LEARNING AND ENGAGEMENT IN IMMERSIVE 3D ENVIRONMENT

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ABSTRACT

Interests in subjects such as Maths have dropped significantly over the years. There is a need to make learning in mathematics more effective and engaging through multimedia.

This project implements a 3D mathematical animation scenario in the Unity3D engine and tests the scenario on subjects with teaching experience. Results of questionnaire and interview are reported and implications for future designs are discussed.

This study also sets out to discover why such a powerful and now widely available technology seemingly hasn't been harnessed in education today and start to open doors to further research in this direction.

1 CHAPTER 1 – INTRODUCTION

1.1 MOTIVATION

In the last century, the pace and acceleration of 3D has been quite substantial. Sales of 3D TVs expected to reach half a million in 2011[1] compared to the beginning of the century when 3D TVs were either too unsafe for the eyes or far too expensive. This explains why meaningful research in this domain for a mass-market use was overlooked. In the middle of the century, as the power of 3d processing cards in normal computers increases [2]

When we look at where virtual environments have made advances in education, the application we see used frequently is simulation. This is a way of replicating a real life phenomenon virtually and in more advanced cases allowed you to toggle some settings to change states. This explains the predominant use in the area of science for experimentation (D Friedman, R Leeb, L Dikovsky, M Reiner- 2007). The immersive effects of engaging VR were displayed with the "AVATAR" production that became so popular and is the highest ever grossing film[3], this mass appreciation for Virtual Environments in the gaming industry and internet is a reflection of the impact 3D technologies are having on a large scale. One of the questions that we find ourselves pondering is why the UK education has failed to keep up with the wave of change, Google has openly criticised the UK's education and technology gap in 2011[4]. This study's purpose isn't to raise a political point but to start to explore how we can use these engaging technologies that have recently become available in our homes and schools to capture the dwindling attention for education in students aged 14-15. Technological advances make the idea of upgrading to new technologies inevitable but now how will the extra capabilities be harnessed to further engage and increase the aptitude of students' learning. The measures we have taken with 3D technology has been influenced by these factors our study will harness the benefits of 3D and prove the engagement effects are substantial.

[1] <http://www.tvlicensing.co.uk/

[2] http://www.technologyreview.com/computing/21901

[3] http://boxofficemojo.com

[4] http://www.guardian.co.uk/technology/2011/aug/26/eric-schmidt-chairman-google-education

At present the methods for education in the UK are not utilising technology to their full potential. As I touched on earlier, the virtual environments community has only made part advances in educational technology, when we focus on 3D learning and environments. Research has been held back due to impracticalities for feasible use of 3D in the early part of the last century.

We have the wave of 3D TVs being purchased in the UK and now widely available in homes to support our research standpoint. If we can change the way the user perceives their environment and make it virtual, we can begin to show that increased engagement allows the participant to learn more. This is the point we are trying to make. This project entails a controlled study which looks at the difference between highly immersive 3d learning in comparison to users' class room experiences., We explore the uniqueness of high end 3d equipment like the CAVE and it's stereoscopic characteristics in order to be able to contrast the levels of engagement have on learning.

This project implements a 3D mathematical animation scenario in the Unity3D engine and tests the scenario on subjects with teaching experience. Results of questionnaire and interview are reported and implications for future designs are discussed.

1.2 Current Scenario

Students in the current educational system are used to the conventional UK teaching methods, which is a class and board approach. Students are used to a methodical way of learning that includes an explanation from the teacher combined with a short demonstration using the board.

This is the basic teaching model I acquired from field research and a general consensus from teachers. It is recognised there may be some variations to teaching but this is the general case.

1.4 Aims and Objectives

Examining the domain of technology and education:

One part of this study is researched based, so we are answering questions we have a hypothesised an answer for:

1. Discover if the use of 3d engaging technologies in a teaching scenario will increase subjects' ability to learn and retain knowledge

2. Discover what type of immersion is more effective or necessary to engage our subjects by using a highly immersive CAVE with stereoscopic characteristics.

In order to achieve the answers to these questions, these aims are associated with the setup of the experiment:

1. The problem domain we are exploring is not entirely new and there is some general knowledge about virtual environments and 3D technologies however not the in depth knowledge required.
    a. Research in to the current field is necessary to familiarise ourselves with the domain, this will be in the form of a literature review.

2. Build the skills necessary to use 3D modelling technology.
    a. Make an informed choice on what 3d modelling technologies to utilise.
    b. Learn how to use a 3d modelling tool to create the virtual teaching scenario
    c. Find a technology application that allows a single development that can be reproduced on multiple platforms.

3. The participants we are using are going to be giving qualitative results, notoriously hard to collect and analyse so need to build skills required to do so effectively
    a. Learn the formal procedures for obtaining analytical results from expert users
    b. Learn the formal procedures I need to follow for a controlled experiment.
4. Measure the difference in results from the 3d environment to the real world-teaching scenario to help challenge the perception of 3d environments when teaching, and show that an environment that engages the user and has extra capabilities could improve the way we teach.
5. Measure the difference in results in the 3 ways of displaying the 3d environment to the subject. Does a candidate have to be fully immersed or are other more practical 3d techniques just as effective, looking at the question of whether the weight of cost involved with a sophisticated environment like the CAVE are justified in the results compared to cheaper options.
6. Using techniques such as think-aloud to measure a user's sense of engagement and excitement in the environments various forms as discussed and as a whole.
7. Looking to build a case for potential business applications for potential business applications for these three separate environments. Especially stereoscopic TV's becoming more prevalent in our homes has an untapped domain we are researching. Produce a report that more deeply looks at the use of stereoscopic displays.

KEY RESEARCH:

1. Get results from viewing of a 3D environment and the normal classroom scenario.
    a. Obtain results that measure how engaged users are using questionnaire and interview techniques.
    b. Learn the skills required to use think aloud to add more qualitative insight into our users' thoughts
2. Measure the difference in results from the 3d environment to the real world-teaching scenario to help challenge the perception of 3d environments when teaching, and show that an environment that engages the user and has extra capabilities could improve the way we teach.
3. Does a candidate have to be fully immersed or are other more practical 3d techniques just as effective, looking at the question of whether the weight of cost involved with a sophisticated environment like the CAVE are justified in the results compared to cheaper options.
4. Develop a 3d virtual learning environment that can be deployed into the CAVE by altering the cameras view. The animation should follow a storyboard that will be engineered to teach and algebra discipline. We can look at this variable by testing candidates before and after.
5. Using techniques such as think-aloud to measure a user's sense of engagement and excitement in the environments various forms as discussed and as a whole.
6. Looking to build a case for potential business applications for these two separate hardware. Additionally think about stereoscopic TV's becoming more prevalent in our homes has an untapped domain we are researching. Produce a report that gives impetus to more deeply looks at the use of stereoscopic displays in further studies.
7. Create analysis out of results that make a justify a business case for Virtual environments used with 3D and 2D technologies

1.6 PROJECT OVERVIEW:

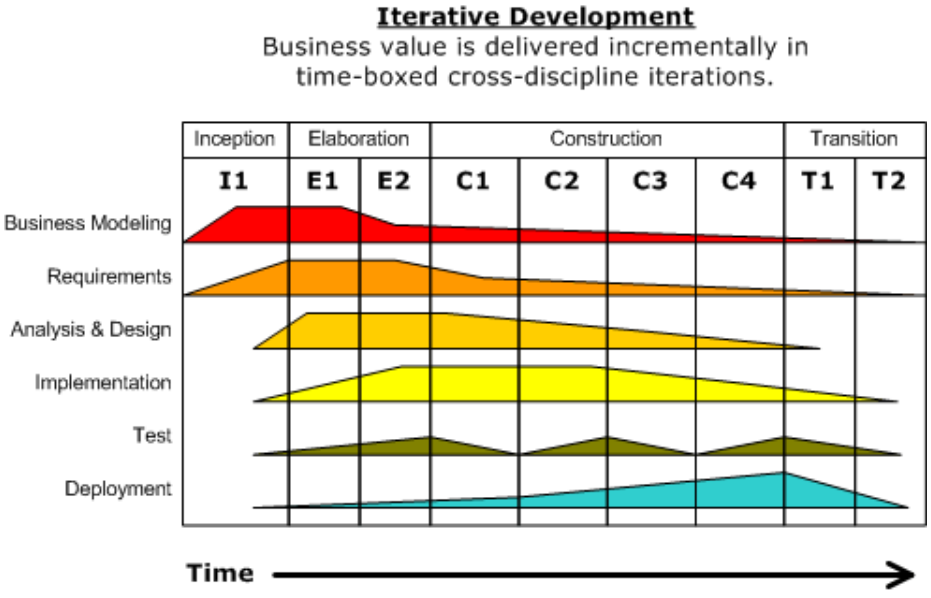
DEVELOPMENT APPROACH:

From having various meetings with experts in the field combined with early stages of the literature review have focused the study on algebra and collecting the like terms. We already also had enough information to:

- Understand different types of user reactions
- Design story board for the animation
- Finish the Literature Review

Part of the goals set was to complete a paper prototype of the system to work out scalability for the Cave and 2D platforms. This was done in order to show clear direction in the project. These techniques have really helped in understanding the current teaching scenario and proposed system delivery. Another important outcome is being able to map expectations to technological feasibility and timescale restrictions. The ideal outcome we would love to have would be a full scale, 3d animation which resembled the standard in the games market for quality and realism. The reality is we don't have a huge team and don't need one to answer the studies question. This is an area where scoping the model produced is important.

The unified process is one that incorporates key principles i want to follow throughout the development. Understanding that at each stage of the lifecycle you are doing more than one discipline through various iterations. The graph below shows throughout the Project Life Cycle you are almost always working on all disciplines and capturing the difference in their emphasis.



1.7 OVERVIEW OF REPORT:

Chapter 2 has a look at current literature in the domain of learning and environment and learn as much about existing studies as we could. To make sure our study had not been done and make sure we did not repeat anything. The amount we can learn from other studies is significant and may shape the way we go about our own study. The literature begins with the educational problems faced at present and gently builds to the technological applications focusing on 3d environments in particular. At the end of this chapter a review has been done on ALICE, which is the closest to what we are trying to achieve in our study. The purpose of the review here is to ensure we scope and place our research correctly and learn from previous studies.

Chapter 3 is an assessment of requirements, the knowledge acquired in the previous chapter in now put into a framework with deliverables. This section extracts key requirements and aims of the study to scope the projected work. Theses design decisions need to be justified and explained with analysis throughout this chapter. Key topics covered are the complexity of the model and the type of experimentation that is deal vs. what is feasible.

Chapter 4 describes the analysis and requirements, explaining the dynamic and iterative process followed and added some structure and design principles. A core component of the study is experimentation this also will be expressed in this chapter. The findings will show any significant improvements in the 3D environments and normal classroom in comparison with each other.

Chapter 5 is a detailed evaluation how to gauge the feelings of engagement and questionnaire process to extract the right information. Looking at the reasons why VR engages and linking in important concepts like learning styles. At this point in the study we are equipped enough to plan the project outcomes and deliverables especially looking at the research delivery questions.

Chapter 6 Results of the experimentation is displayed in a table and graph along with the lesson we learnt through the experimentation process. The proven statistical ANOVA test was then carried out on the results to support the eventual discussion. The discussion goes through each section of the questionnaire exploring the concepts and lessons learned. The discussion then continues to cover more comparative analysis with a further set of 2D non-stereo results.

Chapter 7 is the studies chance to conclude its main points, by deciding whether it has met its predictions about the effects of VR, 3D and 2D technologies on learning. As well as concluding on a new and interesting discovery that came out of the work which has been elaborated in further

detail. Part of the aims of the report was to give the tips and advice required for future development in the next stage of development, which is also included here.

CHAPTER 2: BACKGROUND INFORMATION AND RELATED WORK:

2.1 BACKGROUND TO RESEARCH:

In the past applications of virtual environment s in education have been using simulations. There are two studies on this in particular that I have looked at using Second Life as a Virtual Learning Environment (J Trindade, C Fiolhais, and L Almeida, 2002) One was utilising second life to give avatars the opportunity to explore ancient Rome. The other was simulating a river for physics and chemistry students. All of these were done on standard desktop displays as that is what the technology at the time made sense for, but this does not cover more immersive 3D applications. Research in this domain for using 3d environments for learning has limited itself to simulations on normal desktop displays.

