass headset or an overlaying tool. This is important as the lack of experience may influence faculty decisions regarding whether to utilise AR or not, as staff may not use a new technology due to being unable to “see the benefit of it” (Interviewee 2, Line 79).

Another staff member describes past experience on developing an AR tool in 1992-3 (Interviewee 5, Line 95) and also in working with students to develop it in 2008 as an interactive media designer (Interviewee 5, Line 110). The final sample member is currently experimenting with AR for use within their course, specifically for prop-based modelling (Interviewee 7, Line 155).

4.1.2 Lack of Knowledge on use of AR by Others
Regarding their knowledge of others using AR, there are only a small number of mentions. 3 participants were able to explicitly identify instances of AR use at universities. Firstly, the University of Lancaster (Interviewee 7, Line 171) is using AR modelling in medical related courses, a Glaswegian university uses it within a Master’s course relating to virtual worlds/environments (Interviewee 5, Line 115) and the University of West England uses it in “their School of Architecture and Environmental Health and Design” (Interviewee 1, Line 166). Some faculty also believe AR is used in their universities Health and Sport Science (Interviewee 1, Line 156) and Art and Design (Interviewee 4, Line 64) schools, although they only allude to this potentiality.

These findings identify a lack of commonplace or well-known AR adoption by universities, to be expected with the aforementioned early stage nature of the technology. The uses of it in medical and architectural qualifications are corroborated with various studies (Noll et al., 2014; See et al., 2016; Bauer et al., 2015; Bauer et al., 2014; Blum et al., 2012) and works that address AR suitability (Martin et al., 2011; Tonn et al., 2008; Wang, 2009).
4.1.3 Need for Training v Intuitive Design Practices

Regarding training, there is a divide between believing training is necessary and those believing AR should instead be intuitively designed. It is identified that training is a requirement for covering health and safety guidelines (Interviewee 1, Line 190) as well as it being useful for knowing “how to use it” (Interviewee 1, Line 199) or the best way to use it (Interviewee 2, Line 59). Also, any learning tool used must have accompanying training (Interviewee 6, Line 103) but a particular problem exists wherein “staff participating in voluntary training can be quite challenging” (Interviewee 6, Line 106). This presents a possible issue for AR where the technology is available but not used to its full potential because of unawareness on how to use it. That suggestion is corroborated with the statement that the “majority of people don’t use” (Interviewee 2, Line 76) new technologies, instead relying on/preferring tried and tested methods (Interviewee 2, Line 83).

Little mention is made as to whether students need training, with one admission that many do not receive it for most currently used technologies (Interviewee 6, Line 109). However, there is a suggestion it would be useful in preventing shock via exposure to an altered environment (Interviewee 4, Line 71). The need for student training is also identified in questionnaire analysis (see Figure 14). Staff that directly train students believe that, ideally, any tool should be able to be learnt in “about 5 steps” (Interviewee 7, Line 191) and that “anything that needs training defeats itself” (Interviewee 7, Line 194). A similar attitude is expressed by others who believe AR should not need training as long as it is intuitively designed (Interviewee 3, Line 80; Interviewee 5, Line 121). This is difficult however, as AR does not have design standards set yet (Interviewee 3, Line 83). Overall, it appears training would be needed in some capacity for educational AR but problems may arise from lack of staff participation and the stretched budgets of universities not being able to support it (Interviewee 6, Line 105).
4.1.4 High University Suitability but Uses Need Defining

As to where AR can be applied in universities, there is an element of vagueness as to areas faculty think it can be applied. There is an admission to having vague ideas about where to apply it but, also state they cannot think of any limits within their university for it (Interviewee 6, Line 133). This lack of limits to implementation across a wide range of subjects (Interviewee 5, Line 128) can also be espoused through a sentiment of “a lot of scope” (Interviewee 7, Line 202) so long as ideas can be generated and developed (Interviewee 1, Line 205).

Specifically, a common consensus is that medical, sport, science and engineering area may be best suited to AR. Support for medicine (Interviewee 2, Line 88; Interviewee 4, Line 91; Interviewee 6, Line 137) focuses on the ability to overlay information (Interviewee 3, Line 108) and model (Interviewee 7, Line 201; Interviewee 4, Line 99) in anatomical study, particularly as a cheap alternative to medical props (Interviewee 7, Line 204). The medical side is extrapolated to sport related fields by some (Interviewee 6, Line 137; Interviewee 7, Line 200) and includes mention of massage, therapy, podiatry or “anything medical that involves props” (Interviewee 7, Line 199); anatomical uses are evidenced in several studies (Bauer et al., 2015; Bauer et al., 2014; Blum et al., 2012; Juanes et al., 2014). Additionally, Interviewee 7 relayed having discussions with a colleague about the potential of modelling for dental courses (Line 179).

Science courses are only briefly mentioned (Interviewee 4, Line 91; Interviewee 6, Line 137) but this still correlates with some studied applications (Lin et al., 2013; Buchanan et al., 2008; Kaufmann and Dünser, 2007). Amid mentions of engineering uses (Interviewee 2, Line 88; Interviewee 1, Line 135), specific examples of overlaying internal car mechanisms and in construction education are made (Interviewee 3, Line 108; Interviewee 7, Line 155). Other engineering uses have been discussed in this study (Srivastava & Yammiyavar, 2016; Wu et al., 2016; Alvarez et al., 2011) and the fields are identified by others (Martin et al., 2011; Tonn et al., 2008; Wang, 2009) as AR applicable areas.
Overall, what can be seen is that courses with practical elements or “visual input” (Interviewee 2, Line 89) within them are better suited to AR whereas the lack of mention of subjects which do not feature this, business or language courses for example, suggests they may not be applicable there. Questionnaire responses for this study (see Figure 9) also indicate this.

4.1.5 Suitable as a Disability Aid
Inquiries have also been made as to the effectiveness of AR as a supplementary disability aid. It can be challenging in adapting course content for students with disabilities, particularly audio and visual ones (Interviewee 4, Line 28), therefore AR may have some use here due to its visualisation aspect. Statements from the majority of interviewees (Interviewee 2, Line 101; Interviewee 5, Line 168; Interviewee 3, Line 113; Interviewee 6, Line 142; Interviewee 7, Line 225) support this particular notion. There is discussion on how those with dyslexia could benefit through the replacement of textual material with visuals (Interviewee 3, Line 117) or supplementing text (Interviewee 6, Line 150), somewhat similarly to the work of Mackay et al. (2002), respectively. Information overlays may also have potential in aiding those with autism spectrum disorders (Interviewee 6, Line 143).

The possibility of having a catalogue of scanned AR models stored for use by remote learning students, with or without disabilities, is also discussed (Interviewee 7, Line 160; Interviewee 1, Line 175), although this is offset with the belief it would not “make much of a difference” (Interviewee 7, Line 239). Also, there is consideration for providing students “material in a way that’s appropriate to them” (Interviewee 1, Line 67), as faculty must aim to cater to people with different learning styles (Interviewee 7, Line 249; Interviewee 1, Line 68).
Feasibility problems may arise however, as “the onus is very much on the teaching staff” (Interviewee 4, Line 38) concerning implementing/developing course content to factor in disabilities (Interviewee 3, Line 43; Interviewee 1, Line 66). This leads to staff having extra work (Interviewee 4, Line 39) and finding it “almost an impossible task” (Interviewee 1, Line 76) to cater to the complete range of disabilities. Another effect of this is staff essentially act on “their own goodwill” (Interviewee 1, Line 90) or are forced to rely on experts (Interviewee 4, Line 40) to facilitate this. These findings could indicate difficulty in using AR for disabilities as staff find it to be yet another tool they must figure out ways of incorporating without having the expert knowledge to do so effectively. Another difficulty could arise from faculty only creating material “the day before” a class (Interviewee 1, Line 109), meaning there may be a problem of poor adaptability when using an AR tool.

4.1.6 **Supplementary v Independent Tool**

A small conflict is shown to the idea of using AR in a supplementary manner. Certain faculty believe that the technology should focus on redefining (Interviewee 1, Line 248) their teaching strategy over substituting, augmenting or modifying as per the SAMR model. This is summed up as “why go and change it when we know it works?” (Interviewee 1, Line 250), which resembles the behaviour of staff using “tried and tested” (Interviewee 6, Line 29) methods over others. However, the majority of staff explain it should be used as a supplement (Interviewee 7, Line 223; Interviewee 4, Line 120; Interviewee 6, Line 160). They believe that tools are meant to work together (Interviewee 6, Line 164) and be used in a collaborative manner (Interviewee 4, Line 120); ultimately educators should have “lots of tools in your toolbox” (Interviewee 1, Line 59).

Considering this, it appears that AR can easily find a role as a supplement in education with a focus on being used in collaboration with other tools. Although, some would much rather it focus on altering the teaching dynamic completely but, this goes against the observed behaviour wherein staff generally stick to traditional methods such as pen and paper or simply talking (Interviewee 2, Line 80; Interviewee 6, Line 166).
4.1.7 Costs of Implementation

Initial financial investment appears to be a mixed point of contention. Some staff believe AR to be relatively cheap (Interviewee 2, Line 107; Interviewee 5, Line 162; Interviewee 7, Line 264) whereas others express concern for equipment cost (Interviewee 4, Line 144) and in hiring experts to develop tailored applications (Interviewee 3, Line 127). It can be noted that the interviewee expressing concern for equipment costs does not have much experience with AR whereas those believing it to be cheap have greater experience. This may suggest that, overall, AR is believed to be cheap as this is expressed by those with more authoritative knowledge of the subject. Also, there are concerns for costs beyond the initial implementation. This includes maintenance of equipment (Interviewee 2, Line 111) and hiring/training a support team for it (Interviewee 4, Line 86).

Essentially, there is greater concern for ongoing costs of maintaining the technology over initial setup costs. This is in an effort to make sure that AR is “sustainable” (Interviewee 2, Line 113), which is done for all technologies used (Interviewee 2, Line 115). It can also be mentioned here that universities in particular are best suited to using new technologies because they push boundaries and are “ideally placed” for experimenting with them (Interviewee 6, Line 120).

4.1.8 Other Feasibility Factors

Finally, other feasibility concerns have been identified. The first is that any AR tool should be amendable for numerous different educational uses, as faculty “want to tailor” (Interviewee 1, Line 224) items they use. Another issue is that clarity must be given regarding the limits and “technological barriers” (Interviewee 4, Line 144) of AR as part of “managing expectations” (Interviewee 3, Line 131). This ties in with the aforementioned finding that many staff have somewhat vague ideas about how/where to apply the technology.
Another issue is difficulty in software availability and the simplicity of it is a “primary obstacle” (Interviewee 7, Line 263). Certain faculty feel they are restricted by their level of “technical expertise” (Interviewee 7, Line 227), although lecturers in computer-based courses may not have this difficulty (Interviewee 2, Line 73). There is also an element of difficulty in “integrating the app software with the learning platform” (Interviewee 7, Line 270), in this case Moodle. This may be a larger scale problem as multiple courses may use the same virtual learning environment, which AR cannot integrate with.

There is also concern wherein collaborative learning with the technology may lead to a loss of control of student activities as they “wander off” (Interviewee 1, Line 143). A solution is proposed however, through the hope of seeing a system by which staff can monitor what individual students see in the AR environment (Interviewee 1, Line 145). Other emergent tools within this technological area such as virtual reality have however been implemented for group work successfully (Interviewee 7, Line 56).

4.2 Questionnaires

Questionnaires have also been used for data collection/analysis with a total of 54 responses having been acquired. This analysis focuses on key interest areas based off of those results, which can be found, alongside the questionnaire itself, in the appendix of this work.

4.2.1 Participant Breakdown

Initial questions focused on both what course the respondent was studying as well as their year level (1st, 2nd, 3rd or postgraduate) in order to establish and ensure participants were of the target demographic, in this case a student population.

As Figure 2 shows, respondents come from a diverse range of subjects which therefore enables greater answer diversification. This is beneficial to the study as it generates results pertaining to AR usage within a variety of courses rather than being constrained to only one, for example. A caveat to these results is that, because of that diversification, many courses have very small respondent numbers; 10 of the 21 courses only have one respondent each. This dramatically limits the ability to extrapolate this gathered data, although an argument can be made that generalising the courses into meta groups may offset this somewhat e.g. sport related courses could be identified as a single group.
Additionally, the majority of participants (68.5%/37 individuals) were in the 3\textsuperscript{rd} year of their course. An assumption can be made that these students are more likely to have a better understanding of course content and how AR use can factor into it as a result of more exposure through time. Remaining participants consist of 10 (18.5\%) 2\textsuperscript{nd} year, 4 (7.4\%) 1\textsuperscript{st} year and 3 (5.6\%) postgraduate students.
4.2.2 Course Breakdown of Diagram/Model Use

**Figure 3: Physical model creation across courses.**

**Figure 4: Model & diagram interaction across courses.**
Further establishing questions were asked regarding whether people create physical models and/or interact with models and diagrams as part of their course often. This was done as the questions relate to the uses of AR described in the literature review of this study, specifically modelling. Asking if these interactions were ‘often’ was done to find courses where they occur regularly; if done rarely then AR use in these courses would be a novelty and could be construed as decreasing implementation feasibility. This can be supported with the statement “take it beyond the gimmick”, espoused by a university lecturer regarding wide scale adoption of AR (Interviewee 7, Line 203).

39 (72.2%) people stated they do not create models and only 15 (27.8%) stating they do. Amongst those that said ‘Yes’, they primarily come from art and computer/engineering-based courses, as shown in Figure 3. Regarding model/diagram interaction, 34 (63%) said they do and 20 (37%) do not. A breakdown of this (Figure 4) shows art, computer/engineering, sport and medical-oriented courses utilise these often whereas English and Business courses do not.

4.2.3 AR Instructional Tool Usefulness

3 different AR uses were then described and participants were asked to rate their overall effectiveness/applicability to their course. The first regards an AR tool that would overlay instructional steps to building an object.
Analysis of these responses focuses on those that said they do build models as part of their course (see Figure 3). This is because the use of this tool holds greater relevance to those people as opposed to those without model building in their course. Of the 15 that do build models, they rated the effectiveness of the tool mainly on a 3-5 scale (neutral to very effective) with only 3 rating below that. An interesting result is that 21 of the 39 who do not build models also rated its effectiveness between 3-5, suggesting that even those on courses where the tool would be less relevant still regard it as useful in some capacity. Of the 18 that rated it ineffective, it could be assumed they did so, in part, due to the irrelevance of the tool to them.

4.2.4 AR Diagram Tool Usefulness

The second tool consists of showing a 3D representation of a diagram/model and providing text and/or audio description of it.
Similarly, to the first tool, those that said ‘Yes’ to interacting with diagrams in their course had their rating of this tool cross referenced due to the greater relevance it has to them. A majority of 22 rate the tool as effective to very effective (4-5) and 12 rate it in the 1-3 range. Further, 12 of those who answered ‘No’ to diagram interaction also rated it in the 4-5 range, with 8 answering anywhere from 1-3. An indication therefore, is that courses with diagrammatic content (engineering, medicine, sciences and art) would find this tool beneficial.

4.2.5 AR Hologram Tool Usefulness

Finally, a tool that generates holograms of objects and replaces having access to a physical version was queried. Sub-analysis of both model builders and diagram interactors was conducted as the tool bears a relatively equal degree of relevance to the subsets.
Figure 7: Usefulness of AR holograms (model/diagram user rating).

Figure 8: Usefulness of AR holograms (model creator rating).
Firstly, 25 diagram users and 14 non-diagram users rated the tool from 3 and above, indicating a 3D hologram would be of benefit to them. Of the 15 that build models, 12 also rated it in this manner. Both subsets had low numbers of responders that rated the tool as ineffective, 9 and 3 respectively. Of note however, is that regardless of the students’ perception of effectiveness, holograms have a problem where the “fidelity of it isn’t very good” (Interviewee 5, Line 154) These two points show contrasting feasibility wherein the student population would find them effective but there is a limitation in the technology that might, in practice, sway that opinion i.e. fidelity problems could potentially reduce rated effectiveness by the students.

Overall, each of these tools has been evaluated by students as generally effective, in some cases even regardless of how relevant that tool is to them, see Figures 5 and 6. Students were also asked how much course content these tools could be applicable with, using general increments of 25%. This general range was chosen as it is ultimately difficult to quantify/evaluate tool applicability with course content.

