iLRN 2015 Prague

Workshop, Short Paper and Poster Proceedings from the inaugural Immersive Learning Research Network Conference

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ISBN (e-book) 978-3-85125-412-9 DOI 10.3217/978-3-85125-412-9

Immersive Learning Research Network

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Keynote Speaker 1: Colin Allison

Biographical Note

Colin Allison is a Reader in the School of Computer Science at the University of St Andrews, the oldest in Scotland. He has worked for over twenty years in two complementary research strands: the use of networked and distributed systems to support teaching and learning, and the analyses of systems and networks when used for these purposes, sometimes characterised as Quality of Service for Quality of Experience. His approach to research has always been to work with colleagues to build, deploy and evaluate learning environments. His attention has recently focussed on the great potential of open source immersive 3D multi-user virtual worlds for education, and the challenges they present to current infrastructure.

Lecture: The Immersive Web: Fact, Fiction or Future?

Multi-user immersive virtual worlds have now been deployed on the Internet for more than twelve years. Their applications in education, cultural heritage and social learning have often been successful in generating strong participant engagement – an important achievement when the average length of effective educational videos has been shown to be less than six minutes [1, 2]. Progress has been made in moving from proprietary to open systems [3], towards smoother motion and higher performance graphics [4] and in connectivity. In addition, novel user interfaces such as games controllers, gesture detection and physically immersive wearable displays have been incorporated. Yet, while the use of the WWW for education [5] has grown in leaps and bounds over the same period – we now have MOOCs for example – the use of 3D immersive technologies in the same domain remains something of a specialist niche with relatively low take-up. This talk focuses on the concept of the immersive web, which is directly analogous to, and maybe even eventually a part of, the pervasive and rapidly evolving WWW. Questions to be asked and partially answered include: What has been achieved to date and what works well? What are the outstanding barriers and challenges to wider adoption? How relevant are recent developments in consumer 3D technologies? Are there meaningful signs of convergence between the 3D web and virtual worlds? Is there scope for a consensually agreed open architecture to enable a fully distributed immersive web that can grow in the same way as the WWW?

In 1968 Ivan Sutherland created the world's first immersive computer experience platform in the form of a head-worn display driven by 3D graphics – the "Sword of Damocles" [6]. Both the terms virtual reality and augmented reality were associated with this pioneering system. Immersion meant that the perspective would change when the user moved their head. This was an impressive breakthrough in concept and technology but was essentially a single person system. Fast forward to 1992 and Neal Stephenson published "Snowcrash" [7] a science fiction book set in the 21st century (!) in which he coined the term Metaverse, a multi-user computer-mediated shared universe which combined virtual and augmented realities into an immersive personal experience. Stevenson's Metaverse is based around the Street - "a grand boulevard going all the way around the equator of a black sphere with a radius of a bit more than ten thousand kilometres. That makes it 65535 kilometres around, which is bigger than the Earth." Other references to early 16-bit and 8-bit architectures include transport systems – a monorail runs the entire length of the Street stopping at 256 stations, each 256 kilometres apart. Participants choose off-the-shelf avatars, or if they can afford it, have custom ones built for them. "Users of the Metaverse gain access to it through personal terminals that project a high-quality virtual reality display onto goggles worn by the user, or from low-quality public terminals in booths (with the penalty of presenting a grainy black and white appearance). … The users of the Metaverse experience it from a first person perspective".

Approximately ten years after Snow Crash was published Linden Labs offered Second Life [8] as a global internet-based service, to all extent a Metaverse. Participants only needed reasonably well equipped personal computers to interact as avatars in the system. Similarly to Web 2.0 which represented facilities for user-generated content to be uploaded to the WWW, Second Life also allowed for user-generated content, albeit requiring permissions or land which had to be purchased from Linden Labs. Even then, options and functionality were quite limited. While the WWW continued to develop as a hugely diverse but connected hyperlinked distributed system, links between immersive environments in Second Life stayed within its commercial boundaries – a walled garden with strictly controlled access. While the WWW was built on open standards and protocols such as HTML and HTTP, Second Life was built on proprietary protocols, offering little basis for organic growth. Nevertheless Second Life offered a view of some aspects of a prototype immersive web.

In 2008 OpenSim was released as open source [9], public domain version of Second Life's Metaverse. Protocols and functionality had been reverse engineered, and while the source code for the Second Life viewer had always been available, users could now compile and run their own servers. OpenSim allowed educators to escape the many serious constraints of Second Life and at the same time construct immersive learning environments that were genuinely open. Many educators who had been using Second Life seriously eventually opted to change to OpenSim, as did NASA in 2010 for example [10] .

Significantly, OpenSim developed a HyperGrid system [11] which allows for the movement of avatars and resources between autonomous virtual worlds. To date this has been one of the best working prototypes for an immersive web, although there are still drawbacks in the functionality of the Second Life protocols that have been copied. For example, communications between the client and server require many ports to be opened that campus firewalls will normally block, and other aspects of the traffic management can impact on the users' quality of experience. Initial download times on visiting a new world can stretch to minutes, which compares badly with the WWW where a few seconds can be critically viewed as unacceptable.

In parallel with the development of the OpenSim HyperGrid model of a distributed system of metaverses, there have been advances in interactive 3D content embedded in standard web browsers. Web3D [12] refers to tools, languages and applications used to create and embed 3D content in the WWW. The 3D Web is a more general term. Web-Based Virtual Worlds (WBVW) are similar to metaverses like OpenSim but are integrated into the web from the perspective of the user. All the user has to do is to navigate the environment from within their web browser. WBVW are built using Web3D tools and languages. Web-Based Virtual Viewers may use Web3D technologies such as WebGL [13] which is now supported in most popular browsers or other 3D languages in which case a plug-in is required. There are a plethora of browser-oriented systems which generate very similar types of 3D content and immersive environments but there are still radical differences in these system's architectures, languages and protocols, precluding interoperability and hyperlinking. What are the prospects for convergence around these different open source systems and open standards? Can the concept of an immersive web facilitate convergence, consensus and interoperability?

"Virtual reality is taking off; indeed, it is on the verge of mass availability. But which of the many form factors and underlying principles will it be?" [14]. This 2015 quote summarises the promise and confusion caused by the increasingly numerous and heterogeneous 3D technologies and experiences on offer to us. The Microsoft Kinect, Oculus Rift and Google Cardboard are examples of relatively inexpensive novel interfaces that can function as part of an immersive environment. Moore's Law has provided hardware designers with a degree of freedom on chip real estate that is often manifest in specialised cores on general purpose CPUs. For example, the chip in a Kindle Fire has a dedicated face detection core, even though the popular versions of the device do not have a camera. Similarly, support for 3D processing is evident in recent consumer electronics and commodity computers. Intel announced a 3D camera in 2013 and their latest generation of standard CPUs have dedicated support for 3D processing. Recent mobile phones can act as 3D scanners as well as high definition cameras; HP are trumpeting a new range of immersive computers which integrate 3D cameras, image projection and depth sensing for gesture capture and links to 3D printing facilities. But what are we meant to do with this user-generated 3D content? Is this simply for 3D photocopying using 3D printers or could this potential growth in 3D content be a stimulus to progress the immersive web?

In summary, this talk will attempt to discern what the prospects are for a distributed, immersive web, as accessible and capable of organic growth as the WWW, and what research we need to do enable its progress.

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Keynote Speaker 2: Jonathon Richter

Biographical Note

Jonathon Richter, Ed.D. is a writer, education technology researcher, professional futurist, and media designer. As Program Chair of Media Design at Salish Kootenai College in Pablo, Montana, Dr Richter's research on the design and implementation of Design-Based Research solutions for indigenous people fits in tandem with his interest in the identities and routines that people develop as members of geo-distributed teams. Jonathon is the founding chair of the Applied Research in Immersive Environments for Learning (ARIEL SIG) of the American Educational Research Association and was formerly a Research Associate for the Center for Advanced Technology in Education (CATE) at the University of Oregon. He is Chairman of the Immersive Learning Research Network (iLRN).Lecture: The Immersive Web: Fact, Fiction or Future?

Lecture: Let's Build Immersive Learning Research Capacity

Immersive Learning is poised to boom around the world. The hardware, software, design, and understanding of how to deliver compelling education and training using video games, augmented reality, virtual worlds, and other technologies have matured rapidly in recent years and appear now ready for a striking convergence. Indeed, there are notable pockets of remarkable advances and activity sprouting throughout the world that suggest such a convergence in immersive learning is imminent. However, the fruition of these trends is not yet widely available, having developed largely within silos of market and disciplinary research sectors -- nor does it appear that these developments will be made available to educators, scholars, and individual entrepreneurs in any comprehensive or publicly accessible manner.

The Immersive Learning Research Network - or ILRN - has been formed to create capacity for anyone interested in research and practice in Immersive Learning to discover and participate in this growing field of learning experience. Launching an interdisciplinary, peer-reviewed, worldwide Knowledge Base and a number of strategically focused activities designed to develop and support the scientific, technical, and applied potential of immersive learning, ILRN is inviting computer scientists, game developers, educators, architects, psychologists, biologists, and others interested in immersive learning to participate in this worldwide cross-disciplinary effort. In this presentation, Network Executive Officer Jonathon Richter will outline the emerging vision for ILRN and showcase the opportunities for organizations and individuals to participate and garner real value through that involvement.

Workshop 1: Finpeda Virtual Space – Meet Virtually “face-to-face”: Pasi Mattila

Finpeda Virtual Space

In 3D virtual learning and training environment development, there is a strong trend moving from native client towards the web-based solutions by using WebGL technology. RealXtend Meshmoon is one of the most advanced cutting edge technologies in multiusers social collaboration and interaction. By using web technology, users do not need special software to install. They can enter virtual world via direct link even by using their mobile devices or tablets. Users can use ready-made learning environments, tailor made learning platforms or create their own virtual learning and meeting space. New features available for users like editing, furnishing and adding technology equipment are under development.

Realistic social collaboration and interaction in 3D

Virtual learning environments create new possibilities for distance learning, social communication and interaction. In virtual immersive environments, interaction occurs via avatars that represent the users. Acting via avatars increases the users’ sense of presence makes meeting virtually “face-to-face”. Users are brought into the same virtual environment to communicate, work and present ideas together. Learning can be very social and interactive, since activity in the same learning space makes the interaction feel almost real. In virtual environment users can communicate by using chat, voice, video or sharing the screen features. They can share their camera or desktop view with other users and make presentations. In addition, they can work on projects together like in real world. Users can create shared documents, which are shown as tablet, pc or notebook, and share web links or already existing documents with other online users.