Why are we looking at 3d environments in learning to begin with? Numerous studies show students learn more when they are engaged. A study on students in US (B DiSalvo, A Bruckman, 2011) showed that students could be engaged when working on game projects as they were intrigued by the virtual world they had the power to explore. This prompted the question of whether we can actually teach in a virtual environment, where you can more easily visualise concepts that are usually read off paper which will engage most students as the game study showed and affect those students with a more audio visual learning style (Gardner and Felder & Silverman). The next point of interest sparks from the simulations, because these studies are based on avatars. Why not fully immerse the student and see if it improves engagement and therefore learning ability. We can use the avatar idea with stereoscopic displays to increase the sense of being in the environment. A few years ago, this field of research may have been viewed as impractical but you only have to look at the wave of 3d TVs sweeping the nation to see its potential. Can we justify another practical use for this relatively new technology in the home? This unravels a new business model in this area and justifies further research into the field. The key piece of equipment needed, the CAVE completely immerses subject.

Technology is having more influence on education today than it has ever done. Students are entering higher education increasingly computer-literate, with high expectations that they will be introduced to appropriate technologies for their subject disciplines. Academic schools are challenged by these new technologies and require appropriate strategies for their effective

integration and adoption. Such strategies should foster greater awareness and understanding of innovation, encouraging others to learn more and embed changes within the academic curriculum (Knight, 2006)[5].

(Gardner and Felder & Silverman have studied different learning styles and developed schemes for determining preferred learning styles) the argument our study should spring is whether visual stimuli is the more dominant learning style, in oppose to traditional textual stimuli.

2.2 LITERATURE REVIEW:

Research supports the connection between engagement, achievement (Wiley 2008) [6] Engagement is a qualitative measurable because there are few ways of quantifying a feeling that our participants experience, and find difficult to put into words. How we use the 3D environment to manipulate the participant's sensory effectors in their brain to create immersion. The feeling or sense we are trying to create will make he/she perceive they are in a virtual environment, to what extent does this immerse the user. The way we are measuring this subjective variable is by monitoring its effects when applied to learning. Also examining whether we can improve the learning process through engagement. The techniques available in the environment to conceptualise and exaggerate concepts and artefacts will be looked at so our model is utilising the digital benefits, in producing magic like effects not possible in the physical realm.

Specifically in the study we will be looking at the problems (as stated with the questions posed earlier) with teaching and learning mathematics. *What are the problems teachers and students have in a normal teaching environment with attempting to engage students in the classroom?*

A Recurrent question that is asked in the world of teaching today is about **"**The teaching gap" (JW Stigler 2009). Knowing something and being able to explain what you have learnt constitute for different things and I assure you one has a higher complexity than the other.

Based on the thoughts in 'Teachers and machines: the classroom use of technology' (L Cuban'1920) related to the 20th century. The younger students going in to education are becoming increasingly more computer literate, and we can find younger and younger students owning smartphones or similar electronic devices such as a Nintendo 3DS which even has 3D capabilities. This means students are expecting a more technical learning environment, and are harder to engage

[5] http://ctiweb.cf.ac.uk/jebe/pdf/Horne&Thompson3(1).pdf

[6] Psychology in the Schools

because teachers are competing with these technologies. First defence to this greater ICT literacy is ban computers from the modern day classroom instead of embracing its benefits and uses towards improved education, or research into why these devices can engage a class more effectively than a standard class.

This clash or void has been created between the negative uses of technology like, in class disturbances like phone calls, ringtones, or idle use of devices in the classroom. This has meant years of falling behind in teaching methodology, and technology has just continued advancing.

The world we are teaching students about traditionally has been theoretical, it worked then because at that time we didn't have the technological advances we have to day. School structure then was more rigid and had much more discipline than today; if a child wasn't paying attention you could 'cane' them for example. Even in those times the most innovation and invention came from those with time on their hands that were able to use their imagination and a range of techniques to engage themselves. The main feeling in those times and very much now is when you get into the world of work you will really learn how things operate. Without the 'cane' how do we get students attention, better teaching, more discipline, etc. these are the usual antidotes, however after all of that we usually find ourselves with some students that still fail to learn or adhere. We are left with the highest number of NEET's in the UK than ever before which means students are being pushed out of education *(The Guardian 2011)*. The predominant question students ask in the classroom when learning highly theoretical subject is how do we use this skill in real life, or ask for a different way of explaining topics. The learning structure is very much one way; you find some teachers attempting to experiment with new methods but to many students are forced to learn theoretically.

The teachers of today are faced with a dilemma because they are taught to teach one way and some students just don't understand, you get a few common scenarios. The teacher spends all of their time with struggling students which limits the better performers progress or the better performers are given more time and effort and lower performers are left to struggle, in some cases moved to a lower skilled class and entered for lower level exams or not at all. This is the harsh reality which teachers are not able to effectively cater for everyone's needs with current teaching material.[7]

However everything we teach at most levels except some highly theoretical studies which is way past the scope of key stage 2 that we are studying, has a practical application in the real world. Most

[7] Based on a wild Study carried out by Olabode Raji in a secondary school

teachers can find it difficult to elicit this link to the real world, which would enable some students to understand.

I conducted an in the wild study, whereby I spoke to experts in the field, in this domain we are talking about mathematics teachers and mentors. The following talking points are from students and teachers in tower hamlets but can represent the entire educational community.

Some students become disillusioned with class and the common view of most subjects is that they are boring, and you end may end up just turning up to class, getting easily distracted, falling asleep, talking to peers, or some other distraction. This is a result of the lack of interest in what Is being taught or lack of engagement, rather than blatant disregard for the teacher which is commonly misunderstood. One of the topics students generally find difficulty in is algebra, because students find it difficult to understand how numbers come into mathematics. The concepts behind algebra are really simple and are just ways of representing something unknown or known. For example algebra can be compared to something as rudimentary as trades in a shop.

As GCSE is a basic requirement before you can progress to A level or BTEC students who have failed have to retake these subjects until they improve their grade. At this point you can see the student is trying harder to learn this subject but more than 50% fail again and re-take their re-take[8]. This shows a problem in the delivery for some students, which is usually identified later in the student's development. This is where we have to take a look at learning styles, as clearly the students who find mathematics very difficult just need a different approach to learning. As most people don't have any difficult going to a shop and purchasing items but some do have a problem with algebra. This is a paradox as money exchange is a form of algebra.

2.3 QUESTION 1

WHY DO TEACHERS HAVE DIFFICULTIES GETTING STUDENTS TO CONCENTRATE AND ENGAGE THEM IN A TEACHING TOPIC?

I touched on the point about student's boredom in the classroom, with the usual style of teaching, especially mathematics. The stereotype, which is exaggerated by movies is the chalkboard written formula that no one understands as the teacher murmurs on about the topic, at a class that is more than disinterested.

[8] http://www.telegraph.co.uk/education/educationnews/8358392/Teenagers-who-fail-GCSEs-to-be-forced-to-retake-maths-and-English.html

The reality isn't much different a usual and commonly accepted style for teaching by schools that Ofsted has classed as outstanding which involves a short example of a problem in a mathematics topic, along with an explanation as the teacher completes a question with essentially a form of commentary over their reasoning. Then the class is given the page in the book to complete some exercises at which point heads go down, some students know what they are doing, some need to examine the books example and some sit confused and may need to call the teacher over for another explanation, this can still leave the student confused. The key to most maths is grasping the fundamental concepts teachers fail to make sure this is grounded and are faced with fundamental errors when complexity increases. The imagery and conceptualisation of mathematics is easy because its based on shapes and numbers, its difficult with a whiteboard even smart board to show this. Usually a maths teacher's technical knowhow is very poor and cannot even tap into the capabilities of the Internet where useful. So the classroom's facilities do not enable the teachers to conceptualise simple fundamentals that would make maths easier to understand.

2.4 QUESTION 2

AND WHY DO STUDENTS FIND IT DIFFICULT TO ENGAGE AND CONCENTRATE IN CLASS?

The world students live in today is filled with technological marvels, and they come into the classroom and it doesn't have the same feel or engagement factor. When lessons are taught outside or they have the chance to visit a real world application of a subject its shown their learning and engagement with the subject area increases. However the logistics in these trips or organisation takes time and means time wasted on travel and extra costs are involved so cannot be common as the students would not be able to cover all content on a syllabus. So this notion of classroom is seen as a area of boredom this perception is then embedded in the minds of students.

Boredom is brought about by repetition, lack of enthusiasm in teachers, and or complexity of the learning point. We find lessons are usually repetitive following the structure as I elaborated on earlier. Mathematics teachers are not usually enthused about really simple topics in maths which are the most important to understand and progress. Fundamentals we don't understand are then built upon with further topics and become a blur. So it's easy to see how the student becomes disinterested with what the teacher has to say. Lack of understanding what the teacher has to say leads to some of the distractions I discussed earlier (R W Larson & M H Richards 1991)

2.5 SUMMARY

We will also be addressing the proposed solution to these problems with the application of a 3d virtual environment. In doing so we will investigate the concept of a 3d virtual environment, and

assess how important 3d environment variables are (Cave immersive VR and Desktop VR are interfaces for a learning tool) and will help us understand if the user has to be immersed in the environment, with a 2d display unit. Can we immerse a student in a 3d learning environment with CAVE, Utilise a desktop in a normal capacity and monitor effect on learning for small groups.

2.6 OUR STUDY

These two methods will be examined against a normal classroom scenario where we will use an experts opinion of the teaching experience they have, as we research the effects of altering the learning domain as discussed prior to this. We can evaluate the performance of the model(s) measuring the differences and improvements in candidates used. Enabling us to obtain statistics to have strong evidence to back up our claims.

Looking at the effects of 3D learning becomes interesting as we look at 3DTV's becoming more widely available in our homes, in the past research like this had no practical application in fact the study of virtual environments began 30years before it was technologically possible.

Utilising the cave moves this field's research forward because we have the high tech technology necessary to almost fully immerse student groups in a virtual environment with the CAVE application.

2.7 MY STATEMENT

"When we learn to study maths in a normal class room we are used to numbers on paper, and don't get to see its practical applications and if we do are not able to establish the link between this 'boring' subject and a formula one racing car for example, yet the mathematics is what has made its advancements possible like other examples."

The use of VR in education so far has been looking at the power of simulation, rather than the effects of engaging and conceptualising teaching. We will focus on maths and ask ourselves the questions of whether it can be conceptualised, can it engage, and can we improve on the existing class room scenario.

We are looking at two separate mediums of VR in isolation to understand what is the key component in effective VR, how important is it to use the CAVE, or is it as or less effective compared to a normal 2D display.

2.7 QUESTION 3

DOES ENGAGEMENT INCREASE THE ABILITY TO LEARN, AND HOW EFFECTIVELY SO?

'The theoretical and research literatures on engagement generally reflect little consensus about definitions and contain substantial variations in how engagement is operationalized and measured' (Wiley

Engagement, a potentially important and useful construct, is at a critical crossroads, one in need of conceptual clarity and constancy (Blumenfeld,2006)

As much as there is dispute over what engagement is we know what the effects of it can produce. This stimuli increases participant's attention and therefore concentration towards a particular task. One of the key issues in education is pupil's ability to learn is their short attention span for learning content, so logic seems to suggest adding an engagement factor will increase the amount learnt some might say a total learning environment that encompasses audio text ,and visual stimuli's will make for a more complete learning tool. The engagement factor is another way of describing the extra features, and an engaging environment will use extra capabilities that will enthuse more of a user's senses and allow multiple ways of absorbing information. What is the benefit of learning through visuals, audio, and text that can be manipulated in any way you want in combination within a realistic environment. There are so many extra effects we can use to bring key points to uses attention, a mixture of techniques will allow for dominant learning style in a mixed audience to take over for each individual. Meaning all learning styles are catered for allot more easily. How does the *Short-term memory and long term memory relate to our study?*

... Hippocampal **engagement** was detected when task demand exceeded the capacity of **short-term memory** processes. Clinical and experimental data suggests hip- pocampal function is essential or the encoding and con- solidation of **long-term memory** traces at a neocortical **...** Figure 1 (R S Frackowiak and K J Friston 1993)

This shows when we have to access to engagement we can activate the long term memory allot quicker and without rudimentary repetition. Which directly supports the argument we are making as the changed factors improve the efficiency of the mind that will translate to improved performance in students.

MJ Kane… - … Psychology: Learning, Memory, and …, 2000 - psycnet.apa.org ... distraction from the environment and interference from events stored in long-term memory (e.g., Conway ... The notion that limits in immediate memory are associated with interitem interference effects is ... For example, Young and Supa (1941) demonstrated that recall of short lists of ... Figure 2 *(M J. Kane RW. Engle 2000)*

This shows wasting of the space in your long-term memory, filled with environmental distractions, which is a key feature of normal classrooms. We argue that the virtual environment will

remove most of these distractions therefore leaving more space for useful knowledge improving mind efficiency.

CHAPTER 3 REQUIREMENTS AND ANALYSIS

3.1 DETAILED PROBLEM STATEMENT:

There has been a shift in the way we prioritise the requirements and new requirements have become apparent. One of the major shifts is the fact that its common place to use an experts opinion instead of the user population before creating the final model. This pilot study is looking at one level of engagement to inform the design decisions for the next level which turns the video into an actual 3d animation.