4.2.6 Course Content Applicability

Figure 9: Applicable course content estimations for AR tools.
As Figure 9 describes, English and Business courses find low levels of applicability with the tools, presumable because they neither create models or interact with them or diagrams often (Figures 3 and 4). Art and computer/engineering courses show a mixture of applicability, with 11 believing up to 25% of course content is applicable and 14 thinking up to 50% is. Also, medical courses find up to 75% of content applicable.

In terms of content it can be applied to, computing courses use a variety of diagrams and graphical representations/simulations because of the usefulness modelling provides (Interviewee 1, Line 19), an area educational AR is focused on. Also, there is an indication that AR could aid in the teaching of computer hardware (Interviewee 4, Line 117) and that “some modules especially” (Interviewee 6, Line 134) may be suitable for it.

For medical courses, it may be that the modelling and 3D actualisation of anatomy (Interviewee 4, Line 96; Interviewee 7, Line 201) may be applicability areas e.g. overlaying skeletal structures (Interviewee 3, Line 108), as several works demonstrate (Bauer et al., 2015; Bauer et al., 2014; Blum et al., 2012; Juanes et al., 2014).

4.2.7 Tools with Similar Functionality

Following these descriptions, students were asked if they were aware of other tools that provided similar functionalities and if those were part of their course.

![Figure 10: Perception of similar functionality in other tools.](image-url)
14 (25.9%) of them said they were aware of other tools with 11 expressing virtual reality as one, with 2 stating it was because of its ability to show/display 3D models. 4 cited CAD, with 1 additional mention of Blender, as being similar for aiding in digital mock-up creation; 3D printing was mentioned as being used alongside CAD in Art and Design courses. Virtual reality was mentioned as not being available on courses by 3 people but, no further mentions were made regarding course availability. It should be highlighted however, as pointed out by 1 respondent pointed out, AR and VR use “different methods” (see Appendix 6.4.20 If yes, are they part of your course and/or what are they?) of interaction to perform these tasks. VR requires the use of headsets, equipment that has been critiqued repeatedly (Pemberton & Winter, 2009; Kato & Billinghurst, 1999; Interviewee 5, Line 156; Interviewee 1, Line 182) whereas AR does not, albeit some applications do use them.

4.2.8 Frequency of AR Tool Usage

![Frequency of AR usage amongst people that would like to use it](image)

*Figure 11: Frequency of AR tool usage.*

A follow-up question of whether they would like to use the described AR tools or others was asked. 41 (75.9%) of the population said they would and 8 (14.8%) were unsure, with only 5 (9.3%) replying “No”. “Yes” and “Unsure” answers were cross-referenced with results from a question about the frequency of use for those tools (Figure 11).
As seen, 16 rated use at a 3, meaning anywhere from commonly to uncommonly. An additional 20 rated use as frequent to very frequent (4-5). Excluding the 5 results saying they would not use AR at all, 13 put usage as rare to extremely rare. These results indicate, with these respondents and relating to described AR tools, a general trend of frequent use. This offsets the expressed worry of taking AR “beyond the gimmick” (Interviewee 7, Line 203), to a degree; frequent use lessens perception of AR as a novelty.

4.2.9 Desire for AR Resources

Students were also asked to rate current course learning methods and resources effectiveness. 11 (20.4%) rated them at 3, 25 (43.6%) at 4 and 17 (31.5%) at 5, with only 1 (1.9%) rating below that range at a 2. These findings indicate an overwhelming majority find current resources sufficiently effective. Although, when asked if they would like more resources to be available to them, 42 (77.8%) said “Yes” and 11 (20.4%) said “Maybe/Unsure”, with only 1 (1.9%) saying “No”.

![Figure 12: AR use cross referenced with desire for more resources.](image-url)
With those answers as a basis, cross referencing with the results of AR usage as detailed in analysis of Figure 11 shows a clear majority would like AR to be an additional resource. 31 (74%) of “Yes” responders would use it and 10 (91%) of those unsure said likewise. 7 (17%) and 1 (9%) of those respective groups were unsure. Interestingly, the first group had 4 (10%) who would not like AR as a resource, suggesting that even though they want more, AR would be ineffective at addressing their desires/needs. Further, nobody that was unsure declined AR adoption, instead remaining unsure. This result could be indicative of a difficulty to identify areas where AR could be used by those individuals.

4.2.10 Training and Experience with AR
Participants were also asked if they had any experiences with AR technology and 22 (40.7%) said they had and the remainder (32/59.3%) had not. As an isolated result, this is not particularly useful however, this was done in order to cross reference results on a question asking if people thought they would need training in order to use AR.
Overall, 31 (57.4%) said they would require training and 23 (42.6%) would not. Figure 14 identifies that those with prior AR experience overwhelmingly feel they do not need training (78%) and those without experience do (73%). While it is difficult to generate a conclusion from these similar results, that 27% of people with AR experience still believe they need training suggests slight favour toward training implementation.

This can be corroborated by faculty opinions, with expressing the need and sensibility (Interviewee 3, Line 84) for training to cater to “basic health and safety issues” (Interviewee 1, Line 190), “how best to use it” (Interviewee 2, Line 59) and stating that all tools need training/support to accompany them (Interviewee 6, Line 103; Interviewee 7, Line 193).
Additionally, those with prior AR use primarily mentioned mobile devices (14) incorporating games (7) and camera filters (11) as their experiences (Figure 15). Linking this to the results in Figure 14 implies the use of mobile AR sufficiently educates people to the extent they feel no training would be needed for other AR tools. The use of mobile AR is a phenomenon studied in the works of both Martin et al. (2011) and Azuma et al. (2011), with their commenting on it being a viable technology through which to implement educational AR tools. Also, 1 mention of the Microsoft HoloLens indicated it being used for a medical application (see Appendix 6.4.10 If yes, describe the technology you used. (Purpose of it, how it was used, etc.)), again correlating with potential medical applicability (Bauer et al., 2015; Bauer et al., 2014; Blum et al., 2012; Juanes et al., 2014).

Also, of the entire sample, only 1 (1.9%) said they had experience with AR through their course. But, only by being shown “images on a table” (see Appendix 6.4.12 If yes, in what way(s) is it used? (e.g. Part of assignment, workshop, etc.)) by a lecturer for a demonstration rather than with a usable tool. Difficulty was also found in finding courses that currently use AR tools, with several interviewees either denying (Interviewee 5, Line 118; Interviewee 6, Line 100; Interviewee 3, Line 66) knowledge of any that use it or only being able to speculate it be in use (Interviewee 1, Line 159; Interviewee 4, Line 64).
4.2.11 AR Usefulness as a Disability Aid

Finally, participants were asked to state if they found current course tools as effective in aiding students with any kind of disability. 30 (55.6%) said “Yes”, 18 (33.3%) were “Unsure” and 6 (11.1%) said “No”. Of those who further explained, there were mentions that “worded material can be difficult” for those with dyslexia and attention disorders; reliance on presentations causing some with autism to “struggle to focus on” the content. Some also that address that a student “may be a better visual learner” (see Appendix 6.4.7 If no, why not?).

They were then asked to rate how effective the described tools would be as an aid for students with disabilities. As Figure 16 shows, 49 (90.7%) perceive the tools as being in the useful range (3-5) with only 5 (9.3%) believing them to not be useful. These questions were asked to ultimately help in identifying if the visualisation of AR could prove useful in this area and the results indicate that there is perception amongst students that AR can be a useful aid. This is also believed by members of faculty (Interviewee 2, Line 101; Interviewee 3, Line 113; Interviewee 6, Line 142; Interviewee 5, Line 168; Interviewee 7, Line 245), or at least they believe there is potential for it (Interviewee 1, Line 267).

Figure 16: AR usefulness regarding disability.
5 Research Conclusion

5.1 Aim, Objectives and Research Questions Completion

The overall aim of this research has been to determine the feasibility of implementing AR educational tools within a university environment.

To achieve this, a literature review was conducted that has identified several key areas where AR is being tested/theorised for use. There appears to be a primary focus on the role AR can play within courses that require either practical work or have emphasis on using diagrammatic information. These include sciences (physics, biology, etc.), engineering applications, which is also supported by their use in industrial contexts, as well as medical related fields.

However, the feasibility of use with these AR tools is still contentious. Systems incorporating headset/HMD technology in their design face numerous criticisms and it could be argued these fall within a wider ‘mixed reality’ system as opposed to an augmented reality specifically. There does not appear to be excessive variance in usability with either marker or marker-less systems, rather the focus is on what the overall tool they are used in is. Attention has been brought repeatedly to the great potential of AR and mobile device synergy with implications that this may be an imperative aspect of mass AR integration.

These findings are corroborated to a large extent with analysed results from both student questionnaires and university faculty interviews. Firstly, both students and staff identify science, engineering and medical courses as high suitability areas for AR. Additional areas found via these results include sport-related courses, as an extrapolation of medical-based ones, as well as art/design-based fields. This, again, is based off of a belief that AR can be useful in modelling and informational overlay through visualisation. However, student perceptions of AR usefulness in courses outside this scope appears to be negative and the lack of mentions by staff or consulted literature about other fields may also imply this, to an extent.
Regarding university implementation, there is an element of vagueness as to exactly identifying what content they may apply AR to. Many identify it can be used but, cannot explicitly state what those uses may be, an exemption is within medical field primarily; anatomical modelling is identified. This appears to stem from a lack of extensive experience with the technology due to lack of current widespread usage. Although, students appear to have more exposure to it through various applications found in mobile devices, correlating with the expectations expressed in literature about mobile AR being of considerable importance.

Tying into this is the need for training identified by both sample groups. Staff state they require training in all technologies they adapt and, relating to AR, they wish for training in how best to utilise and tailor it to their subjects. Students also desire training for it, although there is evidence to suggest those that have used mobile AR, even for non-educational purposes, feel training is unnecessary. Some staff point out however, that training would be less of a necessity so long as AR devices are intuitively designed. A caveat of this is that, as they also point out, AR technology is not at a stage wherein standards have been made that can be adhered to, increasing the difficulty of achieving this.

Regardless of the lack of clarity with how to use it, there is a clear expression that AR educational tools are considered wanted and useful. Students overall express a desire for more learning resources and they state AR is a tool they would like to have implemented, with the majority indicting they would use them semi-frequently. Staff support this notion in their wish for tools that can help cater to the needs of as many learners as possible but, the technology must be sustainable and not reduced to novelty/gimmicky uses. Further, using AR as a supplement rather than on its own seems preferential to most staff, as they stress that teaching focuses on using myriad tools collaboratively as a standard practice.
Furthermore, staff wish for there to be the implementation of a support system around the technology, just as IT systems have a support structure. Including the training, other factors include incorporation of maintenance, help teams and the consultation of experts in developing applications. Another important consideration is that AR tools should be compatible with existing frameworks/infrastructure present at a university, such as virtual learning environments. These are the principal concern with costs, rather than initial implementation as equipment is relatively cheap for a university to acquire. As a counter to that, university budgets may be stressed which could lead to an unwillingness or incapability of purchasing the technology and building a support network around it.

Finally, the use of AR in aiding learners with disabilities is suggested to be highly feasible. Staff identify the visualisation capability to be applicable in supporting those who struggle to work effectively with textual materials, such as students with dyslexia. The possibility of using a library of AR models as a resource for remote learning students is also speculated on. Also, universities must ensure all disabilities and learning styles are catered to for inclusivity purposes. Therefore, AR tools could also be used in a supplementary capacity to facilitate this objective. Students likewise indicate that AR can be highly useful as a disability aid. Care must be taken however, to mitigate the potential stress/overwork staff may have from attempting to implement and adapt the technology to various students and scenarios. They may also simply struggle to identify areas AR can help with disabilities due to not having expertise in the area.
These conclusions and the methods relied upon to obtain them definitively achieve the detailed aim, objectives and research questions outlined for this body of work. The literature review performed has detailed a variety of AR applications in varying developmental stages and evaluated them. The addition of questionnaire and interview analysis has served to identify potential areas for AR implementation and given regard to staff and student opinions in that area. Overall, it appears AR can be used within a diverse range of subjects, so long as they have content of a visual and/or practical nature. Students opinions seem to indicate a favourable inclination toward using tools and finding them useful, staff likewise indicate a willingness to introduce them to their teaching as an additional, supplementary tool. The visualisation of AR is also considered highly useful for factoring in the learning needs of those with disabilities. However, feasibility factors need addressing before this can take place, including building a support network around the technology, training staff and students and clarifying how to use and what potential AR applications may be.

5.2 Research Limitations

The findings of this study are based primarily from interviews and questionnaires which, while useful, have some key limitations that impact the nature of these findings.

Firstly, the questionnaire sample size consists of 54 participants. While enough data has been generated to indicate trends, the small sample makes extrapolating conclusions to a larger population difficult. Considering the size of the student population, these generated results cannot be considered overly representative therefore. Additionally, the sample is taken from the same general geographical area which means differences in opinion from universities in other areas may exist and are not considered. For interviews, the demographic focus on computer-oriented lecturers means generalisability is low. This has been done in the hope of generating data based from more expert opinion. However, this results in exemption of opinion from the wider faculty cohort.

Ultimately, low generalisability is apparent in this study however, this is primarily a result of lack of sufficient time/resources to research such a large topic.
5.3 Further Research

The scope of this study could ideally be expanded to cover a much greater population of staff/student cohorts across a range of institutions; generate high generalisability findings. Further, greater focus should be given to feasibility of mobile AR integration within learning environments as well as on theorising/developing compelling applications for them. Research on how best to use AR visualisation as a disability supplement is also of interest. Generating case studies and observations of student/staff interactions with existing AR tools could be utilised to facilitate this. They may also be helpful in evaluating usability factors of the technology and how best to improve the human computer interaction factor.
6 Appendices

6.1 Ethical/Proposal Form

PART ONE

<table>
<thead>
<tr>
<th>Name of applicant:</th>
<th>Adam Nicholas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervisor (if student project):</td>
<td>Simon Thorne</td>
</tr>
<tr>
<td>School / Unit:</td>
<td>Cardiff Metropolitan University – School of Management</td>
</tr>
<tr>
<td>Student number (if applicable):</td>
<td>ST20080353</td>
</tr>
<tr>
<td>Programme enrolled on (if applicable):</td>
<td>Computing (BSc)</td>
</tr>
<tr>
<td>Project Title:</td>
<td>An evaluation on the feasibility of augmented reality (AR) visualisation as a supplementary learning tool</td>
</tr>
<tr>
<td>Expected start date of data collection:</td>
<td>05/02/2018</td>
</tr>
<tr>
<td>Approximate duration of data collection:</td>
<td>2 months</td>
</tr>
<tr>
<td>Funding Body (if applicable):</td>
<td>N/A</td>
</tr>
<tr>
<td>Other researcher(s) working on the project:</td>
<td>N/A</td>
</tr>
<tr>
<td>Will the study involve NHS patients or staff?</td>
<td>No</td>
</tr>
<tr>
<td>Will the study involve human samples and/or human cell lines?</td>
<td>No</td>
</tr>
</tbody>
</table>

Does your project fall entirely within one of the following categories:

| Paper based, involving only documents in the public domain | No |
| Laboratory based, not involving human participants or human samples | No |
| Practice based not involving human participants (eg curatorial, practice audit) | No |
| Compulsory projects in professional practice (eg Initial Teacher Education) | No |
| A project for which external approval has been obtained (e.g., NHS) | No |

If you have answered YES to any of these questions, expand on your answer in the non-technical summary. No further information regarding your project is required. If you have answered NO to all of these questions, you must complete Part 2 of this form.
In no more than 150 words, give a non-technical summary of the project:

Augmented Reality (AR) is a technology that overlays digital graphics onto the real world. This project aims to evaluate the feasibility of this technology as a learning tool within an educational environment. To do this, a literature review will be conducted analysing relevant sources with a focus on AR educational uses both tested and proposed. Alongside this, primary data will be gathered via the use of both interviews and questionnaires. These different data sources will be collated, compared and contrasted against one another in an effort to draw a conclusion to the evaluation.
## A RESEARCH DESIGN

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 Will you be using an approved protocol in your project?</td>
<td>No</td>
</tr>
<tr>
<td>A2 If yes, please state the name and code of the approved protocol to be used</td>
<td>N/A</td>
</tr>
<tr>
<td>A3 Describe the research design to be used in your project</td>
<td>This project will utilise a mixed-method approach to data gathering by collecting secondary literature sources with primary research conducted through both questionnaires and interviews. The sample size for the primary research will be in the range of 30-50 people with purposive sampling being used; students within computing/engineering subjects along with University staff in this area. Convenience sampling is also an aspect of this research as data collection is determinant upon the consent of participants. Semi-structured interviews will be used to obtain data that may not be gathered within a questionnaire due to the more closed nature of the questions generally found within them. Interviews will be with anywhere from 3-10 staff members and shall be recorded for their full duration. 3-10 has been chosen as qualitative information is better suited to smaller sample sizes and the small number of staff that fit the aforementioned purposive sampling criteria is small. These participants will be asked if they are willing to be part of the study and if agreed upon will be given consent and information sheets. Any information relevant to the research aim that stems from these interviews will be transcribed and used in the research analysis where applicable/appropriate, primarily through a combination of quoted text and paraphrased wording. Questionnaires will be paper-based and conducted using students who have agreed to participate in the data collection with a sample size of 30-40. This sample size is relatively large enough to identify data trends which can be analysed. These students will be asked to participate in the study and given necessary documentation (consent and information sheets) before the data collection itself takes place. There will be a mixture of both quantitative and qualitative questions to broaden the scope of the answers that can be obtained. These questionnaires will also be distributed physically to ensure possible participants have received them. Qualitative and quantitative data will be gathered to allow for elaborate answers alongside data that can be placed in easily comprehensible formats, such as graphs, charts, etc. respectively. Secondary data sources will be analysed both on their own in a literature review and also, where applicable, linked with primary data that has been gathered.</td>
</tr>
<tr>
<td>A4 Will the project involve deceptive or covert research?</td>
<td>No</td>
</tr>
<tr>
<td>A5 If yes, give a rationale for the use of deceptive or covert research</td>
<td></td>
</tr>
</tbody>
</table>

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1 An Approved Protocol is one which has been approved by Cardiff Met to be used under supervision of designated members of staff; a list of approved protocols can be found on the Cardiff Met website.
<table>
<thead>
<tr>
<th>A6 Will the project have security sensitive implications?</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>A7 If yes, please explain what they are and the measures that are proposed to address them</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**B PREVIOUS EXPERIENCE**

B1 What previous experience of research involving human participants relevant to this project do you have?