Benefits by using virtual spaces in teaching and learning

Virtual learning environments enable the use of collaborative and inquiry based learning methods. The same interactive learning methods that have already been used at many schools, for students’ motivation in learning and for steering their learning process. Students can work on projects together and connect curriculum topics in a motivating way. Use of virtual 3D learning environments can increase rapidly, as soon as educators around the world discover their potential in supporting learning, especially distance learning and project work. Inquiry and phenomenon-based teaching can be implemented in different kinds of authentic learning situations in virtual 3D environment. Game-like content motivates to use 3D environments and take the full advantage of simulations, e.g. safety demonstrations.

Fire safety training in a 3D learning environment

Virtual learning and educational environments are used in many ways to develop various practical skills in different levels of education. We have create realistic authentic models of real buildings in order to develop different sub-games like fire safety simulations at the top of these models. Learning about safety matters e.g. fire safety issues, finding how emergency escape routes work or practicing fire drills as games or simulations in virtual worlds are effective ways of learning about important issues and acquiring necessary skills. After safety demonstration exercises users have learned about new issues concerning their own school, e.g. where emergency signs are located, how to use safety tools or how to escape from different area inside the building. Safety practice in virtual model is far safer, than training in real world environment. Nothing can completely replace the power of real safety demonstration, but virtual environment can make it much more effective. Resent experiments show that after virtual fire safety practice the users start to pay more attention to exiting signs and safety issues in the real environment.

In iLRN RealXtend Meshmoon and Finpeda Virtual Space workshop, we will show how to create a Virtual Space on your own, how to use Virtual Learning space and its main features. We will discuss the benefits of native and web technologies in 3D immersive environments e.g. in fire emergency situations or demonstrations.

Workshop 2: MERLOT – Multimedia Educational Resource for Learning and Online Teaching : Jonathon Richter

The Immersive Learning Research Network has partnered with the Multimedia Educational Resource for Learning and Online Teaching (MERLOT) to create a community of practice and showcase learning materials around immersive learning. The ILRN Immersive Learning Taskforce kicked off in late 2014 with co-chairs Dennis Beck and Jonathon Richter. Working with expert practitioners and researchers from augmented reality, virtual worlds, and video game applications for learning, they began the work set forth by MERLOT. Join Jon Richter as he introduces the Taskforce members and the Immersive Learning Knowledge Base - a wiki being developed by the ILRN Taskforce. See and try out the tools set up for ILRN members and others to use to assist the Taskforce to find and showcase "what works, when, and for whom" in immersive learning environments. Provide feedback and consider joining the ILRN Taskforce in this key project of the research network.

Structured Learning Activities in Embedded Computing Using a Pedagogical Virtual Machine (PVM)

Malek ALRASHIDI[a,1], Michael GARDNER[a], Vic CALLAGHAN[a] , and Jennifer B. ELLIOTT[b]
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Abstract. In this work-in-progress paper, we investigate the creation of a technical framework (the Pedagogical Virtual Machine or PVM) which provides a layered analysis of the technical and pedagogical processes that are interacting together for any given learning activity (in the context of learning about embedded computing). We particularly focus on describing the structure of the pedagogical layer and how it handles the computational objects within it. This model is used as a means to create more effective tools for students who are studying embedded computing, which are typified by topics such as the internet of things, pervasive computing and robotics. This approach aims to enrich the experience for learners by constructing a meaningful view of the invisible things around us. Finally, we propose an embedded computing scenario that makes use of the PVM model.

Keywords. Pedagogical Virtual Machine, Object Oriented Programming, Augmented Reality, Mixed Reality, Pedagogical Framework, Learning Objects, Buzzboards.

1. Introduction

In Computer Science (CS) many of the computational processes are hidden inside the computer. As a human it is often difficult for us to see these processes as they are invisible. Often all that we can see is the final results from a computing process, with very little information about the underlying computational processes that caused the result. This is particularly true for embedded computing projects where often students will be constructing applications by assembling computing components which have a very limited user interface. Thus, a student might take an action that causes a particular result, but from an educational point of view there is very little explanation for how the internal processes have operated to achieve the result. Often, the only way to discover this is by using some form of Augmented Reality (AR) or by using more traditional debugging tools to test the programs being used. The key challenge for this study is to construct a technical framework (PVM) which provides a layered analysis of the technical and pedagogical processes that are interacting together for any given learning activity (for learning about embedded computing). The user interface for this PVM will make use of AR to allow the student to visualise the static and dynamic information

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within, and provide mechanisms for interacting with the underlying computing environment.

In the following section of this paper we start by describing some related work. Then, we extend the PVM model to describe the structure of the pedagogical layer and how it handles the computational objects within the pedagogical context inside the learning environment in section 3. The conclusion and future work will be outlined in section 4.

2. Related Work

Several previous studies have explored different approaches for supporting students learning embedded computing and robotics. For example, Lalonde et al [1] proposed a predictor for mobile robot programming called robot observability. This predictor is used for diagnostic transparency, which provides guidance about the incremental process of constructing and debugging robot programs. It is considered to be an important tool for students as it can be used for diagnosing a misbehaving robot. Students can build a tool that improves the performance of the predictor by identifying the evolution of the robots internal state through the use of audio feedback. For example, the robot can speak its actions and state its purpose. In addition, the authors reported in their survey that 86% of students believed that data logging and visual interfaces are very valuable debugging tools. This study has not considered the wider implications of using augmented reality as a visual interface that could be used to guide the students and reveal the internal communication processes that are happening inside the physical objects in real time.

In another study, Chan et al. [2] presented and evaluated the design of LightUp, an augmented reality learning platform for electronics. LightUp has several electronic components such as wire, bulb, motor and microcontroller. To form circuits, the learner needs to connect these components to each other magnetically. LightUp is implemented as a mobile application that provides an “informational lens” that uses computer recognition to identify electrical components, augmenting the image with visualisations, which makes invisible circuit behavior visible. The system was used to help children to learn, understand and construct circuits in real time via simulation. The drawback of this study is that they relied on extracting information using a simulation for the learning activity, and did not use physical objects.

3. Structuring Learning Activities using a PVM

In a previous paper [3] we presented a PVM model that uses an object oriented approach to combine concepts from computing together with a pedagogical model. The model consists of a data layer, aggregation layer, pedagogical layer and user interface layer. In this model, the pedagogical layer is responsible for managing and providing a structured description of the pedagogical context (i.e. for the learning activities). This layer maps data from the the computational (compound technical) objects that are provided from the lower layer (aggregation layer) to support the teaching and learning activities which are then used to guide the student using the user interface layer above. By correlating learning and computational objects we are able to make sense of a learning activity, providing guidance or feedback to the various learning stakeholders (e.g. teachers, learners) via the user interface layer. This layer consists of three main sublayers; the pedagogical context, the learning design description and an algorithmic state machine which are explained as follows:

- ***Algorithmic State Machine (ASM):*** this sublayer utilizes the ASM methodology for organizing the state flow of the compound objects and the state of the learning activity. Therefore, this sublayer takes every compound object that comes from the aggregation layer, and represents it as a state that indicates the current state of the physical objects. Then, it maps the states to the related learning object steps, so that each state is actually a compound of two things; the step of the learning activity and the state of the compound object itself. Finally, we check each state to determine whether the learning outcomes of the learning task have been met or not.
- ***Learning Design:*** this is based on the concept of 'learning objects' (a well-established scheme for creating and delivering bite-sized lessons, frequently referred to as units of learning) [4] . The main benefit of designing the learning activity in this way is to maximize their portability and re-usability. Also, it simplifies the structure of the learning activity, and it can be more easily modified. Thus, in this sublayer, we follow a well-known learning design specification called IMS (Instructional Management System) to define our learning object structure [5]. This allows the teacher/instructor to define the learning activities, the task steps, the learning objectives, the description of each task and the expected outcomes. Each learning object can have one or more steps in order to accomplish the learning objectives. This layer uses the states provided by the ASM to map the technical state of the equipment to the appropriate stage in the learning activity.
- ***Pedagogical Framework:*** this sublayer can make use of a variety of useful pedagogical frameworks that are mapped to the learning design layer below. For instance, Bloom's taxonomy of the cognitive domain can be used to describe how the learning objectives can be arranged in a hierarchy from less to more complex [6]. The levels of Bloom's original taxonomy, in ascending order from simple to complex, are: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. Therefore, each learning design (learning object) can correspond to one or more levels in the Bloom taxonomy. Using the PVM it should also be possible to make use of other structured pedagogical frameworks if this is required.

To demonstrate the structure of the learning activity, we present a learning activity in which the student will be asked to build a wall following robot. To accomplish the learning activity, the students must follow three phases:

- ***Introduction:*** this phase is where students are introduced to the learning activity, the requirements, learning objectives and goals. By the use of augmented reality, the learner can look at the physical object (robot) and reveal the objects services/operations available that they can make use of. This phase is related to knowledge and comprehension in Blooms taxonomy.
- ***Operation:*** Students will write their program using the Python programming language environment and then compile and load it onto the robot. This phase is related to the application level in Blooms taxonomy.
- ***Assessment:*** Once the program is loaded, the PVM model will listen to and reveal the processes being communicated inside the robot. For example, Figure 1 shows the hierarchy of the wall following task decomposition which contains several sub-processes. In practice, when learners debug/execute their program, they will see the

final result which is the robot following the wall, but from the pedagogical perspective this does not tell them what causes this result. Thus, the PVM model starts to inspect the learners program, and will feed each layer with the required information related to the learning activity. The data layer receives the objects data which are *detect-wall*, *move-to-wall*, *detect-continuation*, and *move-along-wall*. The aggregation layer takes the objects data and enhances the functionality by aggregating the data to provide higher value information to the pedagogical layers, for example, it takes *detect-wall* and *move-to- wall* to produce *go-to-wall* etc. Furthermore, the pedagogical layer maps the aggregated objects (*go-to-wall and follow-wall)* to the learning activity, *wall following*, and informs the learners via the user interface layer about their learning achievements and whether the wall following robot has accomplished the task or not. The learners use their tablet/smartphones as an augmented reality display to see the internal communication processes of the robot and obtain feedback and guidance based on each learning activity. This phase is related to the evaluation and analysis stages in Blooms taxonomy.

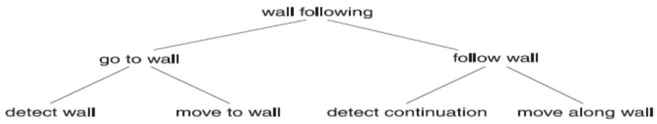

Figure 1. Hierarchical decomposition of wall following [7]

4. Conclusion

In this work-in-progress paper we described the structure of the pedagogical layer and how it handles the technical activities that are derived from use of the physical objects. It shows the realisation of the pedagogical layer, which combines learning and computational objects within a pedagogical context. We have demonstrated the workflow of the PVM model based on an embedded computing scenario. Clearly, this is still work-in-progress. We hope to demonstrate that the PVM model will have achieved its aim of seamlessly combining hardware, software and AR events within a seamless learning environment.