3.2 AIMS:

To discover if the use of 3d engaging technologies in a teaching scenario will improve the learning experience of students based on the view of an expert teacher. Also to look into what is necessary to engage students in the professional opinion of our experts.

(MOSCOW) NON FUNCTIONAL REQUIREMENTS:

1. Record the Opinion of experts in the teaching field on the effectiveness of different devices
    a. **M:** To inform future development
    b. **M:** To compare the effectiveness of the different mediums to view the virtual environment
    c. **M:** A straight comparison between the virtual environment approach to a standard classroom scenario
    d. A comparison between the virtual environments on the on the different devices
        i. **M:** In terms of effectiveness
        ii. **M:** In terms of engagement
2. **M:** Create a 3D model that has been given the approval by VR experts, namely Wole Oyekoya, and will Steptoe
3. **M:** Getting and co-ordination 12 experts in teaching to use devices and then voice their opinions
4. **W:** Measure the difference in results from the 3d environment to the real world teaching scenario to help challenge the perception of 3d environments when teaching, and show that an environment that engages the user and has extra capabilities could improve the way we teach.
5. **W:** Measure the difference in results in the 3 ways of displaying the 3d environment to the subject. Does a candidate have to be fully immersed or are other more practical 3d techniques just as effective, looking at the question of whether the weight of cost involved with a sophisticated environment like the CAVE are justified in the results compared to cheaper options.

6. **S:** Using techniques such as think-aloud to measure a user's sense of engagement and excitement in the environments various forms as discussed and as a whole.

7. **W:** Looking to build a case for potential business applications for potential business applications for these three separate environments. Especially stereoscopic TV's becoming more prevalent in our homes has an untapped domain we are researching. Produce a report that more deeply looks at the use of stereoscopic displays.
8. **W:** A student review of the 2D stereo 2D stereoscopic view

(MoSCoW) Functional Deliverables:

1. **M:** On-going literature review which acknowledges similar work in the field which shows the scope for the scope for this study and where it fits in the overall picture
2. **M:** A document outlining our findings with the use of 3d technology (environments) in learning to pave the way for further research in this field with more advanced environments and to prove a business case for investing in 3D learning environments
3. **M:** A basic 3d model (environment) of a classroom and a story boarded animated scenario
4. **W:** An advanced 3d model (environment) of a classroom and a story boarded animated scenario
5. **S:** Develop a 3d virtual learning environment that can be transposed onto the 3 different mediums by altering the cameras view. The animation should follow a storyboard that will be engineered to teach and algebra discipline. We can look at this variable by testing candidates before and after.

Technology:

1. The animation should follow a storyboard that will be engineered to teach and algebra discipline. We can look at this variable by testing candidates before and after.

3.4 Possible challenges:

- Quality of the Model
    - The virtual environment will be created in unity and will hold the lesson that teaches the mathematic topic using symbols and visuals.
    - The environment should be intuitive and virtually afford what the participants should do at every point.
    - This can be done by making the environment utilising real world items that the users are already familiar with. This is a supporting factor in the decision to go for a living room

layout with a TV. The TV affords our participants viewing attention and the living room environment keeps our users relaxed.

- Participants
    - Our participants are young we don't want a learning need to in addition to the mathematics lesson that is being taught because it adds the burden of learning our system to the mathematics lesson this will skew results negatively.
- Over scoping
    - It's not difficult to end up spending all the time creating the model because of all the potential features and increases in model quality that are being worked towards.
    - The VR field is huge and you need to be careful you don't have too many variables disturbing the study, that can't be measured by a single person.
- Compatibility
    - Despite the fact we are using a model development program that exports in different formats there will still potentially be some compatibility issues.
    - How will the CAVE deal with a generic model that has a mouse enable navigation in the cave you are the navigation as you walk around, this may cause a compatibility issue.
    - How well the animations work in the respective devices is also not certain and we may find a hindrance in the experience due to low memory on a 2d display in oppose to the powerful cave.

REQUIREMENTS CAPTURING TECHNIQUES:

The processes employed for the experimentation that will take place is a combination of standard methods and advice from within the department (this is expert opinion from Virtual Environments field). We will also obtain expert opinion from a PhD holder in Educational psychology and mathematical teachers (this is expert opinion from teaching field).

Looking at the entire Edexcel, AQA, and OCR mathematical syllabus and the most easily conceptualised topic we discovered was algebra. This was because algebra is a language of symbolism it will be easier to express it visually. The next key discussion point was the topic within algebra to deliver, for this we again required looking at the syllabuses. We have eventually decided on 'collecting the like terms' as the teaching point we will hold the experimentation on. It was important it was a fundamental and introductory algebra topic so a beginner is expected to understand, rather than relying that other knowledge was common to our student participants as this was somewhat difficult to control. It was easier to direct our attention at students that had no previous experience with algebra.

The initial groundwork involved me talking to teachers and mentors in a secondary school. It was important I didn't impose any of my views on the academic staff and obtained their opinion entirely on the:

- Difficulties of learning maths for students
- What are the key problem areas
- What techniques do they use on struggling students
- What is the advice for teaching children with signs of dyslexia

The results of this short survey matched most of my own opinions and ideas:

- Some students are unable to grasp the root principles required to learn a topic in maths, and then struggle as the class progresses without really knowing the fundamentals. A lot of students then follow a pattern and execute that instead of knowing and understanding the maths they are doing a memorising technique which can enable some struggling students to pass examinations.
- The key problem area is algebra for the struggling students, because they already struggle to deal with numbers and now algebra introduces letters. Some of the common questions teachers are asked include 'do we add the letters then numbers? or how do we add letters they are not numbers?'. Students here are expressing a real fear of the unknown and this fear is reminiscent of many students view of maths in general. The fear then inhibits a student's confidence in attempting questions because 'it's too hard'.
- Struggling students are given extra classes, which they are likely not to attend because of the fear for the topic. The real question is why these students aren't catered for in the classroom. In my experience more emphasis is put on the better performers and then lower performers are moved to a lower class or left to struggle. The extra classes are seen as a burden to the struggling students and teachers are not always able to explain to a severly struggling student.
- There usually isn't much advice, as I finished my field study they began to introduce some dyslexic kids into school and it would be interesting to see what the advice is if there is time towards the end of the study.

It's not surprising because I have experience as a mathematics mentor and teacher already that I knew some of these problems students were facing. It's the same problems that we all seem to be experiencing all the time with struggling students. In the case of algebra the main problem students have is, understanding what letters have to do with maths in your common '3x + 4x = 7x' problem.

CHAPTER 4 DESIGN AND IMPLEMENTATION:

4.1 RESEARCH DESIGN:

The early stages of research incorporated an in the wild data gathering session in a secondary school. The questions in the school centred on three themes Barriers to learning maths, what students find most difficult and techniques used for learning. Then had open discussion around these themes with members of staff in the natural teaching setting and gained considerable insight. I spoke to 20 academic staff of which 9 were student mentors and 11 where teachers.

Design decisions and requirements were drawn up and evolved, as the knowledge of the field grew stronger in the form of a literature review, which was being completed. The literature review focused on the innate problems with learning and maths then went on to how technology may solve that issue.

4.2 DESIGN DESCRIPTION:

Storyboard (in appendix)

4.3 IMPLEMENTATION DESIGN:

The environment will be created on unity and is to be tested on the CAVE this is due to foreseen compatibility issues. The way we obtain the results for analysis has evolved from a simple quantitative test from students who would struggle to provide their opinion, to utilising expert opinion. We expect the experts to provide informative criticisms that can shape the next steps of development.

4.4 FORECAST OF IMPACT:

Every diagnosis of dyslexia can impact on half a dozen people, possibly more.[9]That is half the UK population so more than 3billion people.

4.6 IMPLEMENTATION:

This is a summary of the key points in the development process:

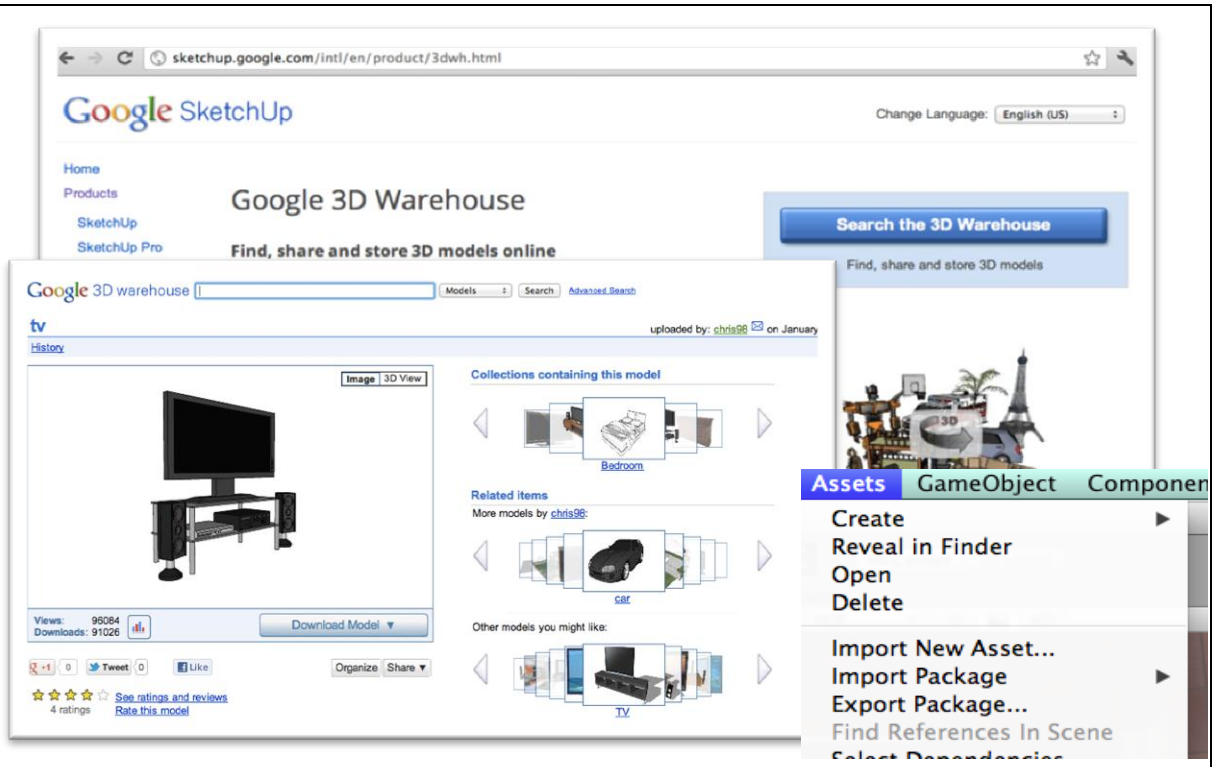
Obtaining the artefacts required for a living room meant using the Internet and 3D Max. There **were many sources to choose from but one in particular was**

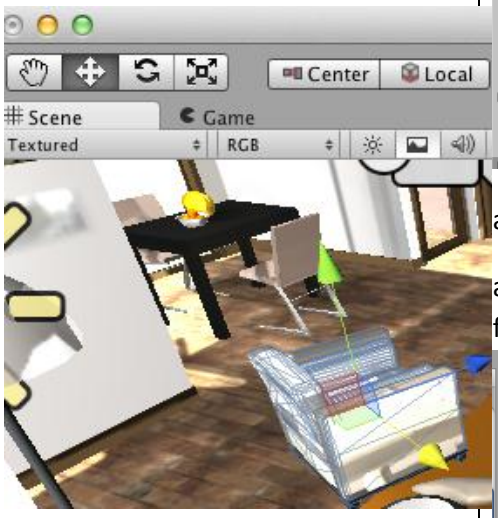
Importing a major asset:

After obtaining assets, its most likely they are 3dmax files. This is the process to Import the assets from the 3DMax version. You can use the assets menu to import or the way I found easiest, was

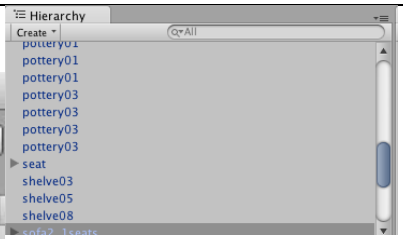
[9] http://www.guardian.co.uk/society/joepublic/2009/nov/03/dyslexia-awareness-week-blog

locating the project file on my directory and dragging and dropping assets into folder and opening unity 3d, the file then automatically imports.