Prior research of this type has been conducted through the Welsh Baccalaureate wherein a study was conducted that required primary data gathering via questionnaire. These were created and sent electronically to approximately 20 participants targeted with convenience sampling.

**B2 Student project only**

What previous experience of research involving human participants relevant to this project does your supervisor have?

Past experience of supervising student projects at an undergraduate level.

**C POTENTIAL RISKS**

C1 What potential risks do you foresee?

- Participants may not respond adequately to questionnaires
- Lack of attendance for interviews
- Interviews may interfere with participant schedules
- Participants may not agree to interviews if they feel their personal information (e.g. name, occupation, etc.) may be used in a public research project
- Sourcing/citing inaccurate secondary literature
- Using unapproved research sources
- Not completing enough work in time for deadlines

C2 How will you deal with the potential risks?

- Perform follow-ups/redo questionnaires if answers are unfit for analysis (e.g. lack of clarity, lack of answers, etc.)
- Outline/plan interviews in advance with complete agreement between both parties relating to factors such as location and time
- Outline privacy protection in consent forms and give copies to participants
- Cross-reference all secondary data sources thoroughly
- Use established/approved research tools such as ACM Digital Library
- Ensure participants have full awareness as to the extent of their involvement with information sheets detailing this
- Inform participants they may choose to have their data excluded from the study at any time
- Create and maintain a consistent work schedule
6.2 Participant Information Sheet

PARTICIPANT INFORMATION SHEET

An evaluation on the feasibility of augmented reality as a supplementary learning tool

Cardiff Metropolitan University Protocol Number:

Project summary
The purpose of this research project is to analyse and evaluate the feasibility of augmented reality technologies being used at a university. Your participation will allow for data collection that will be used in a study being undertaken at Cardiff Metropolitan University.

Why have you been asked to participate?
You have been asked to participate in this research study as you fit the sample demographic being used for data collection. This means you are either a University student currently studying or a staff member responsible for facilitating these courses i.e. a lecturer, tutor, etc.

An in-depth knowledge of/experience with augmented reality, or lack thereof, is not a major contributing factor being considered for your participation. This data collection primarily seeks to gauge the opinions of a specific audience regarding the study topic, meaning the disparate knowledge each participant has will not impede the study.

Please note that your participation in this study is entirely voluntary and you may remove yourself from it at any time without needing to give a reason.

Project risks
The research being undertaken involves the completion of a questionnaire (students) and the conducting of interviews (staff), the interviews being recorded for later transcription. Your personal information is not the focus of either of these research aspects and no sensitive data is to be collected, your opinions on the study topic are the only information of importance.

To reiterate however, if you wish for any reason to exempt yourself from the study data you can do so at any point.

How we protect your privacy
All information gathered from you in this study will be held securely and in confidence. The data collection will be designed in such a way as to diminish the extent of personally identifiable information; data such as consent signatures that are sensitive will be kept securely. Upon completion of the data analysis and study the documentation used to gather data will be destroyed excluding the signed consent forms which shall be kept securely for a duration of 5 years. Audio recordings of interviews shall also be kept for this specified duration.

YOU WILL BE OFFERED A COPY OF THIS INFORMATION SHEET TO KEEP

If you require any further information about this project then please contact:

Adam Nicholas, Cardiff Metropolitan University
Cardiff Metropolitan University email: st20080353@cardiffmet.ac.uk
6.3 Participant Consent Form

PARTICIPANT CONSENT FORM

Cardiff Metropolitan University Ethics Reference Number: 2016D5650

Participant name or Study ID Number:

Title of Project: An evaluation on the feasibility of augmented reality as a supplementary learning tool

Name of Researcher: Adam Nicholas

Participant to complete this section: Please initial each box.

1. I confirm that I have read and fully understand the information sheet for the above-mentioned study. I have had the opportunity to consider the information presented to me, ask questions pertaining to it and have found these answered to my satisfaction. [ ]

2. I understand my participation is voluntary and that I am free to withdraw at any time, without having to give reasoning. [ ]

3. I agree to take part in the above-mentioned study. [ ]

4. I agree to participate in an interview relating to the above-mentioned study [ ]

5. I agree to the use of anonymised quotes in publications [ ] [ ]

6. I would like my organisations’ name to be anonymised in all publications [ ] [ ]

---------------------------------------------------------------  ------------------------
Signature of Participant                                      Date

---------------------------------------------------------------  ------------------------
Name of person taking consent                                 Date

Signature of person taking consent
6.3 Questionnaire

An evaluation into the feasibility of augmented reality as a supplementary learning tool.

* Required

Questions

1. What University course are you currently studying? *

Your answer

2. What course year are you on? *

- Year 1
- Year 2
- Year 3
- Postgraduate

3. Do you build/create physical models of things as part of your course often?

- Yes
- No

4. Do you interact with physical models and/or diagrams as part of your course often?

- Yes
- No

5. How effective do you find the learning methods and resources on your course? (Learning methods as in presentations, group work, book reading, lecturer contact, internet searching, etc)

Very ineffective 1 2 3 4 5 Very effective
6. Do you think these methods and resources are effective at helping students with disabilities?

☐ Yes
☐ No
☐ Unsure

7. If no, why not?
Your answer

8. Would you like more resources to be available to you on your course? E.g. more software, hardware, teaching materials, etc.

☐ Yes
☐ No
☐ Maybe/Unsure

9. Do you have any experience using augmented reality (AR) technologies? *

☐ Yes
☐ No

10. If yes, describe the technology you used. (Purpose of it, how it was used, etc.)
Your answer

11. Is AR used as part of your course? *

☐ Yes
☐ No

12. If yes, in what way(s) is it used? (e.g. part of assignment, workshop, etc.)
Your answer

13. Do you feel you would need training to be able to use AR technology? *

☐ Yes
☐ No
14. How useful would an AR tool that overlays instructions over an object be to you? E.g. when developing something, the AR tool would overlay 3D graphical steps needed to build the object. *

Not useful at all 1 2 3 4 5 Very useful

15. How useful would an AR tool that gives a description of an object/diagram be to you? E.g. Piece of software on a mobile that shows a 3D representation of a diagram with text/audio explanation to go with it. *

Not useful at all 1 2 3 4 5 Very useful

16. Would you find an AR tool that creates a recreation/model of an object useful? E.g. rather than having a physical object you have access to a digital/holographic version instead? *

Not useful at all 1 2 3 4 5 Very useful

17. How useful do you think these tools would be for students with disabilities of any kind?

Not useful at all 1 2 3 4 5 Very useful

18. How much of the work on your course could these tools be used with?

☐ 0-25%
☐ 25-50%
☐ 50-75%
☐ 75-100%

19. Do you know of any other technologies/tools that do the same things as the described AR tools? *

☐ Yes
☐ No
20. If yes, are they part of your course and/or what are they?

Your answer

21. Overall, would you like to have AR (these tools or any others you know of) available to you on your course? *

- Yes
- No
- Unsure

22. How often would you use these AR tools? *

<table>
<thead>
<tr>
<th>Extremely rarely</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Very frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

58
6.4 Questionnaire Results

6.4.1 What University course are you currently studying?

<table>
<thead>
<tr>
<th>Course</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Science</td>
<td>12</td>
<td>22%</td>
</tr>
<tr>
<td>Software Engineering</td>
<td>4</td>
<td>7%</td>
</tr>
<tr>
<td>Computer Games Development</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Fashion</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Fine Art</td>
<td>6</td>
<td>11%</td>
</tr>
<tr>
<td>Illustration</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>Graphic Design</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>Graphic Communication</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>English Literature</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>Business and Management Studies</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>Events Management</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>Environmental Health</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Optometry</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Nursing</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>Psychology</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Sports Management</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Sports Studies</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Sports Performance Analysis</td>
<td>4</td>
<td>7%</td>
</tr>
<tr>
<td>Sports Coaching and Physiotherapy</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>Sports Conditioning, Rehabilitation and Massage</td>
<td>1</td>
<td>2%</td>
</tr>
</tbody>
</table>

6.4.2 What course year are you on?

<table>
<thead>
<tr>
<th>Course Year</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>37</td>
<td>68.50%</td>
</tr>
<tr>
<td>Year 2</td>
<td>10</td>
<td>18.50%</td>
</tr>
<tr>
<td>Year 3</td>
<td>4</td>
<td>7.40%</td>
</tr>
<tr>
<td>Postgraduate</td>
<td>3</td>
<td>5.60%</td>
</tr>
</tbody>
</table>

6.4.3 Do you build/create physical models of things as part of your course often?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>15</td>
<td>27.80%</td>
</tr>
<tr>
<td>No</td>
<td>39</td>
<td>72.20%</td>
</tr>
</tbody>
</table>
6.4.4 Do you interact with physical models and/or diagrams as part of your course often?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>34</td>
<td>63.00%</td>
</tr>
<tr>
<td>No</td>
<td>20</td>
<td>37.00%</td>
</tr>
</tbody>
</table>

6.4.5 How effective do you find the learning methods and resources on your course? (Learning methods as in presentations, group work, book reading, lecturer contact, internet searching, etc.)

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1.90%</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>20.40%</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>46.30%</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>31.50%</td>
</tr>
</tbody>
</table>

6.4.6 Do you think these methods and resources are effective at helping students with disabilities?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>30</td>
<td>55.60%</td>
</tr>
<tr>
<td>No</td>
<td>6</td>
<td>11.10%</td>
</tr>
<tr>
<td>Unsure</td>
<td>18</td>
<td>33.30%</td>
</tr>
</tbody>
</table>

6.4.7 If no, why not?

<table>
<thead>
<tr>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>little regard for accessibility in content</td>
</tr>
<tr>
<td>They might be a better visual learner</td>
</tr>
<tr>
<td>It's focused on word/literature which is not good for those with dyslexia (I imagine)</td>
</tr>
<tr>
<td>As most of them might not be a visual learner</td>
</tr>
<tr>
<td>Coz they have learning disabilities</td>
</tr>
<tr>
<td>Lots of content is only on lectures/presentations which I know some freinds with autism struggle to focus on</td>
</tr>
<tr>
<td>The heavy focus on written word can be difficult for some with attention disorders.</td>
</tr>
<tr>
<td>With dyslexia lots of worded material can be difficult, unsure about other disabilities.</td>
</tr>
</tbody>
</table>
6.4.8 Would you like more resources to be available to you on your course? E.g. more software, hardware, teaching materials, etc.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>42</td>
<td>77.80%</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td>1.90%</td>
</tr>
<tr>
<td>Unsure</td>
<td>11</td>
<td>20.40%</td>
</tr>
</tbody>
</table>

6.4.9 Do you have any experience using augmented reality (AR) technologies?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>22</td>
<td>40.70%</td>
</tr>
<tr>
<td>No</td>
<td>32</td>
<td>59.30%</td>
</tr>
</tbody>
</table>

6.4.10 If yes, describe the technology you used. (Purpose of it, how it was used, etc.)

<table>
<thead>
<tr>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>My stepfather augmented a dinosaur on the kitchen table.</td>
</tr>
<tr>
<td>Snapchat and Instagram filters</td>
</tr>
<tr>
<td>Previous used Microsoft hololense to playback Minecraft at an event</td>
</tr>
<tr>
<td>Hololens - demonstration of application in medicine</td>
</tr>
<tr>
<td>Camera filters for snapchat and skylanders game</td>
</tr>
<tr>
<td>Used it at an event to see how it feels</td>
</tr>
<tr>
<td>Gaming Expo to check out this new game</td>
</tr>
<tr>
<td>Snapchat</td>
</tr>
<tr>
<td>Used a phone camera to show an object on a marker</td>
</tr>
<tr>
<td>Relatives house</td>
</tr>
<tr>
<td>Pokemon Go</td>
</tr>
<tr>
<td>games like Pokemon go and snapchat filters</td>
</tr>
<tr>
<td>phone filters</td>
</tr>
<tr>
<td>snapchat shows avatars through the camera</td>
</tr>
<tr>
<td>I dont knowo</td>
</tr>
<tr>
<td>My google pixel has AR that shows characters through the camera and I can interact with some of them</td>
</tr>
<tr>
<td>Saw a showcase of Hololens and snapchat filters are basically AR</td>
</tr>
<tr>
<td>Smartphone AR games e.g. Ingress and Pokemon GO</td>
</tr>
<tr>
<td>Played pokemon go and have snapchat</td>
</tr>
<tr>
<td>Snapchat is one!</td>
</tr>
<tr>
<td>Snapchat</td>
</tr>
</tbody>
</table>

6.4.11 Is AR used s part of your course?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
<td>1.90%</td>
</tr>
<tr>
<td>No</td>
<td>53</td>
<td>98.10%</td>
</tr>
</tbody>
</table>
6.4.12 If yes, in what way(s) is it used? (e.g. part of assignment, workshop, etc.)

<table>
<thead>
<tr>
<th>Answer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Our lecturer displayed some images on a table through their phone camera as part of a demo but, all we did was play around with it a bit</td>
</tr>
</tbody>
</table>

6.4.13 Do you feel you would need training to be able to use AR technology?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>31</td>
<td>57.40%</td>
</tr>
<tr>
<td>No</td>
<td>23</td>
<td>42.60%</td>
</tr>
</tbody>
</table>

6.4.14 How useful would an AR tool that overlays instructions over an object be to you? E.g. when developing something, the AR tool would overlay 3D graphical steps needed to build the object.

<table>
<thead>
<tr>
<th>Usefulness</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>27.80%</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>11.10%</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>18.50%</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>16.70%</td>
</tr>
<tr>
<td>5</td>
<td>14</td>
<td>25.90%</td>
</tr>
</tbody>
</table>

6.4.15 How useful would an AR tool that gives a description of an object/diagram be to you? E.g. Piece of software on a mobile that shows a 3D representation of a diagram with text/audio explanation to go with it.

<table>
<thead>
<tr>
<th>Usefulness</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>13.00%</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>11.10%</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>13%</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>29.60%</td>
</tr>
<tr>
<td>5</td>
<td>18</td>
<td>33.3%</td>
</tr>
</tbody>
</table>

62
6.4.16 Would you find an AR tool that creates a recreation/model of an object useful? E.g. rather than having a physical object you have access to a digital/holographic version instead?