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Preliminary Results from a Study of the Effectiveness of Active Learning Techniques and Virtual Environments on Course Delivery

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Abstract. This paper summarizes the interim findings of what has become a 4 year study to determine the efficacy of using active learning within a standardized first course in computer science using a blended delivery format. The faculty implementing this approach to course delivery rely heavily on collaborative problem solving. Since the approach uses active, blended and collaborative techniques and we whimsically refer it as the ABC method. Since collaboration is considered to be of great importance the effect of introducing a virtual world into the ABC methodology to enhance and extend collaboration is also under study. We see some promising results emerging.

Keywords: virtual worlds, active learning, flipped classroom, on line education

1. Introduction

In the United States the majority of secondary and post-secondary course work is delivered using the traditional model of lecture led education. The Sloan Foundation found that over the past decade there has been a rather dramatic increase in the amount of secondary and post-secondary coursework being delivered in either a completely online asynchronous manner or a partially online blended manner [1].

Our study investigates a particular type of blended delivery which uses of active learning and collaborative problem solving. The authors of the study have whimsically labeled our approach to blended delivery the ABC method. To enhance collaboration we introduced a virtual world platform into the the ABC method and as a result we label it ABC with virtual world or simply ABC-VW.

To test the relative e_ectiveness of traditional lecture led, ABC and ABC-VW approaches we established a 3 year study in which student progress, engagement and advancement are measured using simple metrics. Due to some encouraging results after implementing the virtual world platform the study has been extended an academic year.

2. Background

Saint Paul College is a two year urban institution located in Saint Paul, Minnesota, USA. The college provides both vocational and traditional academic instruction to a very diverse student population. The college has been rated the top two year institution in the US for the past two consecutive 3 year award cycles.

Computer Science is one of the largest departments at the college. Annual enrollments are approximately 200 full time students of which approximately half are non-traditional students.

In order to accommodate the needs of all of students the computer science department now delivers academic course work in three basic scheduling formats:

1. Traditional lecture led instruction, (about 48% of offerings)
2. Blended lecture and online, (about 45% of offerings)
3. Online format only(asynchronous), (about 7% of offerings)

The department has been experimenting with and using virtual reality in the form of virtual world platforms for over 7 years and has a competence in their development, deployment and operation.

3. Study Design

The study was designed to develop data with which to compare the efficacy of three distinct approaches to course delivery. These approaches are as follows:

1. Traditional lecture led delivery This type of delivery utilizes a traditional instructor led course.
2. ABC This type of delivery involves the substitution of active learning laboratories in place of lecture meetings and content is delivered using an online learning platform and streaming video.
3. ABC-VW This type of delivery uses the ABC approach but implements the use of a virtual world platform to enhance collaboration.

All sections of the course are being conducted by the same instructor who has taught this particular course and its predecessors for over 10 years. The study is using an introductory computer science course, "Introduction to Computing and Programming Concepts". This particular course was selected as it is a standardized undergraduate _rst course in computer science in the US.

The study is using a small and simple set of metrics which are designed to be easily understood, unambiguous and easily reproduced. The following 3 measures were selected as a basis of comparison:

1. Student progress as measured by the results of an objective examination given during the first meeting of the course and serving as the final examination.
2. Student retention as measured by class meeting attendance.
3. Student advancement as measured by the portion of students electing to take the second course in the series.

The study is being conducted according to the schedule found in Table 1.

Offerings Comparison	Start	End
Traditional Lecture vs ABC	August 2013	December 2013
Traditional Lecture vs ABC	January 2014	May 2014
Traditional Lecture vs ABC-VW	August 2014	December 2014
ABC vs TLB	January 2015	May 2015
ABC vs ABC-VW	August 2015	December 2015
ABC vs ABC-VW	January 2016	May 2016
ABC vs ABC-VW	September 2016	December 2016
ABC vs ABC-VW	January 2017	May 2017

Table 1. Schedule of tests of delivery methods 2013-2017

4. Interim Results

The study is at its midpoint and continuing. In the Figures 1 & 2 below are some preliminary graphs of the results through the fall semester of 2014.

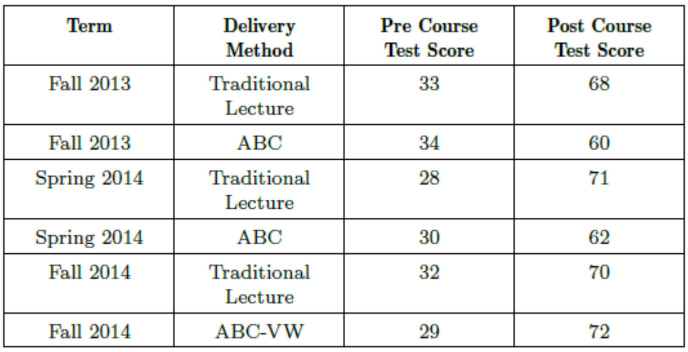
As can be seen in Figure 1 graphs (a) & (b) student engagement as evidenced by session attendance is consistently higher attendance in lecture based class meetings over the ABC sessions.

In Table 2 for the Fall term of 2013 and the Spring term of 2014 student progress as measured by pre-course testing and post-course testing was higher for those students in the traditional lecture led sections over those in the sections using the ABC method. Students in the lecture led sections improved exam scores by an average of 39 points on a 100 point scale while those in the ABC section improved an average of 34 points. This seems to show a nearly 15% learning advantage to those in a traditional lecture led section.

Once a virtual world was introduced during the Fall of 2014 student engagement in the ABC-VW sessions was actually higher than that of the traditional lecture based course. This can been seen in graph (a) of Figure 2. Student progress also increase and exceeded that of the traditional lecture led section this can be seen in graph (b) of Figure 2 and in Table 2.

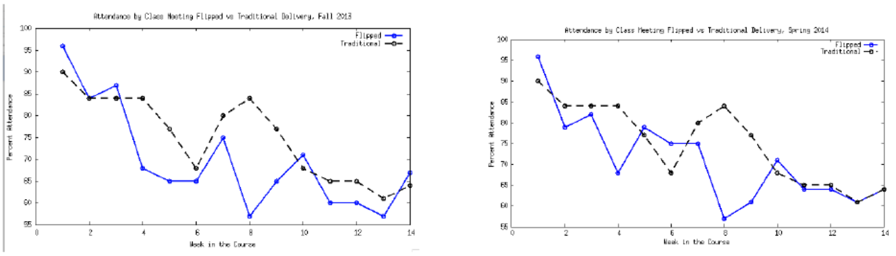
5. Findings to Date

This is a preliminary review of some data from a 4 year study which is currently underway. While the study is only at its midpoint some clear findings have emerged.



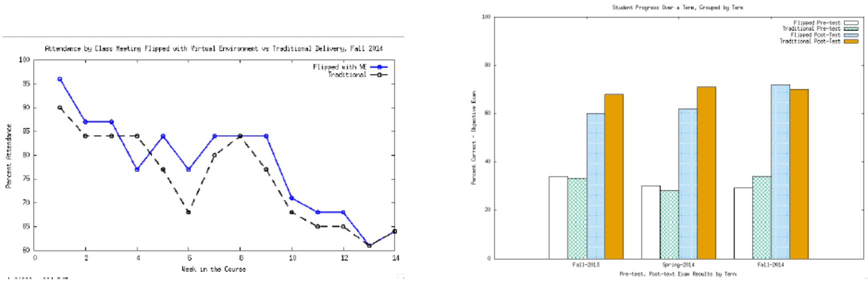
Term	Delivery Method	Pre Course Test Score	Post Course Test Score
Fall 2013	Traditional Lecture	33	68
Fall 2013	ABC	34	60
Spring 2014	Traditional Lecture	28	71
Spring 2014	ABC	30	62
Fall 2014	Traditional Lecture	32	70
Fall 2014	ABC-VW	29	72

Table 2. Student progress based on pre-test, post-test scores, Scale = 100pts



(a) Traditional v ABC, Fall 2013 (b) Traditional v ABC, Spring 2014

Figure 1. Academic Year 2013-2014



(a) Traditional v ABC-VW, Fall 2014 (b) Student Progress

Figure 2. Fall 2014 Attendance and Student Progress in 3 Separate Terms

1. We have not been able to replicate or verify any sort of large scale gains in student progress attributable to the ABC approach or its more popular namesake the flipped classroom reported in the popular and academic press.
2. We noticed an improvement in student engagement and collaboration once the virtual environment was introduced into our ABC active learning approach. Student progress and engagement exceeded that found in the traditional lecture led sections.

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Experiences of Collaborating and Learning through Collab3DWorld

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Abstract. Collaboration is an activity that is considered important during the learning process. Good communication between group members is essential to achieve quality output. Recently, virtual worlds gained excessive popularity in educational settings and more and more lecturers are incorporating live activity or lecturing sessions in environments like Second Life (SL). In this work we are investigating how students of a conventional university perceive collaboration, communication and attending lectures in a 3D virtual environment. Initial results show high perception and students' openness to the 3D world's experiences.

Keywords. Second Life, Collab3DWorld, collaboration

1. Introduction

Virtual worlds (VW) are " *synchronous, persistent network of people, represented as avatars, facilitated by networked computers"* Bell [1: 1]. These environments provide shared multi-dimensional spaces that support synchronous interaction and communication, enhancing the socialisation between users [2]. VWs support real time interaction between users and objects, providing the immersive feeling to its users of actually '*being there*' [3]. Using their avatars, users can navigate and synchronously interact with other users and the environment and can also create, manipulate, manage and interact with virtual objects [4]. VWs are mainly used for socialising and recreational purposes, however, the use of such environments have also been adopted for educational purposes.

VWs provide a range of multimedia presentation tools such as video, materials presentation, 3D graphics, synchronous audio and chat communication etc. which are richer than the standardised email, chat and forum based techniques used as part of the traditional E-Learning environments [5]. These environments allow to develop constructive and engaging activities that promote involvement in learning [6]. The ability to bring students and teachers together in the same shared space, facilitates collaboration which is essential in the learning progress [5]. Through these attributes, students immerse in the environment, are aware of the existence and actions of others and develop the feeling of belonging to a learning community [7].

In this paper we describe an experience report of how students of a conventional university in Cyprus perceive communication, collaboration and learning through Collab3DWorld - a virtual campus built in SL for the purpose of this and future studies.

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[1] Corresponding Author.

Specifically, in this study we aimed to answer the following research questions: *How the students who attend a conventional university perceive the: i) lecturing experience, and ii) the collaborative work through a 3D world environment?* and also: *iii) How written communication influences student perception for lecturing and collaboration.*

2. Collab3DWorld

Collab3DWorld campus (Fig. 1) is developed in SL, and its layout mainly represents a real campus with recognisable facilities and surroundings. We designed the appropriate educational structures to offer the possibility of managing educational resources and support collaborative activities using Moodle[1] and Sloodle[2] components.