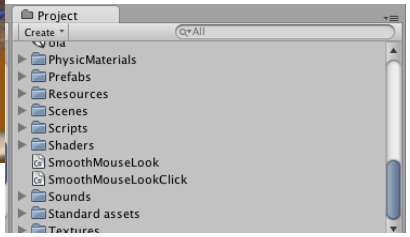


3D movement of object

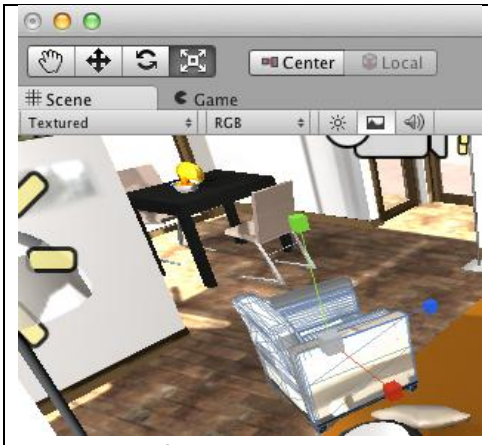


assets in the scene

assets available in the project folder



Preview unity construction



3D scaling of object

3D rotation of object

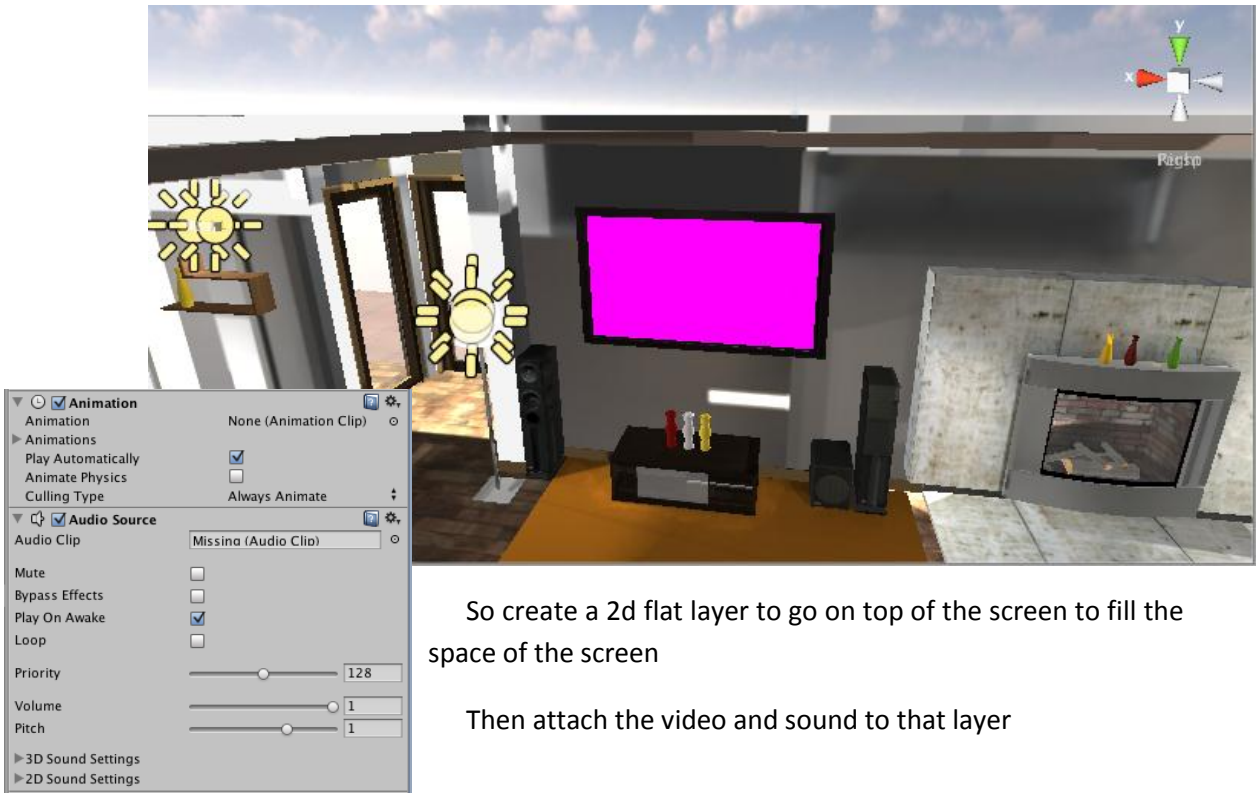
Alternate perspective

Finished model:

Importing a video layer:

The TV in the room should play the video like its coming from the TV.

Because of the nature of the texture structure for the TV its not possible to apply the video to the screen and you get a double effect when that was attempted



So create a 2d flat layer to go on top of the screen to fill the space of the screen

Then attach the video and sound to that layer

Code snippet 1:

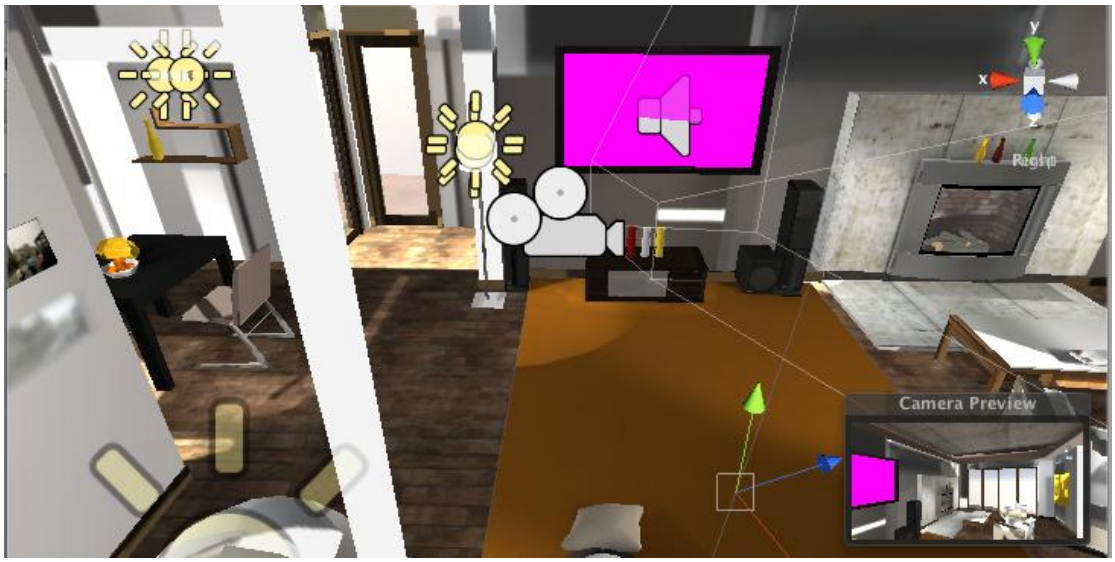
Simple script to play the video

```
function Update () {

    if (Input.GetButtonDown ("Jump")) {

        if (renderer.material.mainTexture.isPlaying) {

            renderer.material.mainTexture.Pause();

        }

        else {

            renderer.material.mainTexture.Play();

        }

    }

}
```

Camera View:

You can adjust the camera view the same way you move assets as shown earlier. The key thing to do when setting this up is constantly looking at the camera preview to see the cameras view. This

double working is essential for correct camera placement because you are manipulating a 3d environment on a 2D screen.



There is a default script that allows mouse control of the camera reaction, which can be applied to the camera. The testing of this default script was done and the movement was erratic and quite annoying from a user perspective, this needed altering for a smoother experience. Had to use different settings to improve the user experience. The sensitivity attribute was added to lower the speed of the camera movement hence improving the smoothness of the rotations when the mouse is moved.

Code snippet 2:

```
....
void Update ()
{
    if (axes == RotationAxes.MouseXAndY)
    {
        rotAverageY = 0f;
        rotAverageX = 0f;

        rotationY += Input.GetAxis("Mouse Y") * sensitivityY;
        rotationX += Input.GetAxis("Mouse X") * sensitivityX;

        rotArrayY.Add(rotationY);
        rotArrayX.Add(rotationX);
        .....
```

This movement was smooth and had a much better experience. The problem now was that anytime the mouse moved the view changed, and this was annoying feature. The final improvement would be allow the user to click before this smooth look around movement occurred this would allow greater control.

The code remains the same except for the if statement:

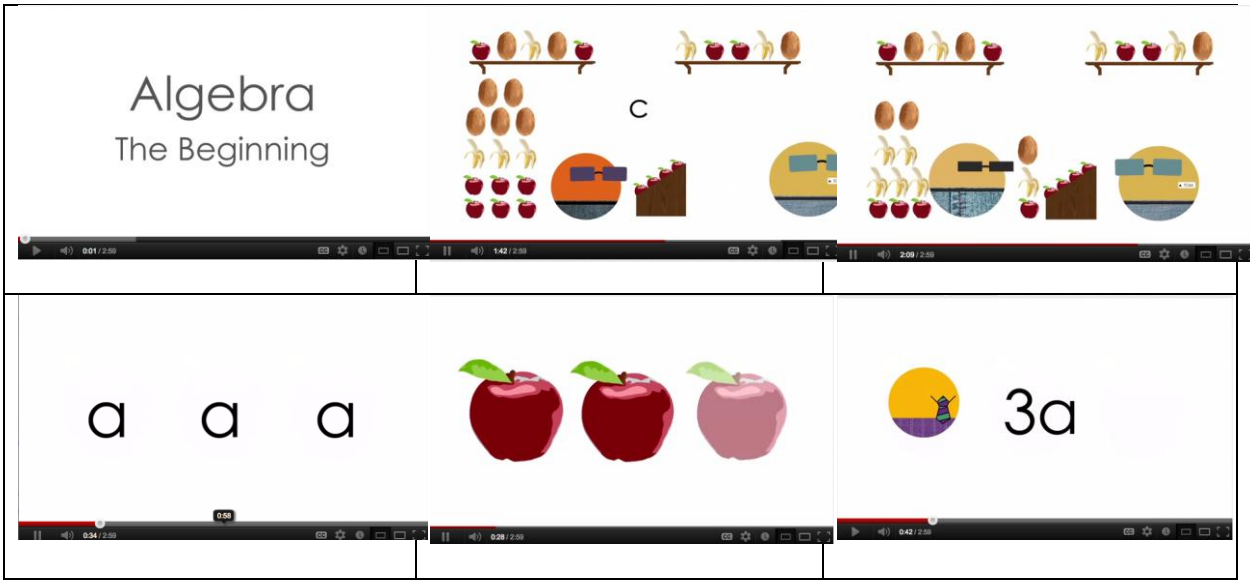
Code snippet 3:

```
void Update ()
    {
        if (Input.GetMouseButton(0))
        {
            if (……..
            }
        }
    }
```

This code is to ensure there is a condition that the mouse button is clicked before the rotations are applied to the camera view.

Video:

I created the storyboard (see appendix) and worked with an animations studio to get it right.



CHAPTER 5 EVALUATION

5.1 EVALUATION QUESTION

HOW WILL WE MEASURE ENGAGEMENT IN STUDENTS?

(G D. Kuh 2004, 2001) Humans are unique so we all have different reactions to what interests us and we show different emotions, however studies have found common features, or behaviour patterns that associate with happiness and deep concentration. These are two key emotions we are looking for purely because it shows the change in perceptions to what is viewed as boring using normal educational methods, and if the retained knowledge of each candidate increases because they concentrate more.

Engagement is a difficult variable to monitor, because it links to satisfaction, which is difficult to measure. The age of candidates involved is also an issue; the inability to communicate their opinion will be an obstacle if we decide to conduct interviews with the students. Both these points are strong influences in the use of observation as an analysis technique. Body language will be a key identifier; to see how engaged each student is while using VR. Peer to peer feedback will also be observed capturing the discussion a student has with another student that has not yet used the environment.

(.. more research in to young children observation methods & body language would be an interesting avenue to pursue for future literature review…)

5.2 KEY POINTS FROM MICHAEL QUINN PATTON:

Our main form of measurement will be in our interview process

- Clarity of questions is important (if names are not correct, language will not be in accordance of the truth of things)
- Posing questions to make it clear to the interviewee what is being asked. Asking understandable questions facilitates establishing rapport
- Will need to facilitate the interview with probes, when you get one worded answers or you want to explore a response in more detail

Actual Questions Asked	*Genuinely Open-Ended Alternatives With Richer Responses*
Question: Were you doing a formative evaluation?	Q: What were the purposes of the evaluation?
Answer: Mostly.	A: First, to document what happened; then to provide feedback to staff and help them identify their "model"; and finally to report to funders.
Q: Were you trying to find out if the people changed from being in the wilderness?	Q: What were you trying to find out through the evaluation?
A: That was part of it.	A: Several things. How participants experienced the wilderness, how they talked about the experience, what meanings they attached to what they experienced, what they did with the experience when they returned home, and any ways in which it affected them.
Q: Did they change?	Q: What did you find out? How did participation in the program affect participants?
A: Some of them did.	A: Many participants reported "transformative" experiences—their term—by which they meant something life-changing. Others became more engaged in experiential education themselves. A few reported just having a good time. You'd need to read the full case studies to see the depth of variation and impacts.
Q: Did you interview people both before and after the program?	Q: What kinds of information did you collect for the evaluation?
A: Yes.	A: We interviewed participants before, during, and after the program; we did focus groups; we engaged in participant observation with conversational interviews; and we read their journals when they were willing. They also completed open-ended evaluation forms that asked about aspects of the program.
Q: Did you find that being in the program affected what happened?	Q: How do you think your participation in the program affected what happened?