<table>
<thead>
<tr>
<th>Usefulness</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>11.10%</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>16.70%</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>20.4%</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>22.20%</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>29.6%</td>
</tr>
</tbody>
</table>

6.4.17 How useful do you think these tools would be for students with disabilities of any kind?

<table>
<thead>
<tr>
<th>Usefulness</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1.90%</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>7.40%</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>37%</td>
</tr>
<tr>
<td>4</td>
<td>17</td>
<td>31.50%</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>22%</td>
</tr>
</tbody>
</table>

6.4.18 How much of the work on your course could these tools be used with?

<table>
<thead>
<tr>
<th>Applicability</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25%</td>
<td>22</td>
<td>40.70%</td>
</tr>
<tr>
<td>25-50%</td>
<td>21</td>
<td>38.90%</td>
</tr>
<tr>
<td>50-75%</td>
<td>13</td>
<td>24.10%</td>
</tr>
<tr>
<td>75-100%</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

6.4.19 Do you know of any other technologies/tools that do the same things as the described AR tools?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>14</td>
<td>25.90%</td>
</tr>
<tr>
<td>No</td>
<td>40</td>
<td>74.10%</td>
</tr>
</tbody>
</table>
6.4.20 If yes, are they part of your course and/or what are they?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual Reality?</td>
<td>On art and design courses, they have 3D printers and use CAD software which is somewhat similar I imagine.</td>
</tr>
<tr>
<td>VR</td>
<td>Virtual Reality is similar but not used on my course</td>
</tr>
<tr>
<td>VR</td>
<td>Virtual Reality is similar to it. Not used on course.</td>
</tr>
<tr>
<td>VR</td>
<td>VR like oculus shows 3D models of stuff</td>
</tr>
<tr>
<td>VR</td>
<td>Some students use CAD to build digital replicas</td>
</tr>
<tr>
<td>VR</td>
<td>VR can do all of those things but you need more hardware to do it</td>
</tr>
<tr>
<td>VR</td>
<td>Blender software creates digital mockups and CAD does as well. These aren't on the course.</td>
</tr>
<tr>
<td>VR</td>
<td>AR and VR do very similar things just with different methods</td>
</tr>
<tr>
<td>VR</td>
<td>I own a VR headset and it can display models in 3D. I've also used CAD for some of my work which does the same.</td>
</tr>
<tr>
<td>VR</td>
<td>Vr I think.</td>
</tr>
</tbody>
</table>

6.4.21 Overall, would you like to have AR (these tools or any others you know of) available to you on your course?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Respondents</th>
<th>% of 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>41</td>
<td>75.90%</td>
</tr>
<tr>
<td>No</td>
<td>5</td>
<td>9.30%</td>
</tr>
<tr>
<td>Unsure</td>
<td>8</td>
<td>14.80%</td>
</tr>
</tbody>
</table>

6.4.22 How often would you use these AR tools?

<table>
<thead>
<tr>
<th>Usage Frequency</th>
<th>Respondents</th>
<th>% 0f 54</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>18.50%</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>14.80%</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
<td>29.60%</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>22.20%</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>14.80%</td>
</tr>
</tbody>
</table>
6.5 Interviews

6.5.1 Interview 1

**Interviewer:** All right this is an interview for my dissertation. First question, can you state your position at the University and your years in the industry?

**Interviewee 1:** Okay, I am a senior lecturer in information systems. This is my 18th year in teaching and using technology in teaching, I’ve got 25 years and uh, I first got into teaching back in… 1986.

**Interviewer:** Okay thank you. Can you describe the learning tools or resources or methods, whatever you want to call it, you use as part of your course currently? So that could be practical work, is there text-based work, modelling, images, stuff like that.

**Interviewee 1:** Okay, when I’m teaching my subject, which is systems analysis, it’s very much about designing, using graphics or, uh, providing simulations or textual based material which they then have to turn into graphical representations. So, from that point of view, I use a lot of graphical tools.

Moodle, being our VLE at the moment, supports that by providing those materials to the students that they then will go off and, say, use Visio, produce UML diagrams or if they are, uh, going to, say, work on a web-based system they might be using things like Dreamweaver. But basically, what I’m doing is very graphical and textual but nothing like, say, using Unity which would be a full simulation model.

**Interviewer:** Okay, can you then describe why they are useful in particular to your course?

**Interviewee 1:** Oh uh, mainly because of the modelling nature because we need to model to be able to explain and share understanding between one or more people. Um, there are other things I do use. I do use a little bit of virtual reality as in explaining or showing students how we can use that kind of reality. What I mean by that is, Google exploration is a nice example of sharing virtuality between one or more people and that’s where we’ve looked at it from the point of view of showing students what they can do rather than, uh, creating content.
So, the little bit I’ve done on content creation was actually for the School of Dentistry and that was, uh, starting to look at how it could be used in dentistry for anatomy and physiology, so that’s really about creating images in a, uh, 360 nature which can then be used in Google expeditions. We, I mean I, uh yeah, I was invited by Google to develop material like that. In fact, they were inviting many people at the time but, I haven’t finished it yet so when I do we will be having something in Google expeditions as part of virtual reality.

Interviewer: Hmm, alright. Using all those different methods, do you have any indication on how effective the students themselves find them?

Interviewee 1: Um, that’s always a difficult one to answer because what I’m doing involves preparing and teaching students how to use those tools so they can use them later on when they’re actually in work externally. So, the assessment isn’t on the tools, more on their understanding of the tools because until you go out to work and try sharing understanding of a system, you don’t actually know how effective those modelling tools are. Also, things change over time and a few years ago we would emphasise tools such as data flow diagrams, entity life histories and ERM diagrams, now we emphasise UML type diagrams, use case diagrams, class diagrams and sequence diagrams which are essentially the same with different names but they have a different emphasis on the way that they look at things. You know, one is looking at the whole system and the others are looking at small proportions of it.

I mean, they’re all just a set of tools for the students to use. It’s the idea that a student, once they have an understanding of one tool, should be able to take that forward into another environment and have some transferable knowledge so they can use tools that are similar in that area. So, for example, here we use SSADM’s version of DFD’s but if I went to America then I’d be using, um uh Anderson uh, Andersons version of the same thing. Again, literally they’re all the same thing, the symbols are just slightly different but they are all modelling a system, same as UML.
If anything, I would point out a difficulty I often find is people look at the diagrams and think that’s where it ends whereas really that’s where it starts, all the paperwork behind it actually making it work. What we often think about SSADM is you model the whole system whereas UML we model, or we use it pretentiously for, um, working with the idea of Agile methods. But, the reality of that is you use the right tool so, you could be using a DFD method or the UML type method, it’s about using the right method, having something in your toolbox in the first place.

That’s what I would argue is what we should be doing, putting lots of tools in your toolbox because the thing is, which is when you go out to work, um, the place you work you want to go in and be able to say ‘I’ve got an academic level and I’ve used some of these tools and I wish to join you and develop further on and you take me off to use more tools’, not just, ‘I’ve got these tools I can use them’.

Interviewer: Right then um, with all those methods you’ve stated can you think of any areas where they’re ineffective or need improving?

Interviewee 1: Well, inclusivity and diversity in a classroom means that we should be trying to present to students our material in a way that’s appropriate to them. So, if I’ve got a student who’s more visual I should be providing them stuff in a visual way, I’d be using lots of rich pictures, diagrams, etc. If I’ve got someone who’s more, more textual I should be having my material all very textual based. If I’ve got a student who’s very uh, I’m going to get this word wrong –

Interviewer: Kinaesthetic?

Interviewee 1: That’s him, that one, yes, thank you kinaesthetic, yes, it’s practice. Practicing doing it, doing it and doing it again. So, um, if we then throw in the diversity bit we’re looking at language, we’re looking at gender, we’re looking at cultural bits and pieces and what we try and do is bring all of that in. Almost an impossible task to cater for every single student in those ways so we end up in a sort of halfway house where you’re trying to get it right for as many as you can.
So, we end up, or I end up, providing booklets and questions that provide things in two or three different ways but not all the ways that can be done. Ideally, you can provide a tool that allows you to cater for all those things and the inclusivity and the diversity and an assessment of all that as well. Because we have to recognise that if someone is very good at text they should be able to give a textual solution to your assessment or someone likes diagrams they can produce that.

Whereas someone who’s very visual orientated might not be able to, if they’ve got dyslexia it might stop them doing this or doing that it, it’s sort of about doing things the best way. We can talk about this but we don’t have the time to do it all. Of course, we can say ‘oh yes, we’d do this of course we would do that’, but reality, the reality is different. There are exceptional circumstances and if lecturers do it, it’s out of their own goodwill. Yeah, its’s um, uh, something I’m trying to support with another tool that I use in the classroom where in theory, my lecture slides, I can do or try to provide um, I can have a partially-sighted friendly version, dyslexic friendly version, partially blind friendly version and an MS friendly version. But it all takes time to put that effort in to make sure there are five different versions available for the students.

Interviewer: Well, I would ask about disabilities but you’ve already addressed that.

Interviewee 1: Partly.

Interviewee 1: Well, we have requirements now where, if you are, let’s say you are dyslexic for example. We have very limited things we can do for you. So, if we have a lecture what I can do is give you handouts for my lecture before or at the lecture time. Now we use PowerPoint and the first thing you need to know about PowerPoint is it’s a small listing meaning you can have five, six images on there which are in their last state. What I mean by that is if you use a lot of overlays in your presentation it gives it to you in the last state you were working on it on. So, it could be obscuring data and also, it’s very small and I don’t think it’s very useful in that way. Other than writing notes, whereby I have a system where the slide can be on your computer and you add your notes alongside of it.
If we think about the very fact we only provide that to some students and that, uh, quite often we only produce it the day before, right, which means any overnight things may have changed or we upload and we mean it’s available to every student beforehand the result may be that they don’t turn up, they’ve already seen the material.

More importantly though, we make notes for those students and take them out but have other notes as well so, which am I going to show on the day? Um, the I’ve got the idea of I like to ask questions in the middle of my session and have answers on the slide. So now, I’ve got to take that out or give a sheet out with the answer on. I’m not allowing a student to struggle to find the answer or learn. These are little things and we can get around it but, the thing is I want to make my life as easy as possible where I don’t have to think about producing many different versions. Same for the students where I want to give them a nice big version.

We’ve also got the thing about putting slides up on a big screen. Big lecture theatres, no repeater screens going on in the very back so even with the largest typeface on the big screen you still can’t see it at the back right. So, our lecture theatres themselves aren’t very well designed for inclusivity. Within that, you can argue you’d want students to have their own electronic devices but we’ve got no power supplies apart from sockets that you can attempt to trip everyone up on as they come down the stairs because the cable ends up going across the stairs.

**Interviewer:** So, to tie all of this, that into augmented reality, firstly do you have any experience in using it?

**Interviewee 1:** Only with historically simple augmented reality where we might have additional information coming up on screens like maps, like uh, information about what’s located on a map, some stuff way back in the past. Google Glass didn’t really do it for me, you’d walk around it’d know where you were and the occasional thing would pop up but, it didn’t really work very well.
But, um, using an app on a phone to be able to build a model on a table in front of me, that was quite interesting. I can see how that would work very well in areas like, um, architecture, trying to visual systems in that way. Done some things, silly things like having something dance on the table in front of me and I have looked at the stuff from Google, their VR Expeditions and now they’ve started their AR but I can’t get access to it because I’m in the UK. It’s only available in America and their classic example was to have a volcano. They’d have all the students sharing this volcano on the table but, um, I’ve also had a look at Microsoft’s, um, Halo. The problem with Halo is it’s a headset still and putting it on is a pain but holding it is not so bad, holding it on the face. But, you still get tired, you still get issues with that and also keeping the class together. Students wander off, which you want them to do but, you also want to keep a level of control, keep them together, asking questions and you’re getting feedback from everyone. One thing I don’t see on any system at the moment is seeing a way of seeing what an individual student saw, went to, answered a question about, etc. and that’s something I’d like to see. What did they actually explore, what did they stare at, where was their attention drawn. It’s the stuff you’d look for with a website, those sorts of stats in the background but, uh, the idea of watching the volcano and watching the simulation run through and then the ability to go below and look below the table and see what’s underneath. All these things you can do with AR, I quite like the idea of using my phone, holding my phone there because I can also move around the, uh, whatever the table, the object. But, then it’s about being able to reference that point and maintaining all the different perspectives.

Interviewer: Okay that’s great. So, then are you aware of any other staff here or at other university’s using AR in any capacity?

Interviewee 1: Yeah um, in the School of Health and Sport Science a gentleman is using VR for his students, looking at rooms for Health and Environmental Studies. Taking 360-degree videos of a room and exploring what’s in it, sort of ‘ooh look what’s up there it might kill the person in here’, ‘something dripping down from there’. He’s also done some, I believe he’s done some AR similar to what I talked about where you’ve got a paper in front of you and then –

Interviewer: With a model on it?
Interviewee 1: Yeah, with a model coming up from it and, um, when I mentioned that to him after seeing it at UWE, the University of West England, he already knew about it and turned out he had been working with them just hadn’t mentioned it before, right. So, UWE are doing something with it for their School of Architecture and Environmental Health and Design.

Guy up at Nottingham, forgotten what his name is, but he’s doing a lot of simulations up there and we do, we have a thing called Labster which is simulations but in a VR world but, you know, it’s not much of a step to make that into an AR world in many ways. Basic things are done with that, um so, health and safety issues of working in a lab, everyone having to do it again and again, they work their way through a simulation.

Interviewer: So, is it as to give instructions as a tutorial sort of thing?

Interviewee 1: Instructional tutorials is a good way of putting it actually, yeah. After that a lot of the things that I’ve seen, uh, it’s a way of getting you to see something that, maybe, you can’t travel to, get to that particular location. Or, see that thing in action. But, they’re not real, they’re not there and sometimes that means there’s something lacking, uh yeah, something lacking in what you’re seeing because it’s a cut down version so, uh, pros and cons to all of these things.

Interviewer: And um, you mentioned the difficulty with headset use. Do you think there are problems with different AR access methods and do you think some kind of training would be required to use this stuff?

Interviewee 1: Yes, first of all I get motion sick so VR sets are a problem to me so immediately I do prefer the idea of, If I you know, use AR I can use my phone. But, that’s just the current interface which disregards the future. There’s nothing stopping you with the headset, or the camera to make you feel like you’re really there but I like the idea that I can move my phone around because of the motion sick issue. In the same way it could be a tablet, etc. not just a headset. Um, what was the rest of the question?

Interviewer: Would people require training?
Interviewee 1: Yeah, they would require training. If we just think of basic health and safety issues with it and then think of it as, ‘would I actually sit someone down in a chair to look at a volcano?’ Because I can only see it from one angle and that kills the whole point of having the augmented reality. So, there’s an etiquette you need to have in place.

We found that using the VR of Google Expeditions you have to identify how you’re going to work with it because students have a habit of ‘WOW! I saw this and then I saw this!’ and then you lose control and you need that control of taking the students where you want them to go, to listen to you, etc. In the same way you sit in front of me in a lesson, I can give you workbooks and let you get on with it or I can guide you. Either way it’s about needing training to know how to use it, what you can get form it, what’s missing. It all depends on what the thing is but there could be limitations in what you’ve got there.

Interviewer: Okay and then, uh, final bit of that. Do you think AR could be implemented at a university now and if so, why?

Interviewee 1: Well if we think of the main platform for VR and AR they’re both using Unity, I say main platform, one of the main platforms right. Unity is relatively easy to use, it’s more about you coming up with an idea, coming up with something you can say ‘ooh there’s a potential there’. So, the idea is really we’ve got it just without much there. If you think about we’ve got Google doing it but they won’t let me in and use it at schools; we already have it at universities.

If you think about Minority Report, the film, they use augmented reality and that film must be a good 15 years ago now. Okay, it was a notional idea of what we might have in the future, at that time, but we’ve moved beyond that already and yet we haven’t got it.
There’s nothing stopping us from creating things here but, these things all take time and that is where the university or any organisation will have a problem. They don’t have time to actually develop these things firstly, form the concept to then what it’s going to be and then actually creating it, testing it, making sure it’s all okay. Um, sometime I’d prefer someone to produce a half-hearted thing and get it over the full-blown fabulous idea which might get developed later on. We know it’s going to get replaced and be out of date by the time it shows up in some form. Um, too often I hear that we should be producing something of incredibly high quality, that takes time and money and once you finish it it’s out of date. I want to avoid that sort of thing, I’d rather produce something quick and useful.

But when we take about this sort of thing, an object for teaching, the way I use the object is different to the next person. Lecturers don’t like taking material someone else produced and then just using it, they want to tailor it to their own so these things have to be tailorable. Whatever you’re creating you have to be able to amend it on some shape or form so others can then use it in a teaching environment. But that’s the same old problem with any teaching object, it’s gotta have that ability.

If we go back to my volcano one, you can take that in say, If I’m doing something on volcanoes, we can take it from a leisure and tourism point of view, I can take it from a pure volcanology point of view, I can take it from a seismic point of view. Three different things that look at the same thing in different ways, that last one was a bit dodgy it was off the top of my head but the other two weren’t bad. So, there’s, yet you’re using the same thing but they don’t want the exact same object.