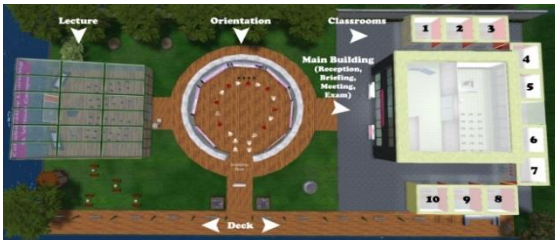

Figure 2. Collab3DWorld Campus

Figure 3: Students while working on designing their digital paper prototypes

When users visit Collab3DWorld, they are virtually transferred (teleported) to the Orientation Room where they can read signs with basic instructions for using SL Viewer. On the ground floor of the main building there is a reception area where users can find information and guidance for the activities and use of the Registration Enrolment Booth to connect their avatar to their Moodle account. The virtual environment also contains a transparent Lecture Room which provides functionalities such as Presentation Boards (Sloodle Presenter) and chat recordings (Sloodle Chat Logger). Finally we developed 10 rooms to support collaborative group activities simultaneously. They included an interactive multipurpose web wall for collaborative tasks, and a Chat Logger to record the written communication for further investigation. These rooms have been used for the study we are describing in the next section.

3. Pilot Evaluation Study

The purpose of this study was to investigate the three main questions addressed at the beginning.

Procedure: We recruited students of a conventional university in Cyprus to attend a lecture and perform a collaborative activity in groups through Collab3DWorld that was part of their overall assessment. Two sessions took place in different days and a total of 22 undergraduate Computer Science students were recruited, of whom 13 males and 9 females, between 20 and 25 years old. The students enrolled in the Human Computer Interaction (HCI) module and called to participate in this study as part of

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[1] www.moodle.org - Moodle is an open source learning management system.

[2] www.sloodle.org - Sloodle is a tool that links the educational activities of Moodle with SL through 3D virtual objects managed through the virtual environment.

their course attendance. Clear instructions were given to the students for the purpose of this study and the steps they had to follow to register and familiarise themselves with SL and the Collab3DWorld environment. In addition a demonstration of the environment was given in class.

At first students had to complete a questionnaire that was designed to provide us with information on their computer skills and most importantly their previous experience with 3D worlds. Then the students registered in SL and teleported in the main orientation area where they could found instructions on basic functions they could use. This was done separately for each student at their own time and without the researchers' supervision. Then the students were asked to perform a collaborative activity in Collab3DWorld.

Students formed groups of 3 - 4 and developed digital paper prototype[1]. For this activity they had to book a 90 minutes slot at one of the 10 rooms constructed especially for this purpose. The rooms were equipped with an interactive wall, where the Google Drawing[2] tool incorporated and used by the students for designing their digital paper prototype (Fig.1). In addition the chat logger tool was used to record the chat communication between the students for further analysis.

The second part of this study was the lecture session that took place synchronously through the lecture room of the VW (see Fig. 2), and students were remotely located. Students were asked to log in the Collab3DWorld and attend a lecture that was given by the lecturer presenting a new learning material.

At the end of the study the students were asked to respond to a questionnaire that aimed at assessing their perception regarding the collaborative activity they performed, their lecturing experience in the 3D environment and also to examine the importance of communication as part of their activities. The questions were extracted from [8-10] and focused on the students' ease of navigation and use of the environment, the importance of nonverbal communication, the perception of collaboration and lecturing through SL and Collab3DWorld. Likert scale of one to five has been used, with five being the most positive option.

Results and Discussion: Before conducting any data analysis, the data were tested and passed a Kolmogorov–Smirnov test thus, parametric approaches were employed. The scales have also been tested and passed the Cronbach's alpha reliability test, denoting high internal consistency between the items comprising the scales.

The importance of communication in VW settings: Firstly, we analysed the data concerning the nonverbal communication within Collab3DWorld. We acknowledge the importance of communication within such environments, thus communication was explicitly measured through the questionnaire. Students' replies show that they communicated very well with others (M=4.23, SD=.75), and the nonverbal communication tools available were sufficient to support their collaborative activity (M=4.00, SD=1.00). Although, we acknowledge the limitation of not allowing verbal communication between students, the results show that this was not an obstacle to their collaboration and participation.

How the students who attend a conventional university perceive the: i) lecturing experience, and ii) the collaborative work through VW: Similarly, we were interested to investigate the extent to which their previous experience with VW environments like

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[1] Paper prototyping is used widely in user centered design by usability professionals. Recently, it has been advocated by companies like Pidoco due to advantages in terms of collaboration, flexibility and cost.

[2] https://docs.google.com/drawings/

OpenSim and SL influences their perception of collaboration and lecturing experiences. We thus run a Pearson correlation between the data collected about students' previous experience in such environments, their collaborative activity session and lecturing session through SL. The results show no correlation (r=.12, p=.61) and (r=.173, p=.44) respectively, implying that previous experience with VW does not influences how students perceived collaboration and lecturing through Collab3DWorld.

The next step in our data analysis is to gather the information about how students perceived their collaboration through Collab3DWorld. The students were satisfied with the collaboration in their teams (M=4.18, SD=.85) and thought that being able to collaborate with their fellow students at any time of the day was very important (M=4.14, SD=.89). Similar results obtained for the lecturing session. The students perceived the lecturing experience very positively, reporting that they following the lecture given through SL was very easy (M=4.18, SD=.79), and that asking questions about the material taught was also straight forward (M=4.14, SD=.834).

4. Conclusion

The study presented in this short paper, is an initial experience report of how students perceive collaboration and learning through 3D environments. The results show that these environments are very promising in supporting collaborative online activities, and can make learning more interesting. We are planning to extend this initial study in a longer evaluation the 3D campus built and also other learning management tools that are available through SL. The purpose is not to create completely new online university but to be able to assist in-class learning and teaching with what technology has to offer.

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It Takes a Virtual Village: Influencing Teen Health Behaviors through Mixed-reality Strategy

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Abstract. The WAVE project is an obesity prevention program that provides healthy teenage soccer players with a 2-year curriculum on basic food preparation, meal planning skills and physical activities. The long-term goal is for the active soccer player youth to adopt a sustainable healthy life-style. This project is coupled with a Immersive Learning Environment (ILE) called Rippleville developed using the OpenSimulator platform. We hypothesize that we may modify health practices through immersive simulation. In this paper, we present the strategies we applied to build Rippleville, in terms of learning objectives, immersive environment, engagement and programming as well as the current state of the project.

Keywords: Immersive Learning Environment, Nutrition, Health, Education, OpenSimulator

1. Introduction

Whether behavior may be influenced by face-to-face instruction paired with immersive environment experience is a research question ofWAVE Ripples for Change, an interdisciplinary project at Oregon State University. Young people tend to exhibit negative health changes in transition from high school to work or college [10]. TheWAVE project[1] seeks to induce modification in diet and physical activity by increasing knowledge of health behavior then applying that knowledge through an immersive environment.We hypothesize that we may modify health practices through immersive simulation. This hypothesis is grounded in research showing that immersive experience may cause change in a persons subjective experiences, body states, and physical space behaviors. Interaction within immersive environments has been shown to induce subjective experiences such as nicotine and alcohol cravings [1,3,4] and fears such as aerophobia [7] and acrophobia [8]. It has demonstrated effects on body states such as blood pressure [9] and body mass index [5]. Individuals who exercised super powers in an immersive environment exhibited greater altruistic behavior in physical space [6]. Simulated exercise activity in immersive environments correlates to increased physical activity in physical space [2]. From this recent literature, we find the basis for expecting that health behaviors may be modified by activity in an immersive environment in which subjective experiences, body state feedback, and simulated

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[1] Sponsor: NIFA AFRI Award No. 2013-67001-20418

behaviors are modeled by design.

Currently, a group of about 25 high school students is piloting Rippleville and the first year of the curriculum. Rippleville is being developed based on the curriculum and the participants feedback.

2. Learning Strategies

Learning Objectives: Rippleville does not aim to teach new material, but to provide an immersive and physiologically accurate environment for the participant to practice making choices toward a healthy lifestyle.

Quests & Health Bar: How do we achieve those learning objectives? The participant monitors the avatars health using a heads-up display called the *Health Bar* which reflects parameters such as hydration and consumed sugar. Additionally, Rippleville offers a set of activities, or quests, to be performed individually as pretext to promote physical activities to the participant. Once the student completes a quest, a reward is awarded based on health criteria which varies according to quest. The rewards are (i) points which are accumulated and mark the progression of the avatar and (ii) WAVE dollars, Ripplevilles virtual currency which can be spent on virtual food and clothes to personalize ones avatar. Our learning strategy is based on allowing the student to be rewarded for making good choices but also to have the freedom of experimenting with bad choices.

3. Immersive Environment

Rippleville: a virtual village: village Rippleville is located on an island and is still under development. It has a high school, a clinic, a dance club, a convenience store, a farmers market, various clothing shops, restaurants ranging from fast food to mid-range, and houses. Each soccer team has its own headquarters called a Club House. The island also has wilderness areas; natural beach and mountain areas offer environmental range and provide interesting areas to explore outside of the village.

Food: Another fundamental element of Ripplevilles immersive environment, each food item is modeled in 3D, either as individual item (e.g. an apple) or a meal (e.g. hamburger and fries). The menus have been created by the WAVE project nutritionists and the location of each food is based on realism (e.g. convenience store sells what you would normally find in a convenience store). Furthermore, each product has a nutritional fact label. Finally, the products brands are invented but give a visual nod to existing brands that are familiar to the participants. This is essential for the transferability of knowledge.

4. Engagement & Adoption Strategies

Rippleville will be used for at least 2 years by the participants. Thus, it is crucial to develop strategies to maximize engagements and adoption of the platform early.

Overcoming the Technological Barrier: The OpenSimulator platform requires some training to control the avatar, in addition to the functionality we added to the program. Thus, we created a orientation program consisting of an hedge maze with challenges in order to make what could be mundane interface learning more interesting and help participants understand how to navigate the environment.

Self Identification: OpenSimulator offers the ability to alter and personalize ones avatar appearance. Successful completion of the orientation hedge maze brings the participant to the Identity Shop which offers a selection of basic skins, hair, eyes, and clothes that allow the participant to customize their avatar appearance and reinforces the self identification. Additionally, Rippleville offers a variety of styles and shops to appeal to different tastes. Finally, the *Club Houses* are themed with team colors and mascot, and have a small soccer field. This provides an identity link between the participant and his/her team as well as a sense of ownership of the space.

Socializing: The OpenSimulator platformprovides a system of profile pages and instant messaging which facilitate the social interactions within Rippleville. Participants can messages each other, “friend” each other, and exchange goods. The *Club Houses* (with the soccer fields) as well as the *Dance Club* (with the dancing) provide spaces to hang out and have fun. Finally, we plan on implementing group quests.