Figure 3 M Q Patton 200**2**

5.3 How does VR engage?

To understand why we believe Virtual Environment will engage a student, we only have to look at the gaming population…enough consoles for nine out of every ten households in the country to have one in the UK [10]

Games are based on virtual environments and have been known to consume some players, nearly 1 in 10 gamers becomes addicted[11]. This shows that a 2d desktop can have immersive capabilities, and maybe another study should look at the level of quality in the 3d environment or the benefits of interactions with a foreign environment.

The study into the effectiveness of engagement in games is one we should pay close attention too when we design our environment. Looking at a particular game we can discover the pros and cons for development of our environment. Users get a sense of personal involvement in the action when they work the controls (**A McMahan 2003).**

[10] http://www.telegraph.co.uk/technology/video-games/4248136/Video-games-eight-out-of-ten-homes-own-a-next-gen-games-console.html

[11] http://thegazette.com/2011/01/17/iowa-state-researcher-contributes-to-global-study-on-video-game-addiction/

So the reality of the virtual environment becomes essential, users react better to real world like materials. Virtual worlds like world of war craft has created a virtual fantasy like world which consumes users or modern warfare 3 which creates a realistic replica of buildings and parts of the world both environments have the same effect on participants involved but have different approaches. Its easier for the majority of students to relate to a realistic environment, because "*immersion*

Means the player is caught up in the world of the game's story". This means the user finds it easier to relate to a realistic story with real world artefacts. Being able to see and conceptualise what is going on in a teaching scenario is a form of engagement, especially when you can see its practical application. A VLE removes the walls from a classroom and allows a student to explore there subject in a variety of new ways. 'Ability to visualise and mentally manipulate shapes is very helpful…. In learning'

5.4 LEARNING STYLES:

The current research in the field suggests ' students learn more if the method of instruction matches their learning style'. The statement seems common sense yet the way education is taught has failed to change upon these discoveries. Its means that currently in the UK: *"A fifth of teenagers leave school are so illiterate and innumerate they are incapable of dealing with the challenges of everyday life"*[12]

This stark figure is representative of the worst performers and you can begin to add more proportion to the number of students that are struggling with the current educational system. In recent years there have been more light shown to students who are dyslexic. Dyslexia is a term commonly used to refer to severe and pervasive reading impairment in otherwise normal children. (Frank R. Vellutino). Dominant approaches to English teaching centre around being able to comprehend through reading, so instantly we have a group that will automatically benefit from VLE. As referred to earlier most students have learning styles some more dominant, which leads us to the conclusion that some students would benefit from a more visual and audio stimuli. The final point is that by introducing a mixed variety of learning styles you can tap into all of a student's ways of learning and therefore elicit better results by using VLE, because it can combine the best of both worlds.

[12] http://www.guardian.co.uk/education/2010/may/07/poor-literacy-numeracy

Our study isn't to test for different learning styles, but we can now expect some student to perform significantly better than others in the process of experimentation as it's likely if our pool contains a mixture of different learning styles. We also know that even though the VLE may not stimulate everyone's dominant mechanism for learning we still expect the VLE environment to show higher average results compared to the control.

(Gardner and Felder & Silverman have studied different learning styles and developed schemes for determining preferred learning styles) the argument our study should spring is whether visual stimuli is the more dominant learning style, in oppose to traditional textual stimuli.

Controlling a virtual body by thought in a highly-immersive virtual environment-A case study in using a brain-computer interface in a virtual-reality **cave**-like … **(D Friedman, R Leeb, L Dikovsky, M Reiner- 2007)** Real-time 3D graphics is becoming mainstream (Alice, 1999), and arguably now is mainstream

5.5 PROJECT OUTCOMES AND DELIVERABLES:

- Investigate the current domain and other similar models
- Investigate expert VR opinion to inform in areas of design and execution
- Investigate the view of experts in teaching toward the model to gauge perceptions of
    - How engaged they were
    - Opinions for improvement

The DELVE project has a strong focus on the Architecture and make up of the environment. The project also has a strong focus on the different user group's perception of immersion

One key element of this project was to compare the types of engagement and the effect of the different mediums. This requirement has been fulfilled by previous projects, including the DELVE project where a spectrum shows the degrees of immersion. To Avert reinventing the will, the intelligent decision would involve placing our hardware choice on the spectrum.

The CAVE in a fully immersive technology and the 2D stereoscopic view is a semi-immersive VR and the normal 2D display is at the end of the spectrum and the lowest form of immersion.

The research in my literature review seems to believe that the Games like the world of war craft immerse the user at a 2D display level which maybe contradicts this spectrum or supports it if the effects of changing the hardware and hence immersion increased the users level of addiction to the

game. It for me goes to show there are other factors to play such as engagement that DELVE has not given much emphasis in their study.

Engagement is a word that is not attached to a specific meaning; so looking into the avenues of an expert's opinion on engagement will help this study clarify its standpoint on the definition.

5.6 REQUIREMENTS:

The Moscow prioritization method helps to understand the where this project has come from and the scoping challenges that had to be made along the way. The initial dream study would incorporate all of these features but the reality is the studies message needs to get across within the given deadline. However if time did become available these are the next set of features to look at. Even if we don't have the time the features can make a good recommendation for future research in this domain. Some of the requirements were found to have already been researched by other projects and part of this studies emphasis was to raise new questions and open new areas of research so those requirements automatically fell down the pecking order.

This next section focuses on the planning of extracting the Must have requirements and the questions to be asked. The questions we are asking can be split into different sections.

5.7 ENGAGEMENT RESEARCH QUESTIONS:

Engagement is a word that is not attached to a specific meaning; so looking into the avenues of an expert's opinion on engagement will help this study clarify its standpoint on the definition.

Effectiveness of the model can mean a multitude of factors as it may be elements of engagement that allow the student to learn, or the conceptual approach actually being the better approach to learning. There may be ever more reasons and asking the experts what they believe in their professional and personal opinion.

The normal classroom scenario has been described in depth in the literature review but the wealth of knowledge an expert has about their own field is priceless. This knowledge will be tapped into as we probe for a comparison in the engagement factor perspective and effectiveness factor perspective. The experts opinion on their students take to this sort of technology and their own perception on whether they felt engaged and was this form of teaching better than their own experience.

5.8 RESEARCH DELIVERY QUESTIONS

The studies nature means it's a pilot study to begin to answer the wider question of engagement and VR in education. Assessing what our experts think about the design decisions for the main study. We want a specific view on feasibility of the concept being explored, and opinions on the process of extracting the information from experts. This will form a crucial part of recommendations for future development.

The storyboard for the 3D animation was based on the official syllabus and had a strong research backing for its development decisions. In regards to the creativity involved its subjective, nether the less we are still very much interested in the subjective opinion of our experts for the studies later discussion. We obtained some general opinions on the environment choice.

When teaching a subject any generic subject there are factors involved that allow a class of students to follow, which is usually classified as speed. Is not uncommon for teachers to express a concern to the class to 'ask questions or prompt me if I'm going to fast'. Bearing that in mind, looking at our expert's view of the speed of the learning process is fundamental, even going too slow will only induce boredom.

CHAPTER 6 RESULTS AND DISCUSSION:

6.1 RESULTS

CAVE model				
Perceptions of technology:	**CAVE Average**	**Response Level**	**Non Stereo Average**	**Response Level**
1. I would feel comfortable to use something like this in the classroom	4.444444444	Greatly Agrees	4	Greatly Agrees
2. I already use a lot of technology in the classroom	3.333333333	Moderately Agrees	2.625	Disagree
3. I think technology can aid teaching	4.777777778	Greatly Agrees	4.75	Greatly Agrees
4. I think the future of education requires technology in delivery of classes	4.111111111	Greatly Agrees	4.25	Greatly Agrees
5. I think 3D environments can aid teaching	4.444444444	Greatly Agrees	4	Greatly Agrees
6. I think technology interests students more	4.333333333	Greatly Agrees	4.25	Greatly Agrees
7. I am confident with using technology in teaching	4.222222222	Greatly Agrees	3.5	Moderately Agrees
8. I have good skills when using computers.	4.444444444	Greatly Agrees	4.25	Greatly Agrees
Model engagement:	**Average**	**Response Level**	**Average**	**Response Level**
1. The experience is better than the class room equivalent.	3.444444444	Moderately Agrees	3.5	Moderately Agrees
2. I enjoyed the experience.	4.777777778	Greatly Agrees	4.125	Greatly Agrees
3. In comparison to when you were taught				
a. My understanding of algebra increased	3.222222222	Moderately Agrees	4.25	Greatly Agrees
b. My perception of the usefulness of algebra increased	3.333333333	Moderately Agrees	3.5	Moderately Agrees
c. I felt more engaged learning in the environment	3.555555556	Moderately Agrees	3.875	Moderately Agrees
a. I felt like learning more mathematics	3.555555556	Moderately Agrees	3.75	Moderately Agrees
4. The learning points are clear	4.333333333	Greatly Agrees	4.125	Greatly Agrees
5. I would be more engaged if there was some interactivity	4.888888889	Greatly Agrees	4.5	Greatly Agrees
6. The model was effective at conceptualizing the mathematics lesson	4.777777778	Greatly Agrees	4	Greatly Agrees

Animation details:	Average	Response Level	Average	Response Level
1. There was a clear learning goal	4.777777778	Greatly Agrees	4.375	Greatly Agrees
2. I understood what was being taught	4.888888889	Greatly Agrees	4.625	Greatly Agrees
3. You could visualize the mathematic topic in you mind	4.777777778	Greatly Agrees	4.375	Greatly Agrees
4. I felt like I was part of the animation story line	2.555555556	Disagree	3.375	Moderately Agrees
Usability:	**Average**	**Response Level**	**Average**	**Response Level**
1. I felt an improvement in engagement when I was completely immersed in the 3d environment compared to classroom experience	3.555555556	Moderately Agrees	3.625	Moderately Agrees
2. I felt having to wear glasses didn't spoil my experience in the environment, in terms of engagement and/or immersion	4	Greatly Agrees	3.25	Moderately Agrees
3. The environment wasn't distracting	3.555555556	Moderately Agrees	4.125	Greatly Agrees
4. To what degree do you think interaction in the CAVE is important?	4.333333333	Greatly Agrees	3.375	Moderately Agrees
5. I felt the presentation was practical	4.444444444	Greatly Agrees	3.75	Moderately Agrees
6. I had a clear view of the presentation	4.888888889	Greatly Agrees	4.5	Greatly Agrees

6.1 Organisation and Adaptation

The data extraction techniques transformed as it became clear what we could do, and the average time we would have with participants in the CAVE based on the total allotted time with the CAVE resource. 9 participants had the full CAVE environment experience, and there were three data extraction points.

1. It only emerged while doing the study that the view the participant had was also on the computer monitor and examination of where they looked was possible. Trends were noted and any distinct patterns examined further
2. The Questionnaires numbered responses gave for a nice quantitative comparable we could compare and summarise with
3. When expansion on a question was required this developed into an interview process as participants preferred talking about their views, and could clarify questions they were unsure of.

After conducting a good collection of expert opinion in the CAVE using the time available began an extension to broaden the horizons of research to look at the contract with 3 different types of 2D display when the presentation was shown without the surrounding environment. This brought to life

a would have requirement and commenced a expert participant analysis of 2D displays. This part of the data gathering would allow for more conclusive results that would be bassis on the class room experience, 2D and 3D which covers all dimensions we could have looked at over the spectrum of views.

The preamble prior to the experiment eluded to the fact its quite difficult to find a standard definition for engagement. The feeling of engagement is subjective anyways so as long as our experts had an idea of what engagement meant for them it was unnecessary to embed a definition in their minds. However it seemed everyone had the same idea and got the point of the model, for the purposes of the study our definition of engagement looked at the results of engagement this is a reflection of the participants general way of looking at the issue.

- The feeling of being engaged amplifies
    - Concentration
    - Enjoyment
    - Ease of learning

This is a localized view of engagement in the domain of learning and are unsurprisingly in line with the literature reviews view of the problems with subjects like mathematics which as deduced is largely due to a lack of engagement.

The questionnaire in a quick summary tries to get a picture of participants view of technology this is key because this could affect the view of the model and its role in teaching when the questionnaire looks at the pros and cons of the model in comparison to a class room. Ideally the presentation should be a 3D animation so critique of the 2D animation is the next section to see if this 3D approach is necessary of there is another more pressing factor that can include of remove. Finally a overview of the usability of the model in a real teaching environment.