**Interviewer:** Okay then, that kinda covers a question on feasibility really. Do you think, what sort of areas do you think you could apply AR to? So, would it be useful as an instructional tool, for group work, collaborative learning, things like that.
Interviewee 1: It could be used for all of those if someone design a way to do it. Somebody’s gotta have a way of, um, producing the work or material. I normally work with what’s called a SAMR model, that’s where you take a piece of technology and say ‘is it substitution? Is it augmentation? Is it modification? Or, is it redefinition of my teaching?’ Substitution basically means I’m taking one technology and I’m, well, swapping it for another, augmentation is essentially the same but I’m now also able to do something I couldn’t before, it’s adding a little bit more. The modification and redefinition, well modification is taking it that bit further where I’m actually changing the way I’m teaching whereas redefinition is a complete and utter change. You know, you’re providing me with this technology and telling me not to teach it this way, you teach it this whole new way.

That redefinition is where we need technology to go because if all it’s doing is substituting then what was wrong with the last piece? We used it for a long time and it was successful, why go and change it when we know it works?

Interviewer: So, would the idea of AR as a supplement, are you trying to say it might not be best for that?

Interviewee 1: It might not be. The cost and time of doing it, I need it to redefine and modify the way I teach. If it’s substituting then the time and effort of getting a substitute, is it worth it? I’ve already got something that does the job. I have to have something, at minimum, that augments what I can do now, if I substitute, uh, it, uh, it’s gotta augment it. Give me something more than a substitution given the time and effort I have to put in. But what I really want is something that totally redefines how I’m teaching. Then it’s worth it provided I can see in the, um, discussions about it that it is gonna provide something for students that’s a benefit. I don’t want to modify and redefine then found out it don’t work. That would be a really good idea hmm? So, the SAMR model is a really simplistic way of evaluating those things.

Interviewer: Right and then finally, not as a supplement but, in adding. Do you think it could help in adding to learning for people with disabilities? You mentioned visual learners, people with dyslexia who might not be good with text-based things. Do you think the modelling aspect, the visualisation would help?
Interviewee 1: Again, it comes down to finding the right tool for the different groups, I would leave it as simple as that. I can’t turn around and say specifically it would because if you choose the wrong colours you’re gonna do the opposite, it can be as simple as that.

One of the things we find with certain age groups and in fact you’re almost showing that to me right now, you’ve chosen a lot of dark colours in your clothing. You know, it wouldn’t surprise me if there was a time where you told me you painted your bedroom black. You know there’s a natural progression people go through so, um, uh, you know. What I’m trying to say there is, a thing of people go in different ways at different times and it changes whether they find one thing acceptable or another.

In that scale of work, with a dyslexic group or any other kind of group it does give opportunity potentially. But then there’s the point of opportunity for all students where what you want is all students should be treated the same. You know, maybe the current way of teaching doesn’t allow everyone to participate and be part of it. In other words, um, something I often draw for people is a fence. You can someone small, someone very large and someone who’s head is way over the top. What we’re trying to do with diversity is add some equality. So, we might give someone a bigger box first of all, to stand on and look over the fence equally. But that’s not necessarily providing equality because we’re providing this extra support. What we really want them to do is look without the fence, it’s really getting rid of the fence altogether so there’s nothing in the way for everyone.

So, if you can redefine, remove the fence, whatever the fence is then that would be really good and worthwhile having. Um, what I don’t want to create is a new fence which is now a bubble and maybe the bubble has taken out something else because I’m replacing it with another technology. I need to have a reason behind that.
Another classic is a tree and this is a very old one where a professor has trees all exactly the same and the exam is to climb the top of the tree. A monkey, he ain’t got a problem. A bird, well, if the assessment is to climb to the top, the fact the bird flies to the top, does that means it’s met the same assessment? An elephant, if it pushes the tree over and stand on it does that mean they climbed it? Might have to walk up the trunk. But the fish in the bowl ain’t got a hope. Right, that would be my inclusivity, I want to remove the fence by this technology and then I’ve got something that’s really useful. But if we only talk about substituting, is the effort worth it?

**Interviewer:** Well alright, uh, thank you very much. That, I believe, concludes the interview.
6.5.2 Interview 2

Interviewer: Okay this is an interview for my dissertation, firstly can you state your position at the university and how many years you’ve had in your industry?

Interviewee 2: Okay well, I’m the head of department for Computing and Information Systems and I’ve been in the teaching industry for around, ooh, twenty-five years.

Interviewer: Now as head of department it’s slightly different for you but, as part of teaching courses what learning methods did you predominately use? Was it a lot of presentations, group work, etc.?

Interviewee 2: Um well, I mainly taught programming and technical work so, there’s a lot of exercises involved, a lot of presentations by students, um, lot of discussions with students on bits of code, couple of online test I used to use. So, I used to vary my sessions quite a bit, try to use as many different teaching techniques as I could.

Interviewer: What ways were they useful in teaching your particular course then, how were the teaching methods useful?

Interviewee 2: Uh, I suppose programming is a practical thing to do and the more exercises a student did the better they got at programming because they were actually getting their hands dirty and doing the programming rather than talking about it, though it’s good to talk about it as well. But, nothing beats actually doing it, again.

Interviewer: Okay and then do you have any indication of how effective the students themselves found those different methods or tool?

Interviewee 2: Okay, well we had module evaluation and feedback, questionnaires, um, and we used to have a lot of discussions within the classrooms. So, if somebody didn’t understand something then I would use that as a talking point and help all the others try and answer the question uh, so, uh, good use of talking points.

Interviewer: So, would you consider that collaborative learning?

Interviewee 2: Um, yes.

Interviewer: Okay and out of all those different methods you would use where would you say they needed any kind of improvement, if any of course?
Interviewee 2: Um, it was always difficult to try and give the stronger students more testing exercises, always found that a bit of a struggle because, obviously you’ve got very mixed students so trying to find a middle ground between you all, always quite difficult. But again, that comes hand in hand with teaching technical subjects. Um, just testing the ones who need testing and helping the ones who are struggling a little bit as much as possible, finding a balance.

Interviewer: Okay and in regards to disabilities, would you say the methods and tools used helped them effectively?

Interviewee 2: Yeah, yeah there was never any difference to me in teaching students who had disabilities and teaching students who didn’t have disabilities. Um, students with disabilities obviously would have more help in class but, that was about it really.

Interviewer: Okay, to move it onto AR specifically, do you have any prior experience using augmented reality or any knowledge of it?

Interviewee 2: No is my simple answer to that. I’m aware of it, played with it but I’ve never actually done much with it.

Interviewer: Uh, did, how did you play with it?

Interviewee 2: Uh, virtual reality, in fact I played with it yesterday with a VR car. To be honest I think that’s pretty much it with my use in terms of it.

Interviewer: Do you have any knowledge of it?

Interviewee 2: Not really, it’s not really my subject area.

Interviewer: Okay, are you then aware of any other faculty here or elsewhere using it?

Interviewee 2: Yes, the one that springs to mind is Eindhoven, Fontys, where they have a virtual reality cave, um, now that was used a little bit but not that much because it was so expensive to set up. They didn’t really, um, use it that much. Trying to think what they did use it for. No, I think it was really to test different programs, program techniques.

Interviewer: So, more of a novelty?
Interviewee 2: Yeah, yeah more than anything, it wasn’t something they were using every day.

Interviewer: Okay, um, and so, in regard to AR, if it were implemented here or anywhere else really, do you think it would require training to use? Like, for example would you need to be trained?

Interviewee 2: Yeah, yeah, I would, I’d like to be trained in how best to use it within my teaching, how’d I’d use it specifically within my teaching I don’t really know. I know someone is using it a little bit in the games lab but that’s specifically for games programming not teaching as such. So, I think I’d definitely need a little training on it.

Interviewer: Do you think everyone would, like students and staff, or just staff?

Interviewee 2: Yeah, staff for sure because I want to know, if I have a new teaching tool because that’s what it would be, I’d like to know how best to use it, might be able to use the software quite easily but, there’s a difference between being able to use the software and understanding how to apply the software.

Interviewer: Right, do you think that would be difficult then?

Interviewee 2: In applying the software?

Interviewer: In being able to understand it and best use it? Based on the fact you don’t really know anything about it.

Interviewee 2: Actually, using the software I think would be pretty quick in using the software, um, teaching computing the last 25 years. But implementing it, no I’d want some help with that, I’d struggle with that. Just having ideas, it’s like having any new technical tool. It’s all well and good having the tool but it’s all about knowing how to use it and where to apply it. We’ve got a lot of tech here at the university but the majority of people don’t use it. There’s a touchscreen that’s been there for years and nobody has really used it properly.

Interviewer: What kind of reasons do you think people not using these new technologies are?

Interviewee 2: Because they don’t really see the benefit of it, don’t see the point of it. Why make more work for yourself when you can use a pen and a board with just as much effect?
Interviewer: So, it’s a case of traditional methods are used because they’re, sort of, tried and true and easier to use for everyone involved?

Interviewee 2: Yeah, yeah, I think they would.

Interviewer: Okay, so, do you think AR, regarding everything been said, could be used effectively in a learning environment as a supplement to other tools or would it be its own thing?

Interviewee 2: Depends what you’re teaching, I can’t see much use of it in programming. Um, but if you’re doing something like medicine or engineering. Where you need that visual type input, designing, any courses where you need visual input. I want to say 3D modelling, the way you’re reviewing an artefact, I think it’d be useful for that.

Interviewer: So, mentioning modelling in design courses and stuff, do you think someone using it for models, would it be students using it in work or would it be more the teacher showing it in presentations?

Interviewee 2: Um, I think both there’s nothing wrong with using it in both scenarios. It’s quite nice to be able to give students the experience of a, sort of, VR thing, um, showing it in a lecture and letting students go off and explore it in their own time. Discuss and evaluate things in group work or individually.

Interviewer: And do you think AR could be used to help people with disabilities. So, for example, the modelling aspect, if someone was dyslexic and they had trouble reading text would visuals help them because of the modelling aspect of AR?

Interviewee 2: Yeah, I think any sort of visual learning would help a lot of students with disabilities or any student really, I think it’s a great leveller with students. It’s a matter of what the disability is and can it help immerse someone is that environment.

Interviewer: Finally, what kind of feasibility issues would there be in implementing AR? Costs, training, putting it in, logistical issues.
Interviewee 2: Well the cost is down a lot isn’t it? You know, you can have some bits on your phone so I don’t think the cost is really a problem anymore. I think the problem comes back to how best to use it. That’s the thing I’d like to know. So, if someone came to me as head of department and said ‘I want you to invest in something’, I’d want to know what the benefits are of using it. Because there are still costs involved, setup, some maintenance as well, they’d have to sell it to me so I would understand the benefits of it and to the students and whether we can use it anywhere else, is it sustainable?

Interviewer: Is that similar to every technology you have to adapt?

Interviewee 2: Yeah, if anybody came to me with any sort of technology I’d want to know the benefits of it over and above any other method of teaching.

Interviewer: Okay, I think that concludes the interview.
6.5.3 Interview 3

Interviewer: This is an interview for my dissertation, first can you state your university role and how many years you have in your industry?

Interviewee 3: Um, I am programme director for Games Design and Development, I’ve been programming and games and graphics since 1984. I’ve been in academia and teaching for about 20 years now.

Interviewer: Thank you. First of all, can you describe the types of teaching methods you use as part of your course? Group work, presentations, stuff like that.

Interviewee 3: Um, we use a mix of group work, the games course itself is built on a spiral curriculum, where you introduce concepts and build on those concepts and further build as you advance through the course instead of throwing all the complexity of a subject at students at once. Um, it’s group work based, we use a number of tools, we use Unity, uh, we use Visual Studio and C++ programming. Um, we also use 3D Studio Max and Unreal as well to widen the experience.

Interviewer: Okay and so, can you describe the way in which those are useful in teaching your particular course?

Interviewee 3: Okay, Unity for useful for us because it’s very visual and so a lot of students are visual learners. So, it provides them with a frame of reference and a baseline for more complex concepts. So, when we come to things like computer graphics and graphics card programming in final year, uh, second and final years then they have, um, you know, we’ll make reference to matrices and they’ve got a visual reference to what they did back in Unity so, things like that are a great platform for that. Then, 3D Studio Max is an industry standard tool so they get used to using that as well.

Interviewer: Okay and do you have any indication of how effective the students themselves find those methods and tools?

Interviewee 3: Um, I think with the methods we use we’ve found they’re more effective than we initially thought they would be. With the teaching methods employed, the games students are only on their first year, the first intake but one of the skills we teach are transferable skills. With programming in particular, we got the students to code in C# and they hadn’t done that before. What we found was they were able to take what they learned in Java and implement scripts in C#, which was great. I think they find the tool, uh, tools we’re using to be really good and so. So far so good.

Interviewer: Can you identify any areas where the tools and methods you use now could have room for improvement?


Interviewee 3: Um, I think one of the things we’re debating is the use of short and fat modules. So rather than hour long lectures over twenty-four week you have two-hour lecture over twelve weeks. Um, that can be challenging with some subject like programming, new languages, it’s kind of students come in and do the work and then it’s relying on own time study to get the actual stuff done. That can be challenging, having so much thrown at them with that kind of delivery, so that’s something we’re looking at for the time period next year.

Interviewer: Of all those tools and methods you use, would you say they aid students with any kind of disability?

Interviewee 3: Um, well when we develop the course we have to do it in mind for students with disabilities so, we have to make it accessible. Not so much from a sort of software point of view but, uh, from a hardware point of view. We spent months designing and developing the games lab and there are very strict guidelines about, you know, what you can and cannot do in terms of accessibility and health and safety. You know, we’d have ideas and then, very quickly, those ideas would be thrown out or thrown in so, accessibility is very much top of the list in terms of what we’ve done.

Interviewer: And to segue into AR, do you have any knowledge of it or any experience of it and if so, what?

Interviewee 3: I’ve, okay, I’ve got experience in the building blocks of AR but, I’ve not used the latest kits for it like ARKit and AR Core form Apple and Google. But, my interest is in computer graphics generally, rendering and my PhD was in machine vision and I kind of think those two elements are kind of the core pillars of AR. So, looking at images, surface analysis, being able to identify features in the environment and the graphics then fits nicely on top of that then. So, I feel I have a lot of knowledge on how the two pillars work quite a lot because I spent years doing that. But, using the latest AR kit, no and I’ve played around with some of the latest AR stuff but it seems a bit basic.

Interviewer: What would that stuff be?

Interviewee 3: Oh, that’s just mobile AR.

Interviewer: Okay, uh, next question would be, do you know others elsewhere or at this university using AR?

Interviewee 3: I got a colleague, a former colleague of mine at University of South Wales who’s very keen on AR and virtual reality in particular. So, I have worked with people who’ve expressed an interest in that. Um, I’ve not worked with anyone who’s had or worked on the technical stuff and the underlying stuff to the same level I’ve done but, I’ve certainly met people who’ve had in interest in that stuff.

Interviewer: Would that be they have an interest in it or they have actually implemented it?

Interviewee 3: More of an interest, yeah, yeah.

Interviewer: Regarding your knowledge of AR, do you think training would be required on the staff and student side to be able to use it?
Interviewee 3: Um, so are we talking about somebody, um, implements an AR application for example?

Interviewer: So, if somebody has an AR learning tool -

Interviewee 3: AR learning tool, yep.

Interviewer: They have it at the university, do you think staff and students would need to be trained to use it?

Interviewee 3: Uuh, I don’t think that question pertains to AR itself, it’s more any application, it depends on how intuitive the interface is. So, I think it really comes down to a, once it boots up, how well or, um, intuitive is the application itself. I think AR presents new challenges because, the thing about any software is, desktop software or even mobile software, is we’ve got a history of standards and conventions we know work. When we look at AR and VR, it’s new. We’re kind of at the starting point for that. I kind of feeling training would be a sensible thing to start with but, again you know, most, coming from a games background, most modern games are released without a manual. The first few levels are tutorial levels that guide you through so I could imagine something similar being applied to help familiarising someone with, um, navigating around AR.

Interviewer: Okay so, based on your knowledge again, do you think this university could implement it successfully or any university could?

Interviewee 3: I think yeah, you could use, with the API, the API’s available and the accessibility given now to augmented reality across mobile platforms in particular. Yeah, it’s just a matter of sitting down with it.

Interviewer: What kind of uses?