Consistent Narrative: Each quest is built with elements linked to Rippleville’s narrative. For instance, the quest “Find the Kraken” tells the story of the Kraken, the mischievous mascot of Rippleville high school, which must be stopped before worse happens!

Creating Content: The OpenSimulator platform provides a programming language called Linden Scripting Language (LSL). LSL can be implemented in all objects and structures in Rippleville. To further engagement, we provide sandbox areas to encourage creative participation and personal contributions to the world.

5. Programming Strategies

Figure 1 summarizes our programming strategy; each avatar is wearing a badge called a Combadge, which monitors the avatars activity in terms of intensity of physical activity, which quest is active or completed, and what alimentation is taken. It then computes the health information to be displayed by the Health Bar and calculates the rewards.

6. Conclusion

Currently, Rippleville is being developed and deployed progressively to a pilot group of 25 high school students. This piloting will end in August 2015, and the WAVE program will be deployed to 500 participants of which 320 will have access to Rippleville. In the following years, we expect to measure the individual and collective activity in Rippleville.

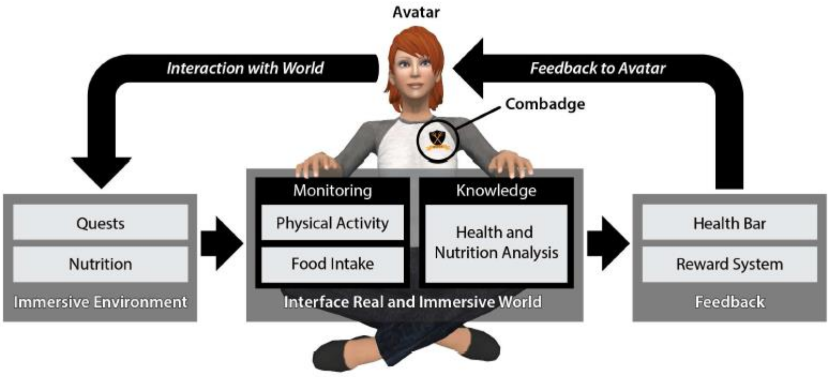

Figure 1. The Combadge centralizes Rippleville's programming strategy

Considering our hypothesis that we may modify health practices through immersive simulation, we expect to collect measurement over at least the two following years of deployment to test Immersive environments provide options for experiences through simulation that are not practically attainable in physical space/time. We believe that the impact of health education for modifying patterns of behaviormay be augmented via experiences in an immersive environment by which learners put new knowledge into application. The Rippleville component of theWAVE project is a platform for testing the efficacy of an immersive environment as a means by which subjective experiences, body state feedback, and simulated behaviors may be modeled and influenced by design.

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Games and museums: Case study of the creation of a new multimedia exhibit for the Glenlee Tall Ship Museum

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Abstract. Multimedia can improve the ability of the curator to communicate and engage with an audience that has many other options for the use of its leisure time. Games are an excellent form of multimedia, and can provide this effectively if they fulfil certain criteria and are designed with pedagogical features. Although this can be a successful approach, compromise will have to be made regarding educational content, and playability of the game.

Keywords: education, computer games, museums, compromise

1. Introduction

The Glenlee Tall Ship museum is located on the Glasgow waterfront, inside the ship the MV Glenlee herself. We explore the issues around building a new multimedia visualisation to aid interpretation and communication of the ship's history to the visitor base. Doing so requires an understanding of the role that multimedia plays in the museum environment, what currently exists in this museum and a consideration of what format, features and characteristics should be present in a new multimedia exhibit, as well as some understanding of the audience requirements.

2. Museums and Multimedia

The use of digital visualisations and various multimedia applications in museums has been a source of contention in the heritage community. For many the introduction of multimedia of any kind is a threat to the core ideas of a museum. In opposition to this others claim that multimedia has a very real role to pay; it can help to enable new democratic associations, and multiple interpretations of an historical era [1]. It can be a force in its own right, improving the ability of the curator to tell a story and elicit a physical and emotional response from the public [2]. At the heart of this is a disagreement about what the function of a museum should be.. MacDonald argues that museums should be dedicated to the dissemination of information, not simply repositories for objects [3]. Museums are 'in the communication business' [4] and as such need to make use of the tools they have available to tell a fuller, and perhaps contradicting story of their exhibits or else risk being viewed as outdated and fail to compete with other leisure activities for the public's attention [5].

Without meaningful curatorship museums are merely rooms full of objects. Multimedia technology can assist in the curator's task. A controlled multimedia environment can provide both multiple interpretations and curator control without damaging the museum as an institution.

3. Games as a pedagogical tool

Of the multimedia options available for museums games are one of the most dynamic choices, as they can combine visual and aural content and allow for manipulation by the user. Games are also, in their various forms very flexible. As Huizinga argues play is innate to living creatures [6] , while Koster stresses how games enable learning, and how gameplay is inherently educational [7].

An educational game must balance narrative and predestination with agency and goals and be optimised for educational ends. Zyda argues that the quality of game play is of primary importance in the creation of educational games [8]. Likewise Wei-Hsin Din argues that good graphics, good character development and good content are also all key factors for a successful educational game [9]. Providing entertainment value will keep the attention of players, resulting in more play, which will result in more learning imparted. The game 'motivates [the player] by virtue of being fun' [10]. However, the more complex the game is, the more opportunity the player will have to deviate from factual accuracy. A more limited game with targeted player agency may help to solve this problem.

It has been argued that a genuinely educational game should be immersive, with different knowledge applied to access deeper levels, with playability elevated over educational content and with a flow controllable by the player [9]. It should not simply 'gameify' learning tasks without including the interpretability of a true game [7]. This said, it is worth considering that the marriage of education and games can create games which lean heavily towards one and do the other very badly [11]. Mayer also reminds us that despite the enthusiasm little hard empirical evidence exists to really support claims about the educational value of games [12]. 'Illegitimate knowledge', that is knowledge that the player knows outside the game, can affect their choices inside the game [13]. Indeed we cannot recreate the human uncertainty of the past and the impact this had on human actions and decisions [14]. Ultimately games function by taking concepts and boiling them down into variables, which a player must gain or dispose of.

Yet at the very least gaming does provide the spark of interest, which an individual otherwise might not receive. For example, discussion forums for popular historical games include many threads about the historical aspects of the game, as well as simply the gameplay, and games with historical settings can inspire and support learning [15]. It is clear that whilst greater study is still required to identify the true extent of gamings educational ability it at the least provides a basic instrument of education if certain characteristics are present, with a basic depth of engagement and care over the educational content itself. This may be supported in linking multimedia and traditional museum exhibits, where the aura and sparkle of the objects and traditional museum displays can generate an interest and context that a game then builds upon.

4. Existing multimedia in the Glenlee museum

Figure 1: One of the basic games on the DVD. The player moves the cat to catch the falling mice

The Glenlee Tall Ship museum has already embraced multimedia and digital content to some extent, with two touch screens on site and a learning pack available for visiting school groups. The pack contains a selection of mostly paper based classroom activities alongside a multimedia DVD. This includes the videos from the touch-screen displays, as well as pictures, stories and information for teachers. A selection of very basic Flash games are also included, but are of very limited educational content (Figure 1). These are very basic generic puzzles, with a thematic skin to suit the purposes of the Glenlee, and don't possess any intrinsic relationship to the educational focus [16]. These are at best 'drill and practice' games and [17] have only a weak relationship between content and context . Simplistic games of this style do not facilitate wide or deep learning [18].

There thus exists a considerable gap in the museum's multimedia repertoire that can be filled. Of what is present, what is a game is not educational, and what is educational is not a game. The graphical style, choice of language and content of the existing multimedia presentations has also focused on a younger (K12 and below) audience. According to the ships management younger children are a key visitor demographic, but just as many adults visit. It is also noted that in recent years, since the ship became free to access, the visitor base has become more diverse. A new games based digital visualisation for the museum should thus seek to appeal to the demographics that are under catered for.

5. Features of the new game

The visualisation should use the advantages of its medium and attempt to show what the museum's current exhibits cannot, and in this way add value. It is necessary to find a way to design for enjoyment and playability whilst also retaining historical and educational information. Information can be presented using 'Explicit' and 'Implicit' methods. Explicit information is openly displayed to the player as information, usually as text for the player to read. Implicit information is not presented directly but emerges through the rules, events and context of the game. The former may be ignored or skipped by the player. The latter cannot, but if not considered carefully can be distorted by the gameplay. A balance must be struck between the two. Too much explicit information will lose the players attention, too much implicit information may overburden the player, providing too many ‘material affordances’, as to the detach the player from their intention, to fulfil the games ultimate goal (or goals) [19].

Trading goods and cargo were very much part of the raison d’être behind the Glenlee’s construction. Yet stationary in dock as a museum exhibit, the economic, technological and political conditions which enabled her to be constructed as a viable commercial concern are no longer obvious. For this reason a game, based around the trading history of the ship was chosen as the subject. The context and gameplay of the game allow for implicit learning of the broad trade and economic context around the ship’s early years. Additional information can be presented explicitly in the game to allow for greater depth, allowing interested players to study the material more closely. Such information should be optional to access or easy to dismiss.

It is necessary when embarking on a project such as this to accept that some warping of the historical facts will occur. Omissions must be made, and compromises reached in order to prevent overloading the game with information that doesn’t aid the players experience. In reality most detailed and specific information must be presented explicitly. It is not possible to represent the full history.

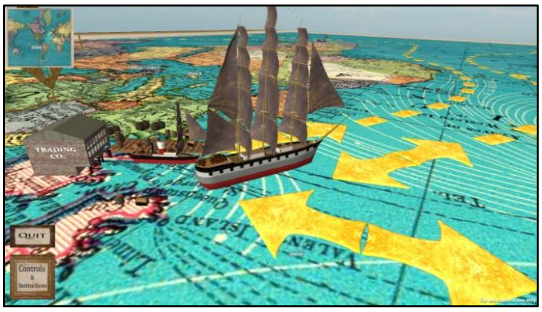

Figure 2. The player travel between ports by clicking on the gold arrows. Each port gives the player a chance to trade goods, based on the natural or manufactured resources available at each location.

A period world map was scanned and brought into the game world as a board for the game to play out on, with players starting each game at home port in the UK. Players then have eight turns to travel the world, visiting different ports and trading (or not) goods each time (Figure 2). The goods available in each port are based explicitly on the common cargoes of the appropriate period, as well as on the goods that the Glenlee actually carried during her life as a trading ship. Profit gained acts as a score to provide an incentive for the player to achieve, and allows competition between individual players across multiple games. Random events ranging from good winds to explosions in cargo holds similarly take into account the events that marked the Glenlee’s journeys and the dangers faced by crews carrying some of common cargoes of the day – such as from ammonia gases from a hold full of guano. The decision to limit games to eight turns was taken to reduce the chance of an individual museum visitor blocking others from experiencing the game for large periods of time – and in practice kept game length to approximately ten minutes.