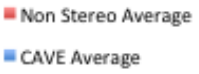
6.2 Expectation of results

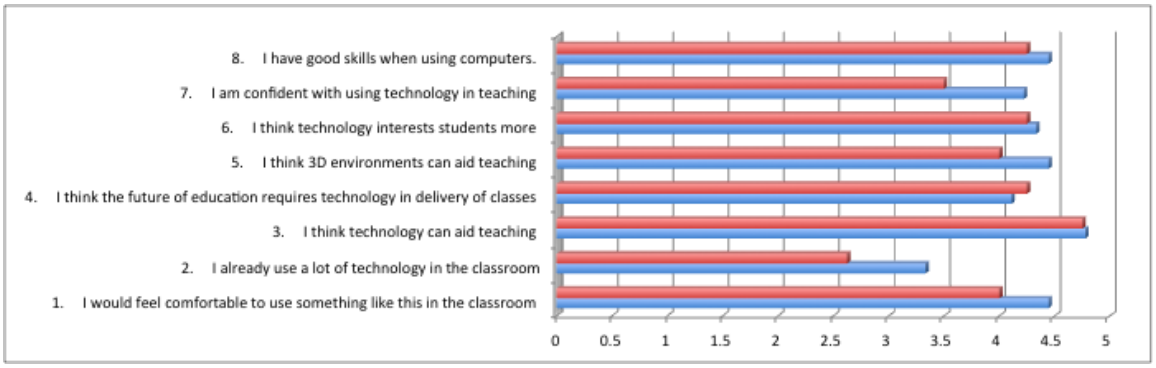
I expect there to be moderately positive results throughout the project because of the models infancy, would have been fascinating to see what including interaction and or having a 3D animation would do to levels of engagement and performance. That being said I think this will be a hindrance to the level of positive results we get, but not significant enough to skew results negatively.

6.3 Results of Experiment

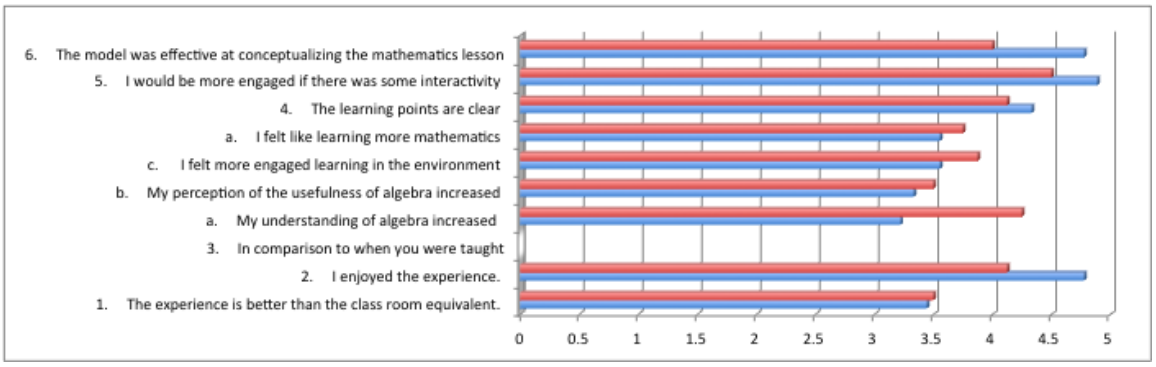
This has been grouped in the sections the questionnaire was asked, however bear in mind there may be some cross over analysis of results in sections. This grouping helps align the discussion with the way the study planned the thought process and will allow for easier understanding. With the aid of the graph, we can compare each score to strengthen our collective view of sections and individually pick out question areas.

Perceptions of technology:

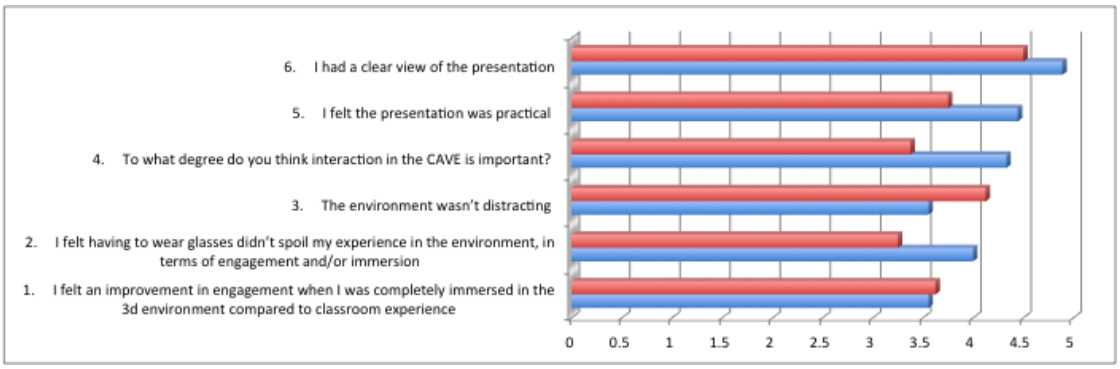




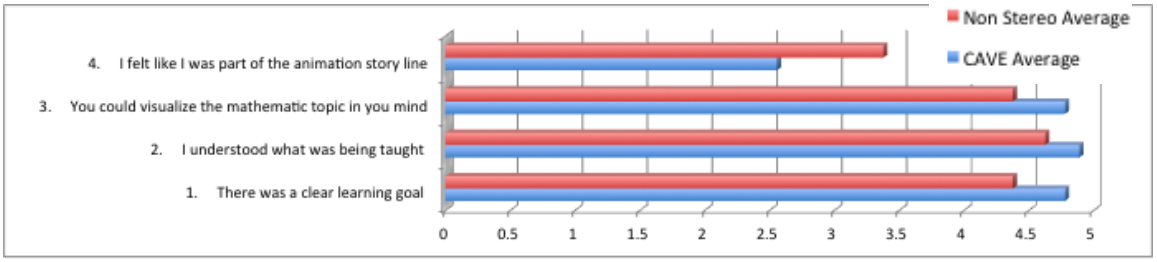
Model engagement:



Usability:



Animation details:



ANOVA Test:

This is an analysis of variance and is a similar measure of variance to the T-TEST. Anova is based on samples from normally distributed populations, we can also assume our data is of similar variances because of the similarities in the population. The sizes of the groups are identical and independent of one another this means our data set meets the requirements of Anova testing.

ANOVA is quite a robust procedure, so as long as the groups are similar, the test is normally reliable. The aim of the test is to compare the means and see their differences in the data they represent. ANOVA assesses whether the means of two groups are statistically different from each other. I have removed the question 2 and 8 from perceptions of technology because its a better representation from the user perception of technology. The two questions 2 and 8 were commenting on the ability of the user rather than their perception.

Comparing the means of the CAVE results and the non-stereo results is a fantastic way to close this eye-opening study. This will help us determine the level of difference from the two sets of results and help us to conclude on weather the engagement factor in the CAVE is as pronounced as we say, and understand if the way the video conceptualises maths has its own ability to engage and simplify.

A one-way ANOVA was conducted. Tests show that there is no significant difference between the subject's experiences when using the fully immersive technology (CAVE) compared to the non-immersive ubiquitous technology (CAVE) compared to the non-immersive ubiquitous technology (phone, laptop, desktop). $F(1,48) = 1.211$, $P<0.05$

All the results here are very speculative and are bases on a very small set of results, so its important bearing in mind that there should be more data before these results are conclusive, but it's a great point to involve some discussion.

PERCEPTIONS OF TECHNOLOGY:

Most of the participants we had in the CAVE had an ICT background so its expected to have a strong agree response. However there is some insight into this section that has become quite interesting for the study.

Discussion with some participants had the emergence of a concern being is this a replacement for teachers. The background and experience of these experts meant that they could foresee the completed attachment from the face-to-face teaching as detrimental. From their on it was stressed that this model and its later versions is a supplement to the teaching process. Even with this level of clarity participants still found it difficult to see this tool as a supplement to teaching.

One of our users had an interesting idea where the teacher could be apart of the environment real time and the students would have a more interactive experience in the participants words 'the environment can do things for free' meaning you an make magic like effects happen that wouldn't be possible in the real world 'almost bring books to life'

It's a natural defence mechanism because they are teachers, we are likely to want to protect what we do or have a passion to express your roles value. Some of Ray Kurzweil views have talked

about ubiquitous computing to the extent computers would replace teachers; he is not the only one who talks about the replacing of teachers with technology in credible literature. The reason these questions on technology perception were added is because this is a fear I believed they would already have. By identifying this fear we could then justify the way participants approached the next sections of the questions even after alleviating that fear by calling a model a supplement to teaching. Its interesting that a fear like this was present even after a reassurance and the this is explored a little later in the discussion.

MODEL ENGAGEMENT:

In the next section when a closer look at model engagement was done. The reason why the data gathering looked at technology perception because it could have negative and positive affect on the perception of the model which is a technology application for the real world. Most users felt comfortable with teaching and technology apart from the concern about replacing teachers as mentioned earlier.

The model engagement questions compare with a classroom equivalent via the expert opinion so if this concern is present during the point of reasoning you can expect a negative skew on responses. It doesn't help that the questions are calling for a comparison to the classroom equivalent, but its essential we compare to the base traditional textual teaching style our literature review constructively criticizes. In hindsight the inclusion of a description that the model aims to supplement the teaching process and give an explanation of the role the teacher plays using the model would have been beneficial. This approach removes some of the mysticism that comes with the model and would help remove the influence this fear had on later follow on studies.

Despite the possible effect on results, I think its conclusive the engagement factor is greater with the model because the 4.77 average out of five (95%) showed participants greatly agreed with enjoying the experience. Based on this positive response it can only translate into thinking its more engaging than the classroom equivalent like the FLOW reasoning suggests. It's an achievement in itself to reverse the feeling of something that is perceived as boring.

The extent of agreement was only moderate in this section on the whole, which may pin down to the concern the participants had originally but more importantly I want to comment on the infancy of the model. This is only a pilot version so we can expect lower results on model engagement its key to the reason why we took the expert opinion approach. Its proven that at early stages of the design its better to use the experts opinion because its more constructive and beneficial to mould better decisions. Its no secret that a younger participants opinion tends to be critical and not as useful qualitatively. The benefits of the quantitative response from younger participants in GCSE (target age for learning material) in the form of a test before and after cannot be over looked, it was only in the interest of time and ethics that this was removed from this particular study and are absolutely vital for the study. Bearing that all in mind high levels of positive responses were not expected and the positive results we did get were above expectations.

In the process of engaging a user you are able to reduce the amount of distractions that are present in the environment to the student. This could enable greater concentration, as you are able to design an environment conducive for learning. The power you have over the level of control there

is over the environment the minute details can be altered so it's the least distracting to the user. A key feature the environment has at its present state is limited interaction as a result of limited time of implementation.

When we start to look deeper into how we can get students interested in a 'boring topic' such as subjects like math's, which are usually labelled 'boring' this, is a barrier to learning. The data gathering enabled our study to stumble upon the 7 steps to flow in the framework [13]

The word 'boring' is associated with not being happy to partake in the subject and a lack of happiness and motivation so the work on investigating what brings us this joy is looked at in depth with FLOW creative subjects like art, music or drama have always brought students happiness

Investigation of the feeling these creative types get, is was described as an ecstatic state when they are creating or innovating (if we look at inventors), ecstasy was described as like stepping into an alternative reality. I thought this point that was made was quite interesting because the CAVE experience creates a different reality for our participants artificially, and this is maybe why we are able to get such 'enjoyment' out of participants.

The flow concepts expand on different environments and look at great Civilizations that were at the pinnacle of innovation, attributing their success is a feeling of ecstasy, such as pyramids or the coliseum where people could live a different reality for the moment. I want to expand on the different reality aspect as I feel the technology we have available nowadays shows this is possible with a 2D display and high quality video games. So what more the huge immersion factor in the CAVE if this is the major key to engagement this explains some of the positive results seen.

This feeling of ecstasy which leads to engagement seems feasible however the facts to back up this phenomenon have to be conclusive before this study uses it as evidence of why participants are engaged. Apart from interviewing 8000 people from different backgrounds and cultures a closer look at our nervous system.

Our nervous system can process only about 110 bits per second. Hearing and understanding speech required 60 bits per second, which is why you can't listen to more than two people talking to you. Being in flow tends to use up all processing power of the brain, such that physical sensations including thirst, hunger or pain, may go unnoticed. Performance becomes effortless. A composer describes this state as "I feel that I almost don't exist". [14]

Nervous system has limited capability to give attention to anything else at this point of full processing, your conscience existence temporarily suspended this euphoria is being described as ecstasy or engagement. Here is a spontaneous flow but our study shows you can engineer floor like the coliseums and pyramids.