Interviewee 3: Okay for example, I’ve spoken to marketing here about it already, about using augmented reality for visitors. So, I think it would be fun to sort of gamify finding your way around campus, Um, and I like the idea, with the games course in particular, with having giant 3D models in the atrium kind of thing, just to start interest and generate discussion really. So yeah, I think for applications like that.

I know you’re talking about AR in education, um, I certainly think it could help. I mean, different people learn in different ways, I’m a very visual learner so automatically fit into thinking it’s fantastic and I know other students who are visual learners. I think it provides a way of presenting information that we didn’t necessarily have before. How to integrate it into environments where, um, I think it could be particularly useful where integration into the real world is more useful.

So, if you got, you know, a model of a solar system hovering above a table, well I’m not sure if that adds value over a 3D picture of a solar system on a screen. But, if you got a patient or a person on a table where you can overlay a skeletal structure or take a car or engine and realistically overlay the components or show flow, the flow of fuel intake, things like that. I think when you’re trying to educate that sort of thing it can be phenomenally useful, yeah.
Interviewer: Um, and then could, do you think it could an effective way of helping people with disabilities? So, if somebody had dyslexia for example -

Interviewee 3: Oh, very much so, yeah, I think so, yeah. I think, I mean diagrammatic, pictorial, visual tools that help dyslexic students is phenomenally useful. I remember many years ago we had a dyslexic Master's student and his support worker talked about his difficulty with maths, algebra, you know, most people have difficulty with that.

The interesting thing was we talked about replacing equations with functions and graphs. So, you could graph a quadratic equation with different conditions for different coefficients. The pictorial version would be very useful for an algebraic expression. So, yeah, I think there's certainly evidence to support that, yeah.

Interviewer: And then finally, do you think there would be any feasibility issues with implementing it? Would there be a lot of cost with it, confusion about how people would use it, stuff like that?

Interviewee 3: Um, I think two main things spring to mind for that. One would be, you talk about cost, I think any, you’re going to have an augmented reality environment with 3D models or any content you need to develop that content and put it in. So, to do that in a realistic, meaningful way might require somebody with expertise to do it, that might incur a cost.

I know the university in particular has some great stuff going on over in the School of Art and Design, I think there’s probably in-house skill to do that anyway. I think, um, in terms of feasibility, I think the other thing comes down to managing expectations about what current AR limitations are. I kind of, I’m very much at this point, of sort of ‘what really can we do?’ and people might have ideas and aspirations for developing tools with AR but, they might very quickly bump into, well here are the technical limitations. I think that’s the big factor at the moment but the goalpost will shift on that as time goes on. Technology improves, ideas that aren’t feasible right now will, of course, become more feasible down the road. But, I think at this point it’s bumping into those, yeah.

Interviewer: Okay, well, thank you for the interview.
6.5.4 Interview 4

Interviewer: This is an interview for my dissertation. First thing, can you state your position at the university and your years in the industry?

Interviewee 4: Uh, I’m a senior lecturer here and, years in industry?

Interviewer: Yeah.

Interviewee 4: Uh, ten years.

Interviewer: Okay, thank you. Um, first of all, as part of your course teaching can you describe some of the learning tools or methods you use currently? So, do you use PowerPoints, make people do group tasks, stuff like that?

Interviewee 4: I use PowerPoint and I use Word as well, Notepad ++ because coding sometimes, it helps out on the uh, um, project on the screen to walk through the code. I use some integrated learning environments like Eclipse or Octave and, uh, Visual Studio, yeah.

Interviewer: Okay, do you make people work in groups or is it all very individual?

Interviewee 4: Combination, a combination.

Interviewer: Um, those methods and learning tools, how are they useful in teaching course content?

Interviewee 4: they are quite useful, yeah, so you know PowerPoint is always good to, uh, convey information. Other tools like IDE and Notepad ++ they are quite useful in showing students a program and running it in front of them, to see output and making changes to the code. Really learning the program and showing them the changed output and trying to correlate what bits in the code produces what output.

Interviewer: Do you have any indication on how the students themselves find those?

Interviewee 4: We do take student feedback and we have different mechanisms of taking feedback form the course, verbal communication, we have student meetings so yeah, we do, you know, get feedback and still find them effective.

Interviewer: Out of all those methods and tools, are there any areas where you think they need improving?

Interviewee 4: Um, there’s always scope for improvement, I think one area that could be looked at is adapting the course content for disabled students. Um, yeah and all kind of disability so visual or hearing. So, you can adapt course, um, material for those students which sometimes can be challenging actually.

Interviewer: So, would you say, currently, the methods you use are effective at helping disabled students?
Interviewee 4: They are effective but they do require a lot of input actually, lot of work from the, um, teaching team whereas if it could be automated at a university level wherein you give them a PowerPoint and a tool, you know, automatically creates them a PowerPoint for a disabled person So PowerPoint for visually disabled, or PowerPoint for colour-blind, you know. Whereas right now I think the onus is very much on the teaching staff. But then, it means much more work and everyone needs to know what standards are, not everyone would know how to aid a blind person; there are experts who know better. So, if someone could take input form the experts, who know how to deal with them and then come up with a tool which would just take an input for a normal file, um, normal material and convert it to a format which is more suitable for different kinds of disability, I think that could be good.

Interviewer: Then to move on into augmented reality. Firstly, do you have any experience of it or do you have any knowledge of it?

Interviewee 4: I have used it just for fun, a rollercoaster in augmented reality.

Interviewer: Are you aware of other uses of it, in terms of educational applications?

Interviewee 4: I know it is used in medicine, the medical field. I know it is also used in, um, tourism industry. Where you go into, um, an old church and using augmented reality you could have different information laid out on the church -

Interviewer: So, overlaid?

Interviewee 4: Overlaid, yes and um, information for tickets. So, I think there was a TED talk video with sixth sense. You know, google sixth sense TED talk, it’s a very good video and it shows uses. Train tickets for example, a train has times that can be updated and if you have a train ticket that is linked to it you can look at it. Uh, a guy with a camera on the head takes the picture, searched Google, gets the right train time and puts in onto the ticket. So, if you’re wearing that goggle, uh, gadget then you see the right time.

If you look at packages, you know a supermarket, you look at a product it has limited information there and usually in very small fonts which you can’t read. So virtual reality, um, an overlay in use so you could see, look at the product like this, takes a picture and gets all the right information and then shows it.

Interviewer: Um, and then are you aware of faculty here or at other universities using AR as part of their course?

Interviewee 4: Um, personally, um, I think that it’s used in School of Art and Design in a studio but beyond that I don’t know.

Interviewer: Okay, then based off of what you do know about AR, do you think if people were to use it, it would require training or not?

Interviewee 4: It would require training I think, it would require training of course. It would require training and equipment as well.

Interviewer: Why do you think it would require training?
Interviewee 4: Because, um, because, I think because you don’t want to make it shocking and augmented reality is like, so, if you’re driving a car or on a rollercoaster ride in augmented reality it’s almost too real you can get shock out of it. So, you need to do it in a staggered way really and expose students to the scenario in a staggered way, bit by bit. If it’s bombarded some people can, can genuinely get stressed if you expose them to this reality -

Interviewer: It’s a new environment.

Interviewee 4: Exactly, a new environment can be shocking. So, you need to know how to expose things to people, you know.

Interviewer: So, again based off of what you do know about it, do you think augmented reality could be implemented successfully as this university or at others on a, sort of, wide-scale?

Interviewee 4: I think it can be yes, I think it could be, uh, yeah innovative. It would be innovative to introduce and it can be if enough resources are put into place.

Interviewer: What kind of resources?

Interviewee 4: So, the resources in terms of training, resources in terms of equipment and resources in terms of who you could turn to for help if you are having a problem. If you’re stuck in a problem, you need people who can deal with that, a help team. Similar to IT where you go to someone and say ‘I’m struggling with this’, so a help team.

Interviewer: Um, and then areas, what sort of subject matters do you think AR could be most helpful in using? Would it be good for science courses, would it be good for a computing course, stuff like that?

Interviewee 4: I think it would be good for science courses, especially medicine, medical courses for sure.

Interviewer: Why do you think that?

Interviewee 4: Because there’s a lot of, I mean right now, um, suppose you’re having somebody there and you’re trying to tell me what is inside the body. You need real people to cut them open, or a mouse to dissect. But with that reality you can give them a feel for what is there without actually cutting them open.

Interviewer: So, because of the modelling?

Interviewee 4: Yes, because of modelling it gives them a real feel. So that’s one. In computing as well, you could use it. One of the problems in computing is when you’re teaching hardware there’s an abstract layer. So, when you have a router you can’t physically change settings all you can do to the router is coding and this is abstract because you’re writing code on a notepad and that is doing something to the router on a physical level. So, I think there’s a level of abstraction and some students find it hard to understand the abstraction.
For example, there is transistors going on here at a very microscopic level and it’s all working, it’s all doing addition or subtraction right? But, because it’s such an abstract level you can’t see it. So, I think a model of a microcontroller which you can manipulate by hand, right now you can’t manipulate by hand because it’s so tiny -

Interviewer: And in the computer as well.

Interviewee 4: In the computer as well, exactly you know. I think the problem for some students is they learn, if they can see it and feel and do it they will learn it. If you show them how to change a wheel on a car they will learn it because they see how to change a wheel on a car. But programming is an abstract concept because you’re writing and then you’re pushing and somebody else is doing something so, there’s a bit of a gap there.

Interviewer: So, it would help in developing on, sort of, concepts?

Interviewee 4: Concepts absolutely and hardware, how it is working.

Interviewer: So, do you think AR therefore, would it be more of a supplement to other tools or do you think it could be used on its own?

Interviewee 4: I think everyone will be a supplement because you, you work in collaboration with a lot of tools. So, it’s for any tool because you can use that and cater to a wider audience here. So, you get different kinds of students, some who will find AR more, some will find pen and paper more. Because you need to teach abstract concepts as well so, I think as a combination it will always work, yeah.

Interviewer: Um, is there, um, any other areas you think AR could be used in?

Interviewee 4: I think entertainment so, Disney Land in Paris. There’s cost involved, there’s risk involved and then you’re getting the feeling. So, in pretty much one room you could create a Disney park. I think some places it’s being experimented where you just sit in a room and all rides are actually virtual reality. Also, it exposes you to, it enables you to give that experience to disabled people, people who can’t walk and want to feel.

I think at some level as well, it may aid for recovery, uh, you know –

Interviewer: Uh, in what way?

Interviewee 4: You know, people who, they can’t walk properly and you want to make them walk everyday little by little and, you know, eventually they can walk. So, I think it’s a matter of experience as well, you experience walking because you’re forwarding that experience and AR is that. You know, don’t just give them that as the experience of walking but, use it as a push for it and give them experience where it’s not hurtful, hurting you, but you’re getting more experience, the feel. Sometimes it’s a confidence thing isn’t it? ‘Oh, I can’t walk’ and then they get into that spiral but, give them that experience and it could help people get better quickly.

Interviewer: Okay, um, so, in terms of the feasibility of using AR, apart from things like cost and training, do you think there are any other, sort of, drawbacks that could affect implementing it at a university?
Interviewee 4: I think cost, resources are one. I think also, the technological barriers I mean, how good that is, it has to feel real. Yes.

Interviewer: Um, I think that covers it yes, thank you for the interview.

Interviewee 4: No problem.
**6.5.5 Interview 5**

**Interviewer:** Okay, this is an interview for my dissertation. First question, can you confirm your position at the university and your years in the industry?

**Interviewee 5:** Uh yeah, my position in, um, at this, um -

**Interviewer:** At this university.

**Interviewee 5:** At this university, yes, senior lecturer.

**Interviewer:** And how many years in the industry do you have?

**Interviewee 5:** Industry or lecturing?

**Interviewer:** Both.

**Interviewee 5:** Uh, 18 years teaching at a university level and, uh, I helped set up a charity so, oof, 10-12 years stating a charity and working within a charity as a board member, uh, trustee. Working industry, I, um, worked in industry for, ooh, 6, 7, maybe 6 years. Got quite involved in it, into several sectors. So, S Micro, SME and corporate.

**Interviewer:** Okay, uh, first of all as part of your course can you describe some of the learning methods or tools that you’d use? So, do you use PowerPoints, presentations, group work?

**Interviewee 5:** All of the above, yeah, just everything.

**Interviewer:** So, it’s everything?

**Interviewee 5:** Yeah, it is everything, it is really yeah.

**Interviewer:** Okay.

**Interviewee 5:** We do, um, I’ve attended many learning and teaching development sessions throughout my 18 years and I like to encourage and use innovative methods of teaching. That are recognised, not just gonna be flash in the pan, that have been established and show a proven track record with pedagogic engagement. Or, that have an appropriate use for context within a learning structure that I’m dealing with.

**Interviewer:** Would you, uh, could you describe the ways in which those are useful in teaching your course?

**Interviewee 5:** That’s too many to name, ooh, so for instance, when I was teaching mobile app development I really liked the use of the Pop application so, a drawing application embedded within the mobile phone, it made very quick prototypes. Well, quick from what I’ve seen and tied into the structure of paper prototyping to rapid prototyping really well. It was engaging, students could, uh, do it on their own machines, on their own phones and they could see different results very quickly.

But I mean, there’s loads and I’ve probably forgotten the vast percentage of them ‘cos as time goes on you, you know, whatever.

**Interviewer:** Do you have any indication of how effective -
Interviewee 5: Do I have any what?

Interviewer: Any indication of how the students themselves find those methods?

Interviewee 5: Yes, yeah, yeah, yeah. So, there are different types of queues that I can formatively, uh, judge the quality of a student work and that’s a formative assessment, which is assessment that happens throughout the module as it’s progressing rather than a summative method where people get a mark just at the very end.

So, I’m gauging my students on how they are dealing with the techniques and theories that I state to them and then I’m asking them questions to see their response with it, as any teacher should do. There are sometimes tests to enable that structure so I can metricise learning quality. However, more often than not I deal with very dynamic groups that have many different levels of learning within that. So, it’s very important that I, uh, use a very good pedagogic strategy, being the teacher, to recognise individual learners needs and find techniques to prioritise those groups of individuals into sub-groups so that I can then deal with them within the right context and the appropriate amount of time that they would need. Without devaluing the service that I’m providing for the rest of the student cohort.

Interviewer: Can you identify current areas where your learning methods or tools are lacking or need improving?

Interviewee 5: Um, I think that, I take that whole idea as somewhat ‘what?!’, um, lacking? Um, me?

Interviewer: Areas where the tools can improve?

Interviewee 5: Pff, I tend not to assess the tools for, um, lacking? It’s kind of a tricky thing to assess, um, ooh. I could look at, I mean there’s a lot of tools that we use so, we can look at virtual learning environments. Our current incarnation and I want to say current incarnation ‘cos it’s been around for 18, you know’ longer than I’ve been teaching. Different virtual learning environments so, we had Blackboard now we’re onto Moodle and they’ve always been.

I suppose we’re working in a department where I do research with human computer interaction, have done for a very long time now. So, we’re in a very good position to be able to analyse that structure and see it’s weaknesses. Now, there was many weaknesses, we’re talking about an application and there are techniques within that application that are huge, I mean, they’re not huge but there are a lot. A quantity of different methods that are applicable and usable within the virtual learning environment, to go into the weaknesses of each of those would take way too long.
But to state, it’s been terrible for quite a bit but, also absolutely brilliant because it enables a supplementary method of learning for individuals that is never built to replace, always there to be additions to and also has shown great pedagogic advantage. That’s been recognised within research as well. That doesn’t have to be, we’re talking about virtual learning environments but, there’s all the add-ons within it and there’s all the different, you know. Panopto, I mean, there’s loads just loads of opportunities. We could be having the same conversation talking about a whiteboard and a marker pen.

**Interviewer:** And these tools and resources, do you think they effectively aid students with disabilities?

**Interviewee 5:** Yes and no, you could say my virtual learning environment could assist someone with, say, ability to travel to university or get around a certain learning constraint. Whether they want to review an area. However, having said that it could work against some disabilities. So, let’s say I have severe MS, a virtual learning environment isn’t gonna do anything for me, I still have severe MS it’s not gonna bridge that.

So, we can say yes in some instances but, at a very granular level, not that I’m necessarily aware of those studies that have been conducted. But, because we are talking about so many different outputs available for, ability of a VLE or any of the learning strategies that we utilise it’s tricky to be able to gauge whether, how they, uh, could then change, a further permutation which would be a different disability, with all of those different spectrums of disability So, it’s, um, a bit of a big question.