With each cargo purchased, the user is presented with a screen of information about the cargo and notes on why it was in demand. It is one thing to know that guano was a common cargo, another to understand the risks it created or the reasons why there was, briefly, such high demand for it to support European industry and manufacturing. While the interested can read at their leisure, the screens can be dismissed in a single click if the player desires. While prices were arbitrary, a simple trading mechanic combined with random chance allows money to be used as a scoring mechanism. With a cap on eight turns in each game, the design also takes into account the demands of a museum exhibit in mixing the need for a sufficiently deep and engaging experience against the need for short game times to allow other visitors to play.

Conclusion

A 3D educational game was developed for The Tallship at the Riverside Museum in Glasgow. While limited in scope, it provides a template of what a museum game can achieve in regards to relaying educational information and retaining playability. Built with Unity 3D games engine the game is modern in its graphical style, providing an attractive and reasonably immersive presentation to the player. With such a limited budget and timescale much that would be recommendable was not possible, such as two player options, greater graphical realism or more detailed modelling measurement based on data capture.

The game aims to provide a necessary balance between simple yet engaging gameplay and dissemination and communication of information. While only very preliminary user tests have been undertaken, including having the game on display to the public at The Glasgow School of Art post-graduate degree show, it is evident that gameplay is simple for users to learn from in-built instructions. Combined with the turn limit, attractive graphics and easily dismissible textual information ensures the game is appealing and not daunting to the casual user, who may have little knowledge, or indeed previous interest in the Glenlee’s trading history. Furthermore trade routes, destinations and cargoes, which are all based on the history of the Glenlee and period merchant shipping, provide implicit emphasis and support to the explicit educational content embedded in the game.

Finally, we concur with a number of other authors that games can be a superb way of communicating educational information, but that they must be focused, playable and present a compromise with the necessary educational content. And we are happy to note that with a little research that this can be achieved to a reasonable degree without adversely affecting either gameplay or educational learning outcomes.

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Reflections on the Design, Development and Deployment of Augmented Reality-Based Learning Environments

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Abstract. This paper describes lessons learned from the design, development and deployment of two augmented reality based learning environments in real school settings.

Keywords. augmented reality; best practices; simulation

1. Introduction

The widespread adoption of mobile devices is opening new opportunities and challenges in education. Nowadays students might have access to augmented reality (AR) systems which could help them to improve their spatial ability, to develop practical skills, or to understand physical phenomena [1], [2]. These educational affordances are mainly due to core characteristic of AR technology, namely to allow users to experience the world enriched by digital information and eventually other sensory inputs in real time. However, there is a lack of studies reporting how to integrate this technology into complete learning designs [3].

In this work, we report lessons learned from the design, development and deployment of two AR-based learning environments: REGARd [4] and AR-SaBEr [5] in real school settings. We summarize their impact in formal education, both in secondary and high level schools to teach the basic principles of electricity and magnetism.

2. Characteristics of AR-Based Learning Environments deployed

This work is based on two AR-based learning environments (REGARd [4] and AR-SaBEr [5]) designed and developed by authors to introduce students to the basic principles of electricity and magnetism. Students are provided with 3D objects wrapped with frame markers which are tracked by the AR-tools. The 3D objects mimic electrical and magnetic components and allow students to build circuits, to make measures, and to test circuit behaviors. Students can observe the behavior of the handled components,

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visualize electrical and magnetic fields and experiment with physical phenomena thanks to AR technology.

REGARd [4] is based on problem-based learning instructional design, thus students were guided through the resolution of an electric-magnetic problem which involved five sequential stages. The narrative of the activity consisted of the construction of the circuit that solved the proposed problem by adding a new element in each stage. In order to be allowed to add a new circuit element, students were inquired about the main concepts related to that circuit element; then they had the option to read about the concepts involved with the new element included or to continue with the learning activity. Finally, students had to solve sub-parts of the proposed problem.

AR-SaBEr [5] used discovery learning, a constructivist learning theory where learners construct their own knowledge by experimenting with a domain, and inferring rules from the results of their interaction with the domain [8]. Students accessed AR-SaBEr's learning materials through the main menu of their tablets which contains three topics: electricity current; voltage, and resistance. Each topic consists of three activities and each activity includes background information, an AR-based simulation and multiple-choice questions.

Although experimental activities are designed to be the focus of attention of students, the experiments are supported by reading activities. The monitorization of students' interactions along with assessment and self-regulation questions guide the individual workflow of learners. Therefore, the simulation scenes are embedded in ad-hoc learning management systems which provide: the working flow each student must follow; background information relevant to the task to accomplish; assessment based on multiple-choice questions; self-regulation questions included as part of the tasks to guide students toward the learning activities more relevant to them; a log file containing students' interactions.

3. Lessons Learned

In this section, we present a set of good practices developed during the design and implementation of the learning environments. Furthermore, we summarize the affective and pedagogical affordances achieved by learners during the interventions.

3.1. Authoring

There is a set of steps that are common to the design process of learning experiences which includes (1) the definition of learning outcomes in terms of the knowledge, skills, and abilities that students must achieve; (2) the definition of the learning contents to be delivered, and (3) the definition of assessment activities. Additionally, in AR-based learning environments, it is necessary to consider the design and implementation of AR scenes and the combination of information, simulation and assessment into meaningful task

Regarding the design and implementation of AR-scenes, each scene should be designed to allow participants the exploration of learning objects with a predetermined learning purpose. The preparation of the scene involves: (1) to choose the objects to be tracked along with its tracking system (image or marker frame); (2) to create the assets (image, 3D objects, audio, animations) to be superimposed on the objects to track; (3)

to implement the AR scene using the objects to be tracked and the assets, and (4) to test the scene for robustness, correctness and usability. The first step requires a careful choice of the size and the amount of frame markers or images to use in order to guarantee a fast and highly precise tracking of the scene. It is worth noting that the modeling of 3D objects mentioned in the second step might require graphic design abilities. Moreover, the third step requires the definition of intuitive ways of handling real and digital objects in the AR environment otherwise, students get confused and the benefits of using this technology are seriously diminished. Finally, the fourth step is particularly important in AR learning because students tend to judge the usefulness of the technology by the user interface. If they do not like it, if it does not work properly, they will not use it.

Regarding the combination of information, simulation and assessment into meaningful tasks. The workflow of activities can be treated in similar ways as in web-based learning environments. However, the use of AR-technology for educational purposes opens new ways of monitorization of learning interactions. This information that can be useful to ensure formative assessment and to provide tutoring in real time.

3.2. Affective Affordances

Emerging technologies when coupled with effective instructional design might attract, motivate and engage students toward learning activities. Empirical studies carried out by the authors of this work have found that AR-based simulation environments have positive psychological effects on students in terms of motivation and engagement.

According to ARCS motivation model [9], instructional material should be designed to attire student attention, the learning activities should be aligned with students' personal goals in order to be perceived as relevant. Moreover, the activities embedded into the learning environment should promote students' confidence toward her success and provide a sense of satisfaction with the process and results achieved. Interventions made by authors of this work using AR-based learning environments [5] showed that the attention factor was always the best rated whereas the relevance factor had always the lower score.

In education, engagement has been associated to students' academic achievements. An engaged student persists in their academic activities despite challenges and obstacles [8]. Therefore, to engage students is one of the main challenges in education. An intervention carried out by authors of this work in a real school setting using REGARd showed that students reached a flow experience achieving high levels of concentration and distorted sense of time [9].

However, the use of AR in education is not exempt from risks. Indeed, in a previous work [5], the analysis of the behavior patterns using an AR-based simulation environment showed that engagement in AR activities can become an obstacle for achieving desired learning goals. Indeed, in the aforementioned intervention students preferred made interactions by trial and error rather than to read the instructions presented in the digital interface.

3.3. Learning Outcomes

Certainly satisfaction, motivation, engagement, concentration are valuable learning outcomes but it cannot be said that AR-technology is useful in education unless students improve their knowledge and skills by learning with this technology. In this regard, initial attempts of using AR as testbed for experimenting with basic concepts of electricity and magnetism [4], [5], have found a moderate learning effectiveness of the environment. However, learning effectiveness of these learning environments was improved when students were supported with learning scaffolding [10].

4. Conclusions and Future Work

REGARd and AR-SaBEr enabled the deployment and evaluation of AR-based learning environments in real course settings. The use of AR technology drove two main considerations in the design of the learning environments.

1. The first was the need to build the two learning scenarios by composing small learning activities. Each simulation was built to instruct about only one idea and it was tied to a unit of knowledge. Special care was taken designing and choosing the amount of 3D shapes to guarantee the best usability of the tools.
2. The second was the opportunity to take advantage of the AR-toolkit to log students' interactions. These logs were used to guide students toward reading activities whenever they were necessary to accomplish experimental tasks.

REGARd and AR-SaBEr proved that it is possible to attract and hold the attention of students toward the experimental activities deployed. However, an analysis of the behavior of students while using the tools revealed that some students have the propensity to pay more attention to the technology than to the learning subject. Therefore, it seems necessary to find effective mechanisms that help students to focus on the learning subject.

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The Evaluation of a Cyber Campus to Support Distance Learning Activities

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Abstract. There are many barriers that hinder access to education for some students, significantly affecting their learning experience. To mitigate the effects of such barriers e-learning technologies are widely used. One example of this is the use of cyber campuses. These are 3D environments where students can meet and share information, and synchronously communicate and collaborate. It has been suggested that the learning experience of students using these cyber campuses is related to their perceptions of presence, awareness, communication and sociability. However, a question remains as to what extent cyber campuses can support students experiencing barriers accessing education.

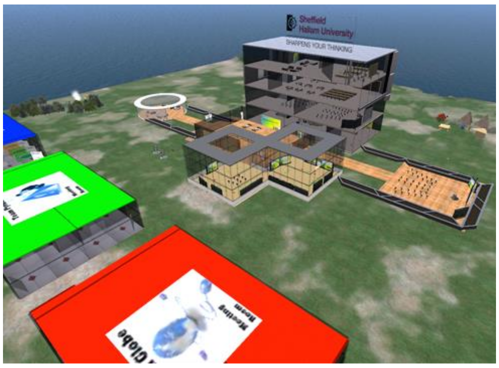
To ascertain this, the SHU3DED (Sheffield Hallam University 3D Education) cyber campus has been developed, and empirical investigation of its ability to support students is on its way.

An initial study evaluating the efficacy of the prototype to support synchronous distance learning activities is conducted. A series of collaborative studies were performed with the participation of remotely located users divided into teams. The activity outcome was to teach users how to design objects in the virtual world, in order to collaborate and build content together. Empirical data based on the users perceptions of presence, awareness, communication and sociability of the environment has been collected. The design of the virtual setting, productivity and satisfaction of the experience was also evaluated.