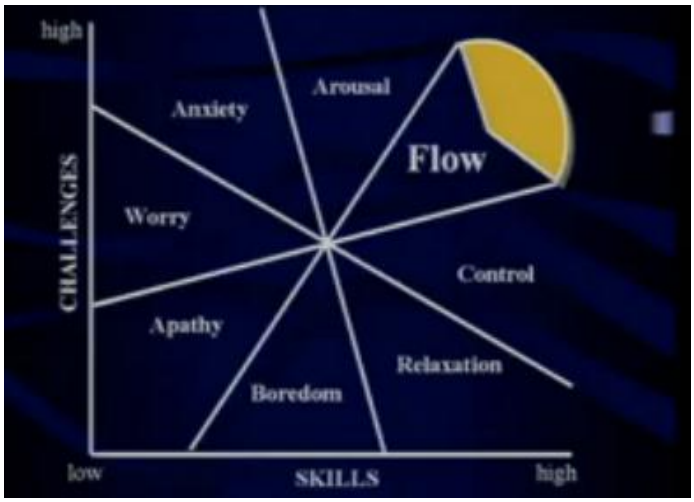
[13] http://www.ted.com/talks/mihaly_csikszentmihalyi_on_flow.html

[14] http://wiki.dandascalescu.com/summaries/mihaly_csikszentmihalyi_-_flow,_money_and_happiness

There are 7 conditions for flow:

- Focused and concentrated,
- A sense of ecstasy,
- Greater inner clarity,
- Knowing that the activity is doable,
- A sense of serenity,
- Timelessness,

Intrinsic motivation



We can begin to start to predict when you will be in flow, with the graph above by balancing the skills and challenges you can achieve flow.

Finally where is our model in relation to flow we know the largest contributor to reducing apathy is watching TV and 7/10 times you are watching TV you are in Flow. Our models aim is to reduce the apathy in mathematics and solves this as well as putting our participant in a new environment. The mathematics lesson helps as you can move into flow easily by developing a little skill, out of you comfort zone like math's again.

According to Csikszentmihalyi, flow is completely focused motivation. It is a single-minded immersion and represents perhaps the ultimate in harnessing the emotions in the service of performing and learning. *Figure 4 http://en.wikipedia.org/wiki/Flow_(psychology)*

ANIMATION DETAIL:

This part of the questions is where it was expected to have a lot of recommendations for improvement that would be a good lead into the next sections which looks at the learning animation in detail. The stand out response in this section relates to immersion and is the only collective negative response the study. The results show that users in general did not feel like they were part of the animation story line with an average 2.55 our of 5. It's clear on discussion with participants that this linked back to the infancy of the model. The timescale concerns meant scaling back the animation to 2D; the follow up study will look at converting this 2D animation into 3D. The model is at its first iteration before its received documented expert improvement advice. This basic model gives the user the feeling of sitting an a room that's separate from the 2D animation, this difference in animation schema creates the mental perception of not being in the story line.

Apart from this disparity to this the way things were taught seemingly improved, as everyone understood the learning point. The object manipulation of real world items in the algebra shop made it was easier to visualize the mathematics topic. It's interesting that there is no textbook, which bashes the conventional ways of leaning topics. Which raises the question of how visual

methods are not used learning subjects like mathematics. Tyson beckThis basic model shows the benefits of visual techniques as they all score very positively above 4.7 out of 5 on effectiveness of learning.

USABILITY:

The experience our users have in the CAVE is crucial, because this can be a severe effector to the other results our participants experience.

Does complete immersion in the CAVE make for better engagement in comparison to the classroom equivalent?

One of the participants in depth views on the different in experiences epitomizes the collective feeling from participants. He commented on making more use of what you can 'do for free' in an environment.

An over whelming response came in a request for greater interactivity in the CAVE. This is something we would love to have included but was scoped out. Its clear that it's a necessary addition to the model as research suggested it enhances engagement. The interesting thing here is participants in the CAVE all jumped at this prospective feature addition, because when the participants were in the model they felt as if it was reality but were unable t interact in this environment that seemingly was within their reach. The fact users wanted to interact with the environment and they couldn't show a need for interaction, and a greater level of control for what the potential student can interact with. This means you can control the level of interactions possible and remove the level of distractions, but to what effect?

What are the pitfalls of the experience participants have with using the CAVE?

The CAVE requires you to wear 3D glasses that are not lightweight 3D glasses that are not lightweight despite this users didn't feel it spoilt the experience all users rated it which is expected as they are already used to lightweight 3D glasses so this comparison is likely to linger in most participants minds one participant eluded to this 'so much heavier than normal 3d glasses'.

The environment wasn't that distracting the younger participants tended to look around the environment a lot more than older ones. The new environment had the first impressions on users whereby they were fascinated by the surrounding environment. Younger participants wanted to look around and see where they were so the first one-minute could have allowed for users to take in the environment then play the animation. Older participants had the feeling that they couldn't be distracted by alone and focused at the screen this is a feeling exhibited by all participants past the first one minute 'I felt like nothing could distract me' which opens a new topic. where by through engagement we are able to over other distractions and therefore increase concentrations and learning time. Which is an improvement on the learning experience.

A key question asked experts in the field who have technology experience in use and application as well as teaching was if this idea of learning in the CAVE was practical? This is an open-ended question that was received quite well; most participants had ideas for improvement and scalability based on the model.

2D STEREO

The engagement factor on the no stereo displays was present, but notably less effective. The main consideration with non –Stereo displays is to have added interaction as a necessary addition, but in the CAVE the engagement factor was enough to enthuse our participants.

Another notable difference was the level to which the participant was distracted in the environment you can control this with the 2D displays the environment is the real world and not as easily controlled in a normal setting. The CAVE practicality concerns are present but the 2D displays shows there can be alternate deliveries in the medium term. But with the advance in technology a cave live experience can be near enough created feasibly in a classroom. Although the study is not looking at feasibility of application it's interesting that the same experience can be seen to be replicated in the near future. Greater research into 3D TV's and their engagement factor can follow up this research for business applications. It's easy to see the corporate world adopting a training animation that can be delivered in this format. The amount of money invested in training shows a potentially lucrative market

FURTHER DISCUSSION:

There isn't much difference between perceptions of technology in the CAVE and the Non-stereo, and this is not unexpected because this has no bearing on the model they have used. This is dependent on the population rather than anything else so we expect it to be practically the same, apart from the fact most of the CAVE participants had a much more experienced technological background. On the whole there is a slight change in the perceptions from the two populations but not great enough to throw our results, in fact the lack of change strengthens the move to compare results.

I felt more engaged learning in the environment: Ubiquity of technology allowed users to enjoy the experience on the 2D devices like iPhones, desktop and iPad, because they are pervasive technologies the users have skill at using already so it felt comfortable using his or her device to experience the animation. They rated the CAVE a bit lower because they expected more from it standing in a Big CAVE expected more interactivity.

Even though you need more data to strengthen this claim, the ubiquitous experience takes this study in a different direction from the one hypothesised. It seems replicating the 3D experience with these types of technologies would be a lot more interesting and engaging.

When people enter the CAVE they are over whelmed **QUOTE if felt like I was entering a different world** and when the participants get there they want to do more in the environment and expect more than our model enables them to do. On a mobile phone, tablet or computer its common for users to get caught up on using them, mobiles are known to cause accidents all the time [15]. These two results leads our study to believe participants also factored in the expectation of the technology when they rated level of immersion.

[15] http://crave.cnet.co.uk/mobiles/phone-distractions-cause-serious-accidents-say-scientists-50006600/

I alluded to the fact users wanted to do more in the environment with the CAVE, touch and interact with it. Especially when you walk into the seemingly impressive “CAVE”. However you have lower expectation on a 2D decide you are already used to interactive with day in day out. For future development its clear If you want to use the 3D the bar is set high which is a key observation when investing in something like the CAVE.

It important to note the data is not conclusive because of the low population sample of 9. This prompts thoughts into whether if we gave participants the mobile phone in a room that looks like the animation they are viewing the results could have been the same as in the CAVE. I think it made a difference to users perception of engagement because of the different physical settings the users were in. Users felt they had to concentrate on the device in the environment they were in, where as in a CAVE they look around away from the animation as observed during trials.

This observation of these key facts about the strength of 2D non-stereo displays is eye opening in terms of cost. The cost of bringing students a CAVE would be far higher because the level of work you have to-do with the non- immersive ubiquitous technologies is much lower cost wise than the CAVE. **CAVE needs more interactivity:** CAVE results have a much higher interactivity cry than the 2D no stereo counterparts, due to the expectation of being able to interact with such a immersive environment. This translates to cost, because it means its harder to engage with 3D technologies yet you can gain the same effect with less effort and cost in the latter.

People can use less costly 3D technologies and include interactivity and users will still feel immersed. The opportunities of using 3D TV’s to immerse participants could prove decisive with this point made. The study leads me to believe even the 2D approach would have some strength and cost efficiencies, but it would be foolish to ignore the positives learnt about 3D and with the CAVE.

Its been mentioned throughout the conclusion and evaluation but re-iteration of the need for more data to strengthen these claims is important. The results we have are still important enough for us to advise decisions future development and begin to ask the questions in the domain of engagement learning and 3D.

CHAPTER 7 CONCLUSION AND FUTURE WORK

The main conclusion I want to draw from this study is not what the study initially intended to draw out. But the capability to extent our dataset to 2D non-stereo displays we stumbled upon a discovery that found there was no effect real of using different technologies when deploying animation style learning with maths in particular algebra. But the findings can be extrapolated to education as a whole due to mechanisms like FLOW which formalise the process of engagement on the other hand the results set may not be conclusive until further tests are carried out.

7.1 PROJECT CONCLUSION

The task of scalability in a project which looks at Human Computer Interaction (HCI) became apparent early on. The task of curbing my passion for this project to match with what was practically possible was difficult. The business aims behind engagement of the audio-visual way of learning in my UCL venture are high so this blurred with the aims of the study. The study can prove the effectiveness of the business concept animation idea, but this meant making my study a pilot to open the doors for further research in that area.

The model created was made for multiple platforms with Unity but once settings were modified run smoothly in the CAVE. The model is key to the experiment as well as the 2D animation that was created in conjunction with an animation studio for timeliness and quality. The results of this study will compare the effects of the CAVE and non-stereo displays and both of their levels of engagement for improved learning. A secondary aim is to gain advice on future developments of 3D models asking questions like is interaction actually necessary or can the model do without?

It was interesting the effect that the CAVE had the participants, in comparison to 2d display and the classroom the state of euphoria in participants when they first encountered the environment. You can tell from the way they looked around in the environment and all participants had a visible expression of happiness on her face. The living room calmed the participants and made them feel comfortable, comments were made in reference to feeling like they were sitting on a couch and the cushions on the floor. Without saying initially without probing, participants feel like the walked into ‘a new world’. This was a large part of the CAVE experience that completely consumed participants and raised their level of concentration.

7.2 DESIGN AND IMPLICATIONS

Top level design:

The key to future studies as demonstrated in this on in comparison between device deliveries, so the need for multiple hardware devices (CAVE, 2D steroscopic, and 2D) means consideration for the development enviroments, ideally a software package that can export executables that can work on multiple platforms. Unity works well but as discovered can have compatability issues with particular features. Which boils down to will software work on multiple hardware devices (CAVE, 2D steroscopic, and 2D) without major distrotion which destroys user experience? If not a large proportion of the Study time is likely to be on development, or this area will attribute a high cost in time as stated or money.

Another issue that arose during the study is the usability concerns. This was a positive exeprience for al participants on average and key that is was because the target users (students) are novice, so it should be built specificcally to be walk up and use. A key thing about the study is its looking at the way participants learn and wheather that rocess can be imporved adding extra complexity via extra features to learn will only distort that experience. We had little problem due to no interactivity, when interactivity is introduced its key the actions are intuitive and easy to understand for users.

Part of the aims of this study was to inform the next stage of design and implementation. This is a combination of the discussion with focus, which is easier when the experiences have not been plotted against each other explicitly.

7.3 PROJECT PROBLEMS

Initially there were scoping problems, which have already been described in the analysis. Lucky enough they occurred that early in the study. It helped looking at research in the surrounding field and realising that it was more important some times to look a t minute.

Knowing what features would need to be disabled in the CAVE to enable running, became apparent on the first attempt at using the CAVE. There was an extra layer of complexity I had to get grips with called middle VR, this was a layer of software that worked between the CAVE and Unity.

The experience in the CAVE at times was completely different to the UNITY model due to compatibility issues, it was important to work in tangent with the CAVE to ensure your hard work on features was worth the effort.