**Interviewer:** Okay-

**Interviewee 5:** If you had asked that about, say, blind people it would’ve been easier to answer. But, because there’s so many disabilities sand so many different techniques that we utilise...

**Interviewer:** Ah right okay. So, to segue into AR itself, do you have any experience of it or any knowledge of it, what would that be?

**Interviewee 5:** Uh, in 199..., ooh, was it, 1992 or 1993 I made a virtual, an augmented reality headset at university.

**Interviewer:** And what was the purpose of that headset?

**Interviewee 5:** It was a, so, I was studying telematic art and I was looking at dislocating information, being, uh, augmented our viewpoints. Now, at the same time virtual reality was in a very virginal state all in itself. So, I developed a, uh, globe like screen that would encapsulate the persons viewpoint and whenever you moved it would follow with you because of the headset you were wearing. It would be displayed through a spectrographic display of a globe. I should send you some pictures, it’s wonderful.
From there on forwards that incarnation died a death really, early to mid-90’s, lawnmower man-esque stuff. I got to engage with artists, world artists like Professor Roy Ascott and, oh, what’s his name, Peter, Ray Appleton, Richard Stockford and Mike Hunt and Professor, what’s his name, uh, Phillips. Interaction with artists, oh, worked up at a studio, PhD student up at Newport, uh, he’s over in Canada now. I forget it anyway, shed loads.

I was also planning designer for interactive media, we had students working on developing VR and AR applications from 2008, was it 2006, 4, 2, uh, 2008-9 and we were using the original glyphs to locate and then, at the time we were trying to, to try shift the technology we were using from non-glyph AR.

**Interviewer:** Are you aware of any other faculty either at this university or others using AR?

**Interviewee 5:** Yeah, I’m an external examiner for the Master’s up in Glasgow for virtual environment and virtual worlds.

**Interviewer:** Okay, any other staff here?

**Interviewee 5:** I don’t know you’ll have to ask them.

**Interviewer:** Do you think those technologies, AR technologies, would require training to use? Either faculty or students?

**Interviewee 5:** No, any well-designed piece of software shouldn’t need training from my viewpoint. This is a human computer interaction issue, bad design needs to be told, good design is intuitive. I’d expect it to engage with natural user interaction theory.

**Interviewer:** Do you think AR is at a stage currently where it could be implemented successfully at a university such as this one?

**Interviewee 5:** Yeah, yeah, course, of course. It has been for many years.

**Interviewer:** So, you could see it adopted on a wide scale in a variety of subjects?

**Interviewee 5:** Yep, yeah, could be yeah.

**Interviewer:** In what ways do you think it would be effective?

**Interviewee 5:** I don’t know but I think it really could be. We are talking about a method of sharing, interacting and engaging with information in different ways. Uh, I wouldn’t say the opportunities for it are infinitesimal but, they are large yeah, But, I’d be naive to say the modalities, the different modes of how you utilise it, are quite unique, novel and shows great possibility for user engagement. I, uh, um, have no worries on it yet –

**Interviewer:** Do you think the visualisation aspect is the most important bit of it?

**Interviewee 5:** No, I wouldn’t say anything is, ‘cos as I say I ain’t got a crystal ball yet. I ain’t daft being ‘oh, it’s not the most important thing’, it is vitally important and research by what’s his name over in Washington University, he did the wearable projector that projects up to labelling systems in factories and augment that information back for the user. I forget his name, he did a TED talk back in, ooh, 2010.
Interviewer: Somebody else mentioned something like this.

Interviewee 5: Oh good, ooh, his name, uh, don’t worry, don’t worry.

Interviewer: Do you think it would be useful for collaborative learning then? For an AR model to appear for a bunch of students, get them collaborating more effectively?

Interviewee 5: Not necessarily because the visualisation, uh, as I say I ain’t got a crystal ball and it would be daft trying to guess that one. But, shared AR I know, a company I read about a few weeks ago is working on visual displays for AR. Damnit, maybe it was last week, uh what are they called? They made this globe of cameras so you could zoom in. We could have a VR, uh, AR world but you can zoom in which is a lovely idea. So, for the quality image, the fidelity higher. Yeah, I don’t know.

Shared, student sharing, one thing I do know it sounds very Star Wars, very ‘help me Obi-Wan’, problem is that’s a flickering model, like, holographic, yet we’ve been able to do holograms through MIST and different screen projection like with AR for quite some time. But, the thing is the fidelity of it isn’t very good. Aah, and you gotta think, well, it only has... If your audiences are moving it’s not a problem, if your audience is wearing headsets it’s not such a problem. But, it’s one of the biggest limitations of VR/AR, headset engagement.

Interviewer: In regard to limitations, apart from headsets, which studies show there are quite a few problems with those -

Interviewee 5: Pff, yeah.

Interviewer: Uh, what other limitations so you think there’d be with implementing it? So, feasibility questions, you know, costs...

Interviewee 5: Cheap. Super, super, super cheap. I mean people have been able to do scans with a webcam, you know. I was able to build an AR camera back in the early 90’s and I had no money. I made it out of an LCD TV and some goggles and some cardboard, my friend.

Interviewer: Very resourceful.

Interviewee 5: Students, they are, um, and penniless.

Interviewer: Uh, and finally, do you think AR could be used to help people with disabilities?

Interviewee 5: Yes, yes, yes...

Interviewer: For example, someone with dyslexia, having models...

Interviewee 5: Yes, yes, yes...

Interviewer: Okay, thank you.

Interviewee 5: Thank you very much Adam, that was nice and quick.
Interview 6

Interviewer: This is an interview for my dissertation. First question, your position at the university and how many years you’ve had in the industry?

Interviewee 6: Okay so, I am programme director for undergraduate studies within the department of Computing and Information Systems. I am also a senior lecturer in software engineering. I have been a lecturer in higher education for 12 years and, um, I had 2 years in further education before that and I had 7 years before that as a software engineer.

Interviewer: Okay, thank you. First question, can you describe some of the learning methods or tools you use as part of your course currently? So, do you use Moodle, do you use modelling, text-based stuff, stuff like that?

Interviewee 6: Okay, I’m pretty traditional in the learning technologies I tend to use. Like most lecturers I use PowerPoint slides and Moodle for posting and sharing material. Um, in terms of videos I will sometimes use YouTube to show videos to supplement my lectures. Simply because I believe hearing form the same person for an hour or 2 can be a little bit monotonous. Um, and I firmly believe it’s good to chop and change the media you’re using to hold people’s attention.

Besides that, I don’t use a lot of different learning technologies. In some way, I’m resistant to it. So, things like audience response units or Kahoot. Um, I think they’re useful it’s just not a form of technology I particularly like, I tend to plan my sessions meticulously. I’m a little bit, tend to see how this flow. If there’s a whiteboard and some pens, I honestly prefer scribbling on a whiteboard and talking.

Interviewer: Okay and then, regarding all those different methods, how are they useful for teaching your course specifically?

Interviewee 6: Okay, um, so Moodle, um, is very useful because students nowadays have come to expect, um, that they can download slides that I’ve used in presentations. I sometime like to share supplementary reading material. So, if I come across a news article that I think is relevant to the course or something I’ve said to the students I will share that on Moodle and of course there’s the assessments. I tend not to use it in any more imaginative ways than that. So, for example, lecturers will use Moodle and post. Like. Video their lectures. I don’t do that, I tend to stick to the more traditional means. Why do I do that? I think because it’s a tried and tested mode of delivery for me and because I teach in a rather informal way I don’t think Moodle helps me as it might some other lecturers.

YouTube, I use a lot, for the reasons I just mentioned. I think its’s good to hear other people’s perspectives. If I post a video link on YouTube and post it on Moodle I now 9 times out of 10 students aren’t going to watch it. So, I will use some of that time in my lecture and I’ll either analyse, expand on it or get the students to discuss it with me and work it in that way. But, I mainly use it as a means of chopping and changing mode of delivery within a long session.

Interviewer: Okay, do you have any indication on how effective the students themselves find those methods?
Interviewee 6: Um, I don’t have any formal means. So, I don’t, um, so, Nigel developed a system called RAGE for measuring interaction and sort of how students feel about particular sessions. I think lecturers should know your audience. So, you should be observing your audience and their mannerisms and if they’re, sort of, falling asleep or on their phones, whether they’re taking notes or otherwise seem actively engaged or humour, you know, pole laughing at bits of the clip. So, for me it’s about observing the students and see how their reacting and then I’ll ask questions to ascertain whether they’ve engaged with that or not.

Interviewer: Okay, regarding those methods again, can you identify any areas where they’re lacking or need improvement?

Interviewee 6: So, um, it’s a bit of a challenge. Moodle as I’ve already mentioned, I tend to use by putting slides up there, assessments, bits of reading material that’s it. Because I don’t personally find students engaging with my Moodle modules. That being said, if I used the capabilities of Moodle more fully, what would be interesting then is to see if students engaged with Moodle more, if that makes sense.

Interviewer: Yeah.

Interviewee 6: Um, so, for example Nigel, on a snow day recently he put up a recorded lecture of slides with his voice and when he told me he was about to do that I was like, ‘well okay’. But, actually I saw students in my class watching his video lecture so I think that if you make that students might use it more. So, I think that my Moodle modules personally, are lacking in the sense that I stick to the basics.

In terms of the actual technical capabilities of Moodle, I think it’s a pretty, pretty comprehensive online learning environment even better than Blackboard was. From a lecturer point of view, it’s more flexible. Um, as with any system there are certain quirks with the Moodle software that frustrate me. So, for example, if I’m updating stuff at home and I’m taking my time to compose something in Moodle, rather than on Word and pasting it in. Sometimes I’m logged out and lose everything, um, get no warning form that and that puts me off using it sometimes.

So, I think there are issues to it, some small quirks of the software that I think could be easily dealt with from a design point of view that would make it more usable. But, on the whole I think Moodle is a very well-crafted online learning environment, which is why it’s so extensively used.

Interviewer: Okay, and then with those tools, do you think they effectively aid students with disabilities?
Interviewee 6: I think Moodle certainly helps, because there are students who may have additional learning needs such as dyslexia and they are able to access materials if they are posted up in advance. It also means students who may have dyslexia or have English as a second language, it enables them to go back over slides and I think that can be useful. I also think for students who maybe have autism spectrum disorders, they can see how the module is planned out when it’s updated well and I think that sense of predictability and structure can also help students with autism engage with their learning.

Interviewer: And so, using things like PowerPoint and YouTube, they also help?

Interviewee 6: Yes, I do, I think PowerPoint, um, depending on ow it is used. Some lectures I deliver, I don’t have many words on the slides, lots of pictures but not so many words. To what extent they help students, I’m not really sure because if they weren’t in the lecture the pictures aren’t gonna make a lot of sense themselves. But, I think that well-crafted PowerPoint slides can also be useful for those with additional learning needs or accessibility issues. We also have students at university who can’t attend due to health issues and therefore, having access to those materials, YouTube videos they can watch in their own time and PowerPoint slides that can be revisited are useful.

Interviewer: Okay, and to segue into AR specifically, firstly, do you have any experience using it?

Interviewee 6: Not really, very limited.

Interviewer: Okay, what sort of stuff did you have then?

Interviewee 6: Just the odd demo really but, I’ve not really interacted with it at all.

Interviewer: Okay so, you have knowledge of it then?

Interviewee 6: Limited, yeah, some experience, as in some knowledge yeah.

Interviewer: So, do you know of other faculty either here or at other universities having used it?

Interviewee 6: Within the learning environment?

Interviewer: Yeah.

Interviewee 6: Ah, no I don’t.

Interviewer: Oh okay then, considering that, with the knowledge you do have of it, do you think people would need training to use it?

Interviewee 6: Yes, I mean we have to have training to use Moodle so yeah anything, I think training would be required. Would that be a barrier to technology acceptance by a university? Maybe, university budgets are stretched and that doesn’t necessarily mean just in terms of money but, staff, hours and resources are stressed. Um, ah, staff participating in voluntary training can be quite challenging.

Interviewer: Do you think then the students would also need training for it?
Interviewee 6: Probably less so than the staff. I don’t know in all honesty, probably some but, you don’t really get much training in other learning technologies that we use. Um, you know

Interviewer: We just kind of, get on with it.

Interviewee 6: Yeah.

Interviewer: So, again, based on what you do know, do you think, as it is now could universities implement it successfully as a learning tool?

Interviewee 6: I don’t see why not, um, I think if any institution would be able to it would be a university.

Interviewer: Why do you think that?

Interviewee 6: Why do I think that? Um, I think that because universities, by their very nature they live on the boundary and they should be pushing the boundaries as well. I think in that sense of willingness to experiment and try new things universities are ideally placed. I think that other further education facilities like colleges or schools just don’t have the time or resources to experiment too much.

Also, they have too structured a curriculum, a university curriculum is more flexible, we have a lot of flexibility built in whereas schools and colleges, you know, it’s planned out lesson to lesson and they have a certain amount they have to cram down to meet a certain deadline, to meet a certain target. So, I think universities are ideally placed to start exploring that.

Interviewer: Okay, I was going to ask about different way you could use it. But, um, AR can be used, from what research I’ve conducted and what others have said, you can use it to overlay instructions. You can use it to have models for, like, 3D viewing and suff so, collaborative learning with group projects where people get involved together.

Do you think those different types of uses, where would they be most effective?

Interviewee 6: Um, I guess lab-based activities. I think, um, that kind of application could be applied in lectures as well but, I don’t really see that there’s a limit. So, yeah, traditional lectures and seminars, especially practical based seminars. In our subject area here, yes, some modules especially. But, I know this sounds very vague, I can’t really think of a limit thinking about the institution as a whole.

You know, sport science, health science, it could be applied anywhere.

Interviewer: Yeah, Nigel mentioned some people using it in architecture for visualising a space

Interviewee 6: Perfect, yeah. Actually, sports performance would be another area.

Interviewer: So, uh, using the types of uses that I mentioned just now, do you think the visualisation that AR provides would be useful for people with disabilities?

Interviewee 6: Yeah, absolutely, um. So, to think of an example, again, the sort of students I gravitate towards have autism spectrum disorders. I think that there would be good scope for application there, where supplementary information could be overlaid. Yeah, again, it’s one
of those things where I just don’t see many limits to it. People with dyslexia, you know, for
every example, could we use it in such a way that...

For example, I have dyslexia and I can look at a piece of paper and see the middle bit of the
page and the rest of it’s all moving. Could there be a way of, you know, um –

**Interviewer:** Visualising -

**Interviewee 6:** Altering visualisations or, picking out key words. I mean, there’s all sorts of
things we could be doing. In as wide a range of learning disabilities that there are I’m sure
there’s some potential for application.

One other example, someone with autism spectrum disorder, having predictability in their
day could be key. So, if they could have information overlay like, this is what’s coming next,
this is what we’ll be doing next and it’s some in a discrete fashion, it um -

**Interviewer:** Just becomes part of their natural environment.

**Interviewee 6:** Yeah, there we go.

**Interviewer:** Okay, so, AR, the research I’ve been doing, is about do you think it should be a
supplement or, do you think should it be used on it’s own?

**Interviewee 6:** Okay, as a supplement.

**Interviewer:** Why do you think that?

**Interviewee 6:** Because I believe that’s how it works for most technologies.

**Interviewer:** That they all work together?

**Interviewee 6:** Yeah, and maybe that’s because, so for example, the Friday, not last Friday
the one just gone before, I went in and looked at some slides. I took over a new module, I
looked at the slides and I went ‘nah’. I went in and I did it with no slide and I just talked for
an hour about the subject. I think there are times where you just need to down tools and just
talk at them. Because, universities are up here in the mind, not in the building, the PowerPoint
slides, it’s here in the students and lecturer’s minds.

I think that if you, uh, do depend on one particular piece of technology you’re in danger of
inhibiting that to some extent. Don’t get me wrong, I don’t mean to sound like a luddite or
not think technology’s important. I really do, but I do believe all of this is supplementary and
it should not be the sole focus of delivery.

**Interviewer:** Okay, well thank you, the, uh, interview’s concluded.

**Interviewee 6:** You’re very welcome.
**6.5.7 Interview 7**

**Interviewer:** Okay, so this is an interview for my dissertation. Firstly, can you state your position at the university as well as your years in your industry?

**Interviewee 7:** I’m a senior lecturer in Public Health, Housing and Risk and I’ve been at the university for 6 years.

**Interviewer:** So, as part of your course can you describe some of the learning methods you use? So, what kind of technology do you use?