The preliminary results indicate that the cyber campus can support synchronous participation in distance learning activities, and be a sound social space that supports effective social interaction.

Further work is on its way to ascertain the extent to which a cyber campus can support students experiencing barriers accessing education. This will involve additional evaluation and qualitative investigation of the environment's characteristics that could mitigate some of those barriers, to devise suggestions for the design of cyber campuses and educational activities to address them.

Keywords. Muve, virtual worlds, cyber campuses, e-learning, vle



Experiments with collaborative blended-reality laboratory technology for distance learners

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Abstract. Traditionally laboratory work for distance learners has been limited to video recordings, simulations using software interfaces and other solutions that restrict the possibility of interaction with real equipment and collaboration with other learners. In previous work we proposed a different approach using mixed-reality to enable collaborative laboratory activities. This paper presents preliminary results on the user evaluation of our proposed conceptual model and architecture, thereby extending our previous progress towards the creation of a blended-reality distributed system for educational uses.

Keywords. Mixed reality, blended reality, virtual laboratory, xReality objects, Multi-user virtual environment (MUVE), constructionism.

1. Introduction

In previous papers [1], [2] we proposed an innovative conceptual model and architecture to interconnect multiple mixed-reality learning environments based on a distributed computing architecture, allowing bidirectional communication between environments, smart objects and users; managing multiple dual-reality states and creating blended-reality spaces. Blended-reality can be defined as a space "*where the physical and the virtual are intimately combined (blended not merely mixed)*" [3]. The goal of the proposed architecture is to enhance laboratory activities for distance learners based on a constructionist perspective [4].

Each blended-reality learning environment is formed by 3 components:

- The **physical world**, where the user and the xReality objects are situated. xReality objects [1] are smart networked objects coupled to a 3D virtual representation of them; creating a dual-reality state that is updated and maintained in real time.
- The **virtual world**, where the real-world data will be reflected using 3D virtual objects.
- The **inter-reality portal**, a human-computer interface (HCI) able to receive, and process in real-time data generated by the physical environment, so it can be mirrored by its virtual counterpart, thereby linking both worlds.

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2. User evaluation

User evaluation took place with 52 students from Essex University (UK), Anglia Ruskin University (UK), Leon Institute of Technology (Mexico), San Diego State University (USA), Shijiazhuang University (China), Shanghai Open University (China), Etisalat BT Innovation Center (UAE) and Monash University (Malaysia) between March and May 2015. The study used a sample of students pursuing different academic degrees (PhD 23.08%, Master degree 40.38%, Postgraduate certificate 9.62%, Undergraduate degree 26.92%) and different courses, ranging from Computer Science (69.24%) and related subjects such as Electronic and Electrical Engineering, to Learning Design and Technology (21.15%) and a broader range of topics (9.61%) (e.g. Economics, Linguistics, Politics, Graphic Design, etc.). The laboratory activity undertaken by students was to create as a team, a set of IF-THEN-ELSE behavioural rules to control a shared xReality object using the 3D virtual interface. After the trial, participants' views were collected using an online survey and the data was analysed using Statistical Analysis System (SAS). Preliminary results showed that 88.46% of participants found it easy to use the proof-of-concept implementation and 76.92% of participants answered that the blended-reality principles were not difficult to them to understand. User's reasons given for not using the technology were related to interface design issues, worries about Internet reliability, and team communication issues. Overall, the users' comments were positive, explaining that they enjoyed the experience and 80.77% answered they were very likely to use the technology if it was available to them in their schools and universities. These preliminary results show that user's acceptance towards the use of blended-reality and xReality objects in collaborative laboratory scenarios open up new opportunities for collaboration and development, which aims to provide real benefit for distance learners.

Acknowledgments

We are pleased to acknowledge King Abdulaziz University, Saudi Arabia for their generous funding of this research project, including the provision of a PhD scholarship to the lead author. In addition, we wish to thank Immersive Displays UK Ltd. and Fortito Ltd. for their support. Finally we are pleased to acknowledge Prof. Minjuan Wang (San Diego State University), Dr. Jeannette Chin (Anglia Ruskin University), Dr. Shumei Zhang (Shijiazhuang University), Dr. Xiao Jun (Shanghai Open University), Dr. Victor Zamudio (Leon Institute of Technology), Dr. Simon Egerton (Monash University) and Dr. Jason Ng (EBTIC) for their invaluable help in our user evaluation sessions.

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Design, Implementation and Evaluation of a Virtual World for Subject-Oriented Business Process Modelling

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Abstract. Business processes and employees are the heart and soul of an organisation. Efficient and effective business processes are critical and a fast adaption to changes is vital. Business process modelling captures the way an organisation executes business processes and provides a framework to improve these business processes. As business processes span across diverse departments or organisations, modelling requires communication and collaboration of distributed individuals, also called domain experts. Subject-oriented business process modelling (S- BPM) is based on a simple notation that enables domain experts to capture models of business processes without support of a business analyst. S-BPM notation is based on natural language sentence structure: subject, predicate, and object. While common BPM techniques see modelling of business processes as flow of activities; S-BPM is moving the subject (domain expert) to the focus of attention. Virtual worlds offer new opportunities to communicate and collaborate together and find application in various areas like e-commerce, social, business or education. Successful practice of business process modelling in virtual worlds provides a basis to build the first virtual world for collaborative learning S-BPM. The literature review investigates how business process modeling is performed in the real world and in virtual worlds. Based on the result of the literature review a virtual world was designed, in which two to four users can learn S-BPM notation by modelling a given business process. This business process is a procurement process, i.e. acquiring needed materials externally from a vendor, and involves four subjects, i.e. warehouse, purchasing department, accounting and vendor. The learning process consists of three tasks. The first task is the subject selection. Users choose the subject they would like to model. A subject can only be assigned to one user and all user need to choose at least one subject. Based on the subject selection, users can view the business process description of the chosen subject. This concept foster communication between users, as only with collaboration the second task, modelling the Subject Interaction Diagram (Figure 1), can be successfully completed. The last task is modelling the Subject Behaviour Diagram (Figure 2). Therefore, each user models the internal behaviour of the chosen subject from task 1. All the tasks are supported with various concepts, like simulation, colour coding, spatially separating tasks and interior that represents the subject's environment. An evaluation with students from FH Joanneum shows that the virtual world is a platform, where geographically dispersed people can learn S-BPM any time. Although usability and immersion need to be improved and some developed concepts that should support the learning process were not accepted as expected, this virtual world is a basis for a learning platform for S-BPM.

Keywords. S-bpm, modelling, virtual worlds, unity3d, immersive learning

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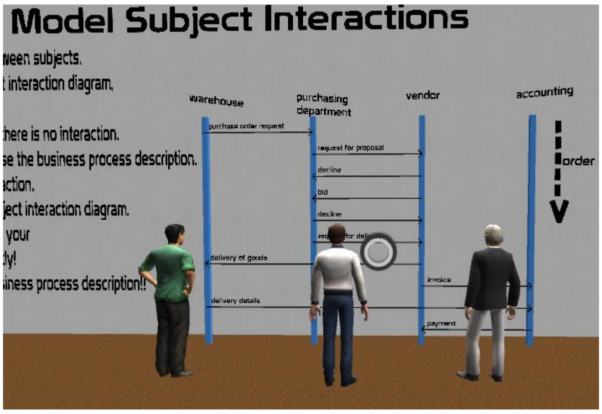

Figure 1: Collaborative modelling of the Subject Interaction Diagram

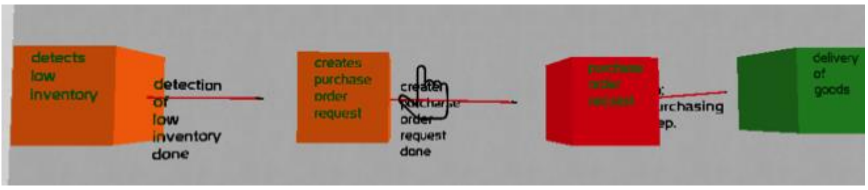

Figure 2: Modelling of the Subject Behaviour Diagram of subject warehouse

The Use of Sentiment Analysis in an Immersive Education Environment to Measure Student Satisfaction and Engagement

Abdulkareem ALZAHRANI[a,b,1], Ans ALGHAMDI[a,b], Fawaz ALARFAJ[a,c] and Michael GARDNER[a]
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Abstract. Analyzing students dialogue in immersive education environment is a promising technique. Wide valuable information can be extracted from the dialogue (i.e. text chat) such as: students satisfaction and engagement. This poster explores the use of Sentiment Analysis to enrich both teachers and student experience. In this first attempt, we use Sentiment Analysis to measure students' satisfaction and engagement. In addition, our proposed conceptual model is introduced.

Keywords. Immersive Learning, Opinion Mining, Sentiment Analysis.

1. Introduction

Immersive Education Environments provide excellent means to enhance communication and interaction among students and between students and their instructors. For instance, Mixed Reality Teaching & Learning Environment (MiRTLE) provides a variety of tools that enable remote and physically-present students to participate in a traditional classroom lecture [1]. MiRTLE and other Environments make the students' engagement and their sense of being there greater than other communication technologies. Student dialogue in such interactive and engaged environments would create a rich and valuable recourse for feedback, a resource that seldom utilised to extract student opinions and to address their concerns. In this poster, we present the idea of automatically measuring student satisfaction in real time in an immersive education environment. We analyse number of inputs from students, which goes through a natural language processing pipeline including a state of the art opinion-mining algorithm [3] to sentimentally analyse text. We build two types of profiles: one global profile, and one profile per learner. The global profile can be used to get students satisfaction reports per module. This global profile can be extended later to report students' satisfaction for the entire department or institute (e.g. a university annual students satisfaction report). On the other hand, the profile our system builds per user is used to support tutors monitor students' behavior in real time. For example, teachers can find out what each student think of different learning objects.

We also present our model for the using of sentiment analysis in an immersive education environment to measure student satisfaction and engagement as shown in figure 1.

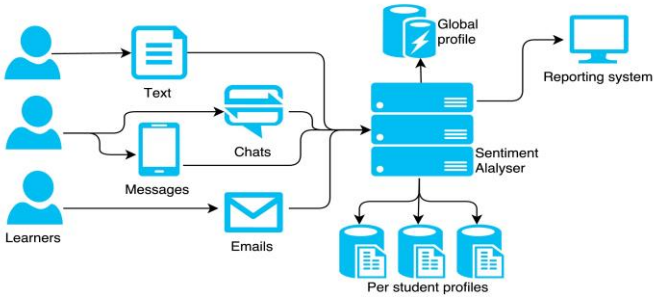

Figure 1. Model for using sentiment analysis

2. Sentiment Analysis

We implemented the state-of-the-art deep learning sentiment analysis algorithm [3]. We gather text-based input from variant resources at an immersive education environment. Unlike many sentiment prediction systems in education, and elsewhere, that treat text as a bag of words or as isolated words, we preserve the text structure and use it as an input for our sentiment analyser. The algorithm we implemented uses a deep learning model that builds up a representation of whole sentences structure. This allows us to keep track of emotions changing by the development of e.g. student interaction. Moreover, this can help us isolate positive feedback from negative feedback per sentence, which we can benefit from. For instance, we can map different part of the text to say learning objects.