Getting participants proved a gruelling task, which slowed down the progress off the whole project. The original plan was to obtain participants from a school however logistically this proved difficult because they couldn't all come at the same time in a crucial April examination period in secondary's schools. Gaining CAVE time seemed an easy task but at times proved telling to get the time slots when it was feasible. Notable challenges with CAVE scheduling was when it was booked for business and my time slots were halved and when a Masters student needed the CAVE in the same time slot I had so managing between us was a new challenge which cropped up.

7.4 FUTURE WORK

It is worth looking at the effects of elements of user interacion to progress the study as this is another factor which increases engagement. In the interest of time this had to be scoped out of this project but is a crucial way of engaging with people and should cannot be over looked. There is a major psycologial element to this study and I believe a cross department paper can be produces and have even more clought.

This is a pilot study, so the simplicity and scale of the experiment requires a more in depth look at engagement with a more developed model.

There is also an argument that a development team simmilar to those who create mainstream games should create a more advanced enviroment to further the delve into what engages students.

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APPENDIX

1 MILESTONES UPDATE

- 3d model - Original 3rd December
    - Technical difficulties with the CAVE and animations that can be shown in it, this has pushed this deadline forward by two weeks. 17th December
- Interim report – Original 2nd January
    - No changes just an update
- Test results – Original 3rd March
    - This is a task that's on the critical path so the changes to the model completion date have translated to the test completion. 17th March
- Final report - Original 27th April
    - There was enough contingency and, re-planning to ensure this was on schedule

2 ALGEBRA SCRIPT

Algebra - The Beginning

Brief

This animation is the first in a series of online videos explaining Mathematical concepts to GCSE students aiming for a grade C.

The aim of this animation is to introduce students to the concept of Algebra. This video should present the idea that letters can be used in mathematical formulae.

Script	Animation
	White background. Title black, "Algebra - The Beginning".
This is Tom.	Close up of Tom the shopkeeper.
Tom owns a fruit shop.	Zoom out to show Tom beside his fruit stall.
It's a very small fruit shop, in which he only sells Apples, Bananas and Coconuts.	Pan across stall to see crates of apples, bananas and coconuts.
This is Bob.	Close up of Bob, the customer.
Every morning Bob always buys 3 apples from Tom's shop.	Bob and Tom chat, Close up 3 apples as they are animated onto the screen.
As we can see, Bob now has three apples. But how could we write this down? To do so, we need to use Algebra.	Three images of apples fill the screen.
We can replace each apple with the letter A. We can now say Bob has 3 lots of A, or three 3As.	Each image of an apple is replaced with a letter A. Now there's 3 A's on screen.
If we were to write this in algebra, we could say Bob has 3A. And we know that 3A means 3 Apples.	The 3 A's condense down to one A and the number 3 appears. 3A is now on screen.
So what if Bob were to buy another Apple, or, another A.	Back to Bob and Tom at the fruit stall.

Script	Animation
Bob would now have 3A plus another A which now makes 4A.	Back to image of 3 A's and another A is animated onto the screen. The As condense to one A and the number 4 appears. 4A is now on screen.
This means that Bob now has 4 Apples.	4A = 4 Apples.
This is Sue.	Close up on Sue, another customer.
Sue is another customer and she needs to top up her fruit bowl. She buys 2 apples and 4 bananas.	Sue chats with Tom. Close up of images of 2 apples and 4 bananas.
We know that Apples can be represented by the letter A, so let's now represent each Banana by the letter B.	Each apple is replaced by the letter A. Each banana is replaced by the letter B.
This still means Sue has two Apples and four bananas but now we can write it in algebra as 2A + 4B.	The above letters condense to the equation 2A + 4B.
This is Terry. Terry wants to make a fruit salad for a dessert.	Close up of Terry, another customer.
He buys 6 Apples, 3 Bananas and 5 Coconuts.	Terry chats with Tom. Close up of images of 6 Apples, 3 Bananas and 5 Coconuts.
As before we can represent each Apple by the letter A and each Banana by the letter B. So lets represent each Coconut by the letter C.	Each apple is replaces by the letter A. Each banana is replaced by the letter B. Each coconut is replaces by the letter C.
This still means that Terry has 6 apples, 3 bananas and 5 coconuts, but we can now write it as 6A + 3B + 5C.	The above letters condenses to the equation 6A + 3B + 5C.
So algebra is simple stuff right? Let's see if you understand.	Fade to white.
You now go in to Tom's shop and you ask for 2A + 3B + 4C. What have you asked for?	2A + 3B + 4C on the screen.
That's right. 2 Apples, 3 bananas and 4 coconuts.	The above equation expands to 2As, 3Bs, and 4Cs. Each letter turns into it's corresponding fruit.
Try some other combinations yourself and see what you get.	Fade in example equations. For example 2A +4C, 100A + 200B, A + B + 10C, Six Coconuts and 2 Bananas.

3 ACTION PLAN

				October				November				December			
Task	system life cycle stages	Description	Duration	week 1	week 2	week 3	week 4	week 5	week 6	week 7	week 8	week 9	week 10	week 11	week 12
1	feasibility study	Introduction	1d												
2		system life cycle diagram	1d												
3		project proposal	2d												
4	analysis	literature review(extended)	5 w												
5		Detailed Requirements(extended)	4 w												
6		action plan	1 d												
7		analysis	3d												
8	design	hand drawn design of 3d model	1d												
9		story board(extended)	5d												
10		methods for data extraction*	1 w												
11		detailed plan of experiment*	4 w												
12		testing plan	1d												
13	implementation	Start Experiments													
14		3d model implementation(extended)	8 w												
	testing	testing 3d model(extended)													
15		report on test results(pushed forward)	1 w												
16	evaluation	report on findings													
17		update/logging progress on action plan	1 w												
18		make backup copies	1h												
19		evaluation													
20		adapt work plan overcome problems (Contingency)													

				January				February				march				April			
Task	**system life cycle stages**	**Description**	**Duration**	week 3.3	week 4.4	week 5.5	week 6.6	week 7.7	week 8.8	week 9.9	week 10.10	week 11.11	week 12.12	week 13.13	week 14.14	week 15.15	week 16.16	week 17.17	week 18.18
1	feasibility study	Introduction																	
2		system life cycle diagram																	
3		project proposal																	
4	analysis	literature review																	
5		Detailed Requirements *																	
6		action plan																	
7		analysis*																	
8	design	hand drawn design of 3d model																	
9		story board																	
10		methods for data extraction*																	
11		detailed plan of experiment*																	
12		testing plan																	
13	implementation	Start Experiments(shortened then extended)	4 w																
14		3d model implementation																	
	testing	testing 3d model																	
15		report on test results	2 w																
16	evaluation	report on findings	10 d																
17		update/logging progress on action plan	5 w																
18		make backup copies	3 w																
19		evaluation	2 w																
20		adapt work plan overcome problems (Contingency used)	3d																

4 3D Model Code

Video playback

```
function Update () {
     if (Input.GetButtonDown ("Jump")) {
          if (renderer.material.mainTexture.isPlaying) {
               renderer.material.mainTexture.Pause();
          }
          else {
               renderer.material.mainTexture.Play();
          }
     }
}
```

Soothe mouse look and click navigation

```
using UnityEngine;
using System.Collections; using System.Collections.Generic;

[AddComponentMenu("Camera-Control/Smooth Mouse Look")]

public class SmoothMouseLookClick : MonoBehaviour {

    public enum RotationAxes { MouseXAndY = 0, MouseX = 1,
MouseY = 2 }
    public RotationAxes axes = RotationAxes.MouseXAndY;
    public float sensitivityX = 15F;
    public float sensitivityY = 15F;

    public float minimumX = -360F;
    public float maximumX = 360F;

    public float minimumY = -60F;
    public float maximumY = 60F;

    float rotationX = 0F;
    float rotationY = 0F;

    private List<float> rotArrayX = new List<float>();
    float rotAverageX = 0F;

    private List<float> rotArrayY = new List<float>();
    float rotAverageY = 0F;

    public float frameCounter = 20;

    Quaternion originalRotation;
```

```
    void Update ()
    {
        if (Input.GetMouseButton(0))
        {
            if (axes == RotationAxes.MouseXAndY)
            {
                rotAverageY = 0f;
                rotAverageX = 0f;

                rotationY += Input.GetAxis("Mouse Y") *
sensitivityY;
                rotationX += Input.GetAxis("Mouse X") *
sensitivityX;

                rotArrayY.Add(rotationY);
                rotArrayX.Add(rotationX);

                if (rotArrayY.Count >= frameCounter) {
                    rotArrayY.RemoveAt(0);
                }
                if (rotArrayX.Count >= frameCounter) {
                    rotArrayX.RemoveAt(0);
                }

                for(int j = 0; j < rotArrayY.Count; j++) {
                    rotAverageY += rotArrayY[j];
                }
                for(int i = 0; i < rotArrayX.Count; i++) {
                    rotAverageX += rotArrayX[i];
                }

                rotAverageY /= rotArrayY.Count;
                rotAverageX /= rotArrayX.Count;

                rotAverageY = ClampAngle (rotAverageY,
minimumY, maximumY);
                rotAverageX = ClampAngle (rotAverageX,
minimumX, maximumX);

                Quaternion yQuaternion = Quaternion.AngleAxis
(rotAverageY, Vector3.left);
                Quaternion xQuaternion = Quaternion.AngleAxis
(rotAverageX, Vector3.up);

                transform.localRotation = originalRotation *
xQuaternion * yQuaternion;
            }
            else if (axes == RotationAxes.MouseX)
            {
```

```
                rotAverageX = 0f;

                rotationX += Input.GetAxis("Mouse X") *
sensitivityX;

                rotArrayX.Add(rotationX);

                if (rotArrayX.Count >= frameCounter) {
                    rotArrayX.RemoveAt(0);
                }
                for(int i = 0; i < rotArrayX.Count; i++) {
                    rotAverageX += rotArrayX[i];
                }
                rotAverageX /= rotArrayX.Count;

                rotAverageX = ClampAngle (rotAverageX,
minimumX, maximumX);

                Quaternion xQuaternion = Quaternion.AngleAxis
(rotAverageX, Vector3.up);
                transform.localRotation = originalRotation *
xQuaternion;
            }
            else
            {
                rotAverageY = 0f;

                rotationY += Input.GetAxis("Mouse Y") *
sensitivityY;

                rotArrayY.Add(rotationY);

                if (rotArrayY.Count >= frameCounter) {
                    rotArrayY.RemoveAt(0);
                }
                for(int j = 0; j < rotArrayY.Count; j++) {
                    rotAverageY += rotArrayY[j];
                }
                rotAverageY /= rotArrayY.Count;

                rotAverageY = ClampAngle (rotAverageY,
minimumY, maximumY);

                Quaternion yQuaternion = Quaternion.AngleAxis
(rotAverageY, Vector3.left);
                transform.localRotation = originalRotation *
yQuaternion;
            }
        }
    }
```

```
    void Start ()
    {
        if (rigidbody)
            rigidbody.freezeRotation = true;
        originalRotation = transform.localRotation;
    }

    public static float ClampAngle (float angle, float min,
float max)
    {
        angle = angle % 360;
        if ((angle >= -360F) && (angle <= 360F))
        {
            if (angle < -360F) {
                angle += 360F;
            }
            if (angle > 360F) {
                angle -= 360F;
            }
        }
        return Mathf.Clamp(angle, min, max);
    }
}
```

5 Animation YouTube Link

http://www.youtube.com/watch?v=d5_7qj29Qn0

6 Unity GAME DropBox Link:

https://www.dropbox.com/sh/hzu0ed1c3pz85e2/mjzI7UNAXc

7 ANOVA Test Results

ONEWAY experience BY immersion

/STATISTICS HOMOGENEITY BROWNFORSYTHE WELCH

/MISSING ANALYSIS

/POSTHOC=TUKEY GH ALPHA(0.05).

Oneway

Notes

Output Created		25-APR-2012 13:27:57
Comments		
Input	Active Dataset	DataSet2
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	50
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
Syntax		ONEWAY experience BY immersion /STATISTICS HOMOGENEITY BROWNFORSYTHE WELCH /MISSING ANALYSIS /POSTHOC=TUKEY GH ALPHA(0.05).
Resources	Processor Time	00:00:00.02
	Elapsed Time	00:00:00.02

[DataSet2]

Warnings

Post hoc tests are not performed for experience because there are fewer than three groups.

Test of Homogeneity of Variances

experience

Levene Statistic	df1	df2	Sig.
5.109	1	48	.028

ANOVA

experience

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.361	1	.361	1.211	.277
Within Groups	14.319	48	.298		
Total	14.680	49			

Robust Tests of Equality of Means

experience

	Statistic[a]	df1	df2	Sig.
Welch	1.211	1	41.561	.277
Brown-Forsythe	1.211	1	41.561	.277

a. Asymptotically F distributed.

8 INTERIM REPORT (ATTACHED)

9 BUSINESS PLAN (ON REQUEST)