**Interviewee 7:** Well, I’m pretty passionate about trying to get engagement. So, one of the ways of ensuring engagement is by providing teaching with a variety of different means and media. One of the ways to approach this is through group work and I, pretty much, have group work in every one of my sessions. Um, I also go outside of that in my first-year module where I try to get the class to operate as a series, a series of groups within a supergroup, if that makes sense.

So, I can give them a research task that they can, sort of, parcel up amongst themselves with some support from me. Um, and then each of them summarises different documents they’ve got to look at which are, um, technical documents and puts them into layman’s terms for the greater group to use. SO, uh, in exchange for a day’s worth of work from one unit, the rest of the cohort gains a very large reservoir of data which ordinarily they wouldn’t have had time to access.

I’ve also been doing problem-based learning, which is groupwork. I’ve been doing it with a group of, I think, 6 at the moment. That’s, uh, giving them tasks, which have been quite well thought out which, uh, requires them to go out and learn about different aspects of the natural and built environment. The work, first of all, is to get them used to working in a group which, um, it’s been quite a steep learning curve for them and then to cooperate on different projects. One of the problems with this, um, they tend to do very in-depth work but it draws a lot of attention from the facilitator, from myself, and colleagues to keep them onto the topic to avoid them going down rabbit holes.

We’ve also got a final year module with groups work where, um, it’s scoping out an area for public health needs and then they work on scoping out interventions, an evidence-based method of intervention and investigating its effectiveness. That with it comes, uh, we have some peer evaluation within that module which helps to avoid problems with people not pulling their weight. But, it’s, because it’s a final year module there’s a lot of pressure on those that are involved, each year we always get interpersonal issues. It’s difficult to get across to the students that that is actually part of the learning experience.
The, so, the group work I’ve recently taken into a new area with virtual student exchange, with a university called Modern University of Business and Science in Lebanon. Using the learning platform at Stanford, uh, their version of Moodle, Cisco, Skype for video conferencing between the lectures for live connection during lectures. Uh, and mainly WhatsApp for communication between students in groups. I’m able to get groups where, again, it’s smaller groups and then a meta group. Again, the smaller groups are given small, different aspects of, the issues of ensuring public good health in refugee camps. This is a real camp in Beirut. They, um, they’ve got half and half work between them, with each group having half my guys and half their guys.

So, what they’re given is a problem-based task where they need to address the different public health needs in different aspects of the refugee camp. For instance, adequate provisions for sanitation, health, food and water. They do some research and make a questionnaire for it and the, uh, Lebanese students go out to the camp, ‘cos they speak Arabic, talk to the people. Collect data and capture some virtual footage using a 360 camera. They then come back and present all this to the UK students. Um, what was the second half of that question, I only got to the first half?

Interviewer: That was the question.

Interviewee 7: Oh great, right then.

Interviewer: Can you then, all of those methods you use, describe how are they effective on your particular course as well as how the students themselves find them?

Interviewee 7: Right, so, I’m going to have to work backwards then. In regards to the virtual; collaboration, the virtual exchange, that’s been very effective in that’s it’s exciting and stimulating for the students so they’re engaged form day one. Their engagement is also ensured through a certain amount of face, you know reputation, doing their bit for the university. So, not only do they feel part of the university, they also feel part of this shared group with other students. You know, they go on FaceTime and show their house, what they get up to and so, it’s been effective in breaking down cross cultural boundaries. Also, it’s been addressing a particular us vs. them approach with students, particularly Middle Eastern and, uh, Islamophobia.

I’ve also found it very effective in teaching the content here. We’re talking about public health in the media of a humanitarian crises, actually a lot of the underpinning issues are stuff we’ve got in a variety of other modules. Communal diseases. Non-communal diseases, ensuring basic shelter and housing, health requirements. So, not only are we teaching them to be more global people, global students, to be more globally aware it also allows them to have a practice at...

So, talk about cultural boundaries, it allows them to look at all these issues you get in humanitarian aid which you get in public health in a safe environment where they can afford to make mistakes. Whereas, if they do it in practice there’s a whole lot of budgets, time and other constraints around that so it’s difficult to do. It gives them a dry run at things which they wouldn’t otherwise.
Through the, um, use of the virtual reality we’re able to take the students out of the lecture theatre in the UK and put them in the environment of the refugee camp. Now, I’ve just come back from Jordan where I’ve done that live with a collection of students. But, there’s practicalities with that, cost, um, trying to find the time and availability to take students out and then the huge carbon footprint that’s involved with that sort of activity. Yes, it’s better to take them to that actual environment but because of, you know, red zones or orange zones which limit travel possibilities mean we don’t get insurance in those areas. It means sometimes it’s impossible to take students somewhere and then locals can visit freely. So, they’re able to, with the virtual reality, put themselves into that environment for a much more immersive experience. But, also, it means the student is actively looking around the environment to gather information themselves as opposed to passive interaction in a lecture, with the 2D interaction of a lecture overhead.

Asking them to look at things, those actual things, improves their investigatory skills whereas, uh, if it’s showing it in a lecture theatre it’s like putting a bloody big arrow in top of something and saying ‘this is what I want you to look at’. So, um, there’s also all of the issues around emotion and their perception of how work impacts them. So, visiting refugee camps live like that gets to you and you have sometime afterwards thinking about it. So, you get some assimilation of what you’re learning but, you also get to deal with the emotional side of that as well which is difficult to get through any other means.

Uh, the group work on the whole module, it very effective in that, if the group are working in a genuinely cooperative manner, um, then the benefits they get are not only the interpersonal benefits and cooperating as part of a team. But, also, got the same issues as the other module where they are able to access a much wider range of information, assimilate it and use it with appropriate critique. Which otherwise, they wouldn’t be able to do, if they did it in isolation and as part of an assignment they just looked at themselves. It also allows for that sharing of ideas that people can ping off of each other and come up with better solutions with critical analysis.

**Interviewer:** Okay, so of all those tools and methods, is there any area where you think they’re lacking in some way?

**Interviewee 7:** So, um, that’s a good thought. Are we talking about the group work or the use of IT in particularly?

**Interviewer:** The IT particularly, yeah.

**Interviewee 7:** Okay, so, for the IT side. We have fundamentals so, we have time zones. We have people dialling in form Lebanon, we have people from California, they, for the lives sessions, are dialling in at half past 3 in the morning. So, time zones are an immediate stopper and provide issues with gaining access to things around campus, what with the typical 9-5 student day.
Um, next thing would be issues around virtual reality. Cost hasn’t really been an issue because the cameras themselves are down to around £400 so, a university can usually find 3-400 quid to find a good camera. Um, it’s worth doing one that’s at least 4K otherwise the image is just too blurry and you don’t get the benefit of feeling really being there. Motion sickness, if the camera moves around as the user views it. Um, permission to capture, the people within the camp or the lecture theatre or wherever.

Um, there’s still issues around student willingness, we had students form the Lebanon side who were not responding to our students. It was actually quite entertaining, here there’d just be some usual chastisement but, in front of both lecture theatres and the pole from Stanford, the Lebanese tutor shouted their head off at these 2 students, absolutely tore them to pieces. It was embarrassing and after that they improved.

Um, the headsets, uh, access to mobile phones, pretty much anyone in a Western or semi-Westernised format, you know, middle income and upwards has access to smartphones. Um, and this university has good internet start-up. Absolute non-starter in developing countries because you don’t have those. Live lecture interactions, um, if you have issues with connectivity, particularly the audio-visual connection it ruins the session.

Um, there was one more, um, which is language, you’re stuck in an English medium so, English is definitely still the language of higher education. But, the instance you step out of higher education, the number of English speakers diminishes so, for instance, the people from the refugee camp didn’t have good English. So, providing learning materials to the people in Jordan, you got translation to take into account.

Interviewer: Okay, and then those tools, again specifically relating to IT, do they effectively aid students with disabilities?

Interviewee 7: Yes, absolutely. I use, I’ve taken virtual reality footage and spliced it together to make virtual field trips. To residential homes, to factories, to quarries and around St. Fagan’s in order to allow mobility impaired students or those who are sick at the time, access to the field trip the same way everyone else has access to the field trip. I also, umm, able. I’ve been doing recording of lectures which means it allows students with a learning difficulty, they don’t have to worry so much about making notes. They can just listen to the lecture again and again and again and because it timestamps with lecture overheads you can quickly go back to the part of the session that you’re struggling with. So, it provides an excellent resource and is regularly requested by students with learning disabilities.

Uh, finally, for students that have language problems, or those with English as a second language, the use of recording, virtual reality and feedback... I, uh, deliver audio-visual feedback through TunitIn, or I’ll deliver a screen capture video for lectures, you know, videos or images, highlight things, change the spelling of things all on the screen. Capture the screen with my voice, erm, narrating it and these, fairly unprofessional short segments but, these ones I’ve had lots of [positive feedback off international students. Because they can listen to feedback and do listen to feedback usually about 3 times. It means they’re properly engaging with the feedback and getting it with, you know, proper intonation with my comments.
Interviewer: Uh and them to segue into AR, do you have any experience or knowledge of AR?

Interviewee 7: Uh, I have experience with AR, at the moment I’ve been trying to do stuff with AR. In a lecture I bring in a lot of props meant to teach construction. You have to show someone what a wall cavity tile looks like or what damp proofing looks like or where it goes. Um, with this sort of thing, it’s fine if they’re in the lecture theatre but what I want to do is take that course online. What I want to do is use AR on the phone, again with the smartphone thing, it’s such an untapped resource. What I want to do is scan these and then introduce them to the remote learning student. So, what that means is I’ve got the virtual reality to put for the student in that environment, in the construction. But, with augmented reality, I don’t have any of the issues with it, motion sickness and things like that. I can show them isolated elements within the environment. So, if you want to put them into the environment, use the virtual reality. If you want to take items from the environment and show them to the learner in their own environment, use the augmented reality. So, I’m intending to use that and put the items and scan them up.

Interviewer: It’s the visualisation aspect then, basically?

Interviewee 7: Yes.

Interviewer: Okay then, are you aware of, um, other staff here using AR or at other universities?

Interviewee 7: I only know of one university which uses it which was Lancaster. Uh, if I remember rightly, they presented at the JISC conference which I attended a few weeks ago. They have been using an attachable scanner on an iPad and scanning models which they use for, basically, teaching medically related qualifications. From what I’ve seen AR seems to be limited to medicine but, I want to get the scanner because when I got virtual reality and started playing with it, once I’d unlocked all the bits of the software, you know. I want to unlock AR build or whatever, for the augmented reality then I can provide easy access to it for students. After that, I find my creative side comes in. I’ve already had a chat with, um, Lewis over in School of Dentistry who’d be interested in using it for presenting models to the students.

Because you can interact with it beyond the 2D side of things, um, he teaches it as an online course so, again, it allows you to take the models to the student; props are very difficult to bring in, even on my course.

Interviewer: Do you think AR would need training to use, on your part and the students, or do you think it’s easy to use?
Interviewee 7: Well, when I did the virtual reality I had to do a fair bit of learning about capturing of images, storage and dissemination of images. Those phases I usually, uh, self-taught, because there’s nobody else at the university doing it. Um, when I’ve done that I put it in a structured programme where I, as a facilitator, teach them to use what it is I want them to use. But, unless there’s literally about 5 steps to it then it’s a waste of time because then, the students, it’s too much effort on trying to access the resource rather than using it. It needs to be real quick and easy. So, um, yeah, I think it does need support on it and absolutely should be simple to use; anything that needs training defeats itself.

Interviewer: Do you then think it could be used on a wide scale at this or any other university?

Interviewee 7: Oh, let me have a think. Any prop bearing course allows the use of AR, that includes people actually. So, podiatry actually, you can take feet in various stages of disrepair and they can quite easily be scanned and shown to students in a more interactive format. Um, which doesn’t require the patient to always be there. Also, anything medical that involves props, I’d imagine that some things in School of Sports must need props. Uh, particularly therapy, massage and thing to, sort of, actualise 3D thing such as bits of humans. So, I think there is a lot of scope for it.

I think the trick is trying to take it beyond the gimmick point to where it does become a useful educational resource. Particularly, to me, it’s a cheaper alternative to synthetic medical models which are excellent teaching aids, um, and because you can touch and feel them you have an extra layer of sensory perception. But, the AR provides easier access to that sort of thing and is very, sort of, replicable. You can have one AR image and share it across ten universities.

Interviewer: So, with that, if you were using AR what kind of, would you be using it in lectures or seminars, what kind of learning environments would you be using it in?

Interviewee 7: Ooh, um, well. I’ve got access to buildings, I can show them that, I’m thinking about construction because it’s a physical thing. I could scan stuff in and bring that to the lecture theatre, um, I don’t know if that would give anymore than if I just showed it on the overhead projector though. It’s less interactive if I do that but, it’s trying to get it beyond the gimmick. So, I think it would be more for trying to contact students remotely and provide some sort of online catalogue of AR images to help them remember different components of a building. That could be helpful and I could do that along with some sort of test now that I think about it. At the moment I use a thing called Building Terminology Bingo, where I get across terminology for different bits of buildings which involves showing them a picture of the building and they’ve got a bingo card with all the names on it, they gotta try and mark them off.

Interviewer: So, you’d use AR to supplement that then?

Interviewee 7: It would be to supplement that process, yes.

Interviewer: Could you see AR being used to help people with disabilities then? Mainly because of the visualised aspect.
Interviewee 7: Hmm, I know there’s some very imaginative uses being made but, I’m very restricted by my technical expertise and the finances available to me and time. So, I’ve seen the Microsoft AR where you’re in a room and can walk into a hologram of a human body that’s effectively pinned into the room by the software. You can move different parts of it and pull it apart and things like that. But, that requires a lot of support around it and one of the issues is you’re quite restricted ‘cos you’re, you’re trapped as a lecturer into what other people have developed. It’s often big budget too. That has, if you’ve got the budget for it, learning for medicine. But, I’m using it in a very simplistic nature to, sort of just, give me an extra tool to engage students with different things.

But, I can’t really see it to be honest, virtual reality yes. If the students are learning remotely, yes, plenty of that if they’re disabled and working remotely because of that, it can help with that. But as a general improvement for students with disabilities, I don’t really know really. Apart from if you’ve got mobility issues for getting to the lecture theatre I don’t really think that interaction with the object would make much of a difference for someone with learning difficulties. Or, you know, being able to repeatedly access it on their own terms because of a disability.

Interviewer: Okay, so, say someone with dyslexia for example, someone who finds text-based learning a little bit difficult. Do you think they would find it helpful?

Interviewee 7: Hmm, I suppose you’ve got audio and visual where augmented reality can work, yeah, it would work with that sort of thing. Yeah, again, it’s just because as I’m in the early stages of it this all actually starts to get out. I would approach that more as the type of learner. So, some learners need to interact and feel something in order to take information on board. Other learners just need to write about it to learn about it. So, that would come underneath the overarching umbrella for learning styles so yes, it would help.

Interviewer: Then, finally, what concerns do you think there would be regarding feasibility of its use? So, costs, training, being constrained by what other people have developed, stuff like that?

Interviewee 7: Surprisingly, the main issue I’ve come across so far is the availability of software. Um, went I went to the JISC conference, people with expertise, people to ask for. Uh, usually where you get into an area there’s some YouTube videos and there’s a standard, maybe you can use a mobile phone to access what you want to access. Um, and I refer to AR as something you can move around as opposed to something you can push about. That’s something I found, um, at the JISC conference, with experts who know more than anyone else in the UK because that’s all that JISC do, they have very little knowledge of what you could use. Uh, all these items, scanned items, render them with appropriate colouring then put them onto a mobile phone, it’s simple stages.
So, it’s the simplicity of the software to do that is a primary obstacle. Otherwise, because it’s accessible on a phone, no problem, and because the scanners are actually pretty cheap, less than £400, I mean, still a lot of money but relatively cheap for a university...

Um, so yeah, it’s that initial, having a handhold through the initial use of it and that was the initial obstruction with the virtual reality too. You need a really supportive environment where you can get to the point you need to. Where you can link all of the bits together with capture, storage and dissemination.

The other one I found an issue, um, integrating the app software with the learning platform. So, um, I found that a real handicap with HTML coding, which I can’t do, then it’s difficult to be able to embed the content easily within a Moodle environment. So, it requires you to download a separate app and it all happens outside of that environment so integration is an issue so far.

**Interviewer:** I think then that concludes it.

**Interviewee 7:** Cool.

**Interviewer:** So, thank you.

**Interviewee 7:** No worries.
7. Bibliography


Doody, O. and Noonan, M., 2013. Preparing and conducting interviews to collect data.


Okoli, C. and Schabram, K., 2010. A guide to conducting a systematic literature review of information systems research.