To explain more how our sentiment analyser works, lets take an example. When a student writes: Today’s class was actually neither that funny, nor super exciting. I did enjoy yesterday’s lab though. Our system can easily find that the first sentience is still negative, and the later is positive. We can also map this to the different part of the curriculum. Tutors can then access this information in real time and get a more in-depth understanding of student satisfaction.

3. Conclusion

In this poster, we presented a novel model that uses state of the art NLP techniques to measures students satisfaction and engagement. To this end, we show how we could employ Sentiment Analysis to cultivate valuable feedbacks, which could later be used in improving the overall educational experience. There are many avenues for future work. In the next stage we intend to use other NLP tools to measure other educational factors such as student’s preferences, interests, knowledge, language level, learning stage and achievement and try to map it to different learning frameworks (e.g. Mays Fowler framework, Bloom Taxonomy, etc.). Furthermore, we plan to apply this technique in our 3D immersive Intelligent Tutoring System iPerSeq [2] to enrich the tutor model with some analysis and interpretations, which helps the intelligent tutor agent to make precise Decisions.

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Digital Educational Game Atlantis Universe

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Abstract. A new generation of students, accustomed to interact with internet and mobile applications, demonstrates less and less interest in the educational content taught in the traditional way. While some people see games as a waste of time and energy, others see as a powerful weapon to engage and motivate students in such ordinary tasks as do their homework. However this vision requires an effort on the part of educators in translating and adapting their content to new media and the new electronic media. Ludo's mission is Educational, so it creates tools that assist educators in this task, aware and demonstrating the capabilities and needs of today's students approach with digital games. The Ludo Atlantis Educational game shows a great interaction in this way, allowing both the Educator and the Student to create a virtual journey to knowledge in a Digital educational board game.

The following work will seek to show an experiment focused on the preparation, development and implementation of a game for teaching Biochemistry, which will be tested not only in high school students but also in Students that are attending Teachers formation Courses of Chemistry At UNESP University in Araraquara in the State of São Paulo , Brazil.

The goal of this project is to facilitate the learning of Chemistry and Biochemistry, pointing out that the games can collaborate in the process of teaching and learning, in a more attractive , dynamic and differentiated way, because the games that have didactic-pedagogical purpose can provide pleasure and fun as well, the construction of effective learning, to connect various aspects of the learning process as cognition, socialization and creativity, not only between students and teachers but also only among students.

Nowadays the students ' disinterest in learning, can be related with the lack of motivation , which is the result of teaching unattractive methods. In this context, work adaptation of games, involving Chemical content, more specifically Biochemistry, and an innovative teaching method is more appealing to try to teach such content sometimes of difficult assimilation by the students for their descontextualization, and the game can make them easier to learn and more pleasant and attractive.

Keywords. Biochemistry, Digital Educational Game, Cognition, Methodology

Using the Uno card game as a Measurable Learning Task in a Collaborative Augmented and Mixed Reality Learning Space

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Abstract. We are currently building a mixed-reality collaborative learning space as part of our smart classroom at the University of Essex. A key challenge of this work will be in measuring the effectiveness of the learning and collaboration that takes place within this environment. We particularly need to establish the affordances of these technologies and determine the benefits of this environment for a group of learners when they work together. We also hope to create an environment where the group members can also learn from each other when taking part in synchronous tasks. Referring to our separate paper presented at this conference, we have introduced our MiRTLE+ test-bed, which enables a group of 4 learners with different levels of expertise (two novices and two experts) to collaborate on the same task at the same time. For the purposes of this study, the learning task was chosen to be a commonly used card game called Uno. In this scenario the players will work in pairs with the intention that the novice player can learn the game and associated playing strategies by observing their partners game play. The novice will also learn the game rules by communicating with their team member (expert). In addition to learning the basic rules of the game (e.g. use of numbers, colours, and signs) they will also learn different playing strategies such as when to play and which card to use. The smart classroom environment will support this interaction by using a range of augmented and mixed reality collaboration tools. This will form the basis for quantitative and qualitative evaluation studies that will aim to measure the learning effectiveness of the mixed-reality environment. This poster will provide a more detailed description of the MiRTLE+ environment being built, the Uno card game scenario and the evaluation approach that will be used.

Keywords. Learning effectiveness, mixed reality, smart classrooms, augmented reality, learners progress, cards game.

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Exploratory and Social Learning in 3D Virtual Worlds

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[b] *Curtin University, Western Australia*

Abstract. The internet offers many opportunities for students to pass the time these days. Social networks and online games are designed in a way that attracts young people and keeps them motivated for long periods of time. At the same time, today's students find common school education more and more boring as it does not meet their expectations of highly stimulating multimedia input they are used to from their free time. As a logical consequence, educators have been asking themselves how they might be able to use the power of computer games and community platforms to deliver educational content. In recent years, some progress in the field of multi-user virtual worlds has been achieved. Virtual environments have successfully been used for learning languages [1], physics [2], and history [3]. However, the creation of suitable learning environments is not an easy task and certainly exceeds the capabilities of an ordinary teacher. That is why we want to present in this poster an approach that allows anyone to easily create virtual learning environments without needing any programming skills at all.

Keywords. Exploratory learning, virtual worlds, Open wonderland, immersive learning

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Exploratory and Social Learning in 3D Virtual Worlds

Markus KIENLEITNER'[1], Johanna PIRKER[a] and Christian GÜTL[a,b]
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[b] *Curtin University, Western Australia*

Abstract. Our world becomes more complex and modifiable. Early products are designed mainly rigid and inflexible and the users' need for flexible and personalized products is becoming constantly more important. Personalization of different product, tasks, and services often requires the use of scripting or programming skills. This programming language can be signs, chain of commands or a specific programming language. The picture of the classical programmer and everyday life are merging constantly and programming skills are becoming increasingly important in our every-days life. This makes it clear that the need to learn programming is very high and the best way to learn such skills is already at an early age.

Different digital and online environment allow children to learn first programming commands. In this project, we focus on developing an engaging game-like three-dimensional environment to attract in particular younger pupils to learn programming. The aim of this project is to create a 3D World with different tasks where users can freely and independently move around and explore the whole world. The tasks have different levels of difficulty. The leaner should have as much freedom in the world as possible and should be engaged to solve tasks to enhance their understanding of programming commands through structured and logical thinking. The world is designed for children; thus is necessary to make tasks playful and interesting. To realize the whole project Unity 3D is used.

The world is designed to support the following pedagogical features: first of all it is possible to program interactively; every line can be tested, there are no limitations of the learner´s creativity since there are many different ways to solve a task. There is no right or wrong solution. Another advantage is the interesting 3D world, this should be increase the passion of exploring. The world is designed as an engaging and interesting scenario with a fixed underlying Code-Execution-Engine, which can be reused in any 3D World. The learning person should have a feeling of playing a computer game instead of a learning program. It should generate a more fun and a more interesting learning process.

Keywords. Computer science education, virtual worlds, unity3d, immersive learning

Help me to catch all boxes.
Try to program me in a circle way to catch all boxes.
For sure, there is a new functionaly!! yippi.
You can loop with a while like
while(is this true)
{
 Move or/and Turn
}
Can you do that ?

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Distributed Pedagogical Virtual Machine (D-PVM)

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Abstract. This is a poster presentation to propose an extension for the pedagogical virtual machine (PVM) model to support informal learning between multiple learners in a mixed reality space. The proposal is to extend the PVM by including new layers and sub-layers that will support building artefacts from virtual and real components, simulating the mixed reality (MR) products, and structuring and planning informal learning activities.

Keywords. Pedagogical Virtual Machine, Augmented Reality, Mixed Reality, Informal Learning, Collaborative Learning.

3. Introduction

Novel technologies, such as mixed reality (MR) and augmented reality (AR) environments [1], have gained great consideration in education because they generate a new visualised environment where learners can collaborate and explore new practices. Collaborative learning between people in maker community has motivated us to connect learners through MR spaces in order to maximize their learning and building practices in increasingly creative ways. With respect to this, we have adopted the pedagogical virtual machine (PVM) model [2] because of its significant support of guiding student activities through a visualising AR interface in a learning environment [3]. However, the PVM model is developed to be used by an individual student and has many limitations in supporting informal collaborative learning and integrating between physical and virtual components. Thus, the model requires extension to support informal learning for multiple learners in the MR environment.

4. Related Work and Proposed Model

The PVM [2] is based on the Java virtual machine, and it makes use of various technologies and approaches, such as the Internet-of-thing, object oriented programming, embedded systems, and augmented reality to read and translate the hidden computational data from robotic boards with the purpose of supporting student tasks in a learning environment. The model, as shown in Figure 1, comprises four different layers: the data layer, aggregation layer, pedagogical layer, and user interface layer. Nevertheless, the PVM model has many limitations, for example, it is built to support formal learning activities for an individual student, while in this study the model needs to be extended to support informal learning between multi users to fit

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maker spaces. Another limitation of the PVM is that it does not support the combination of virtual and physical resources to assist learners to finish their building tasks without deferral if they have missing real components.

The distributed pedagogical virtual machine (D-PVM), as shown in Figure 2, is the extended model of the PVM, and each layer in the model will include the following:

- The data layer will be distributed to multiple learners who work together and have real or virtual objects of a product.
- The aggregation layer clusters and aggregates data from the distributed data layer below to make the information more suitable for the pedagogical layer.
- The simulation layer, a new layer, will view the entire picture of a MR product, which has real and virtual components, and then simulate running the product in the real environment using AR.
- The pedagogical layer will be extended to contain informal learning besides the formal learning by including two sub-layers. First, the learning community formation sub-layer will help to identify learners' tasks and plan the learning activities. Second, we will include the collaborative framework sub-layer to describe how the collaborative learning objectives can be arranged and structured. Third, the new sub-layer, the assessment sub-layer, will be introduced to assess the formal and informal learning with the intention of evaluating the achievement of the learning goals.
- In the user interface layer, the AR application will guide and assist learners in making decisions about the resources based on the relationship between components. Then, the system will generate 3D virtual objects and overlay them on the real components if there are missing ones.

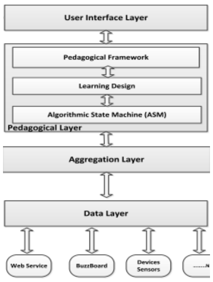

Figure 1. PVM Model.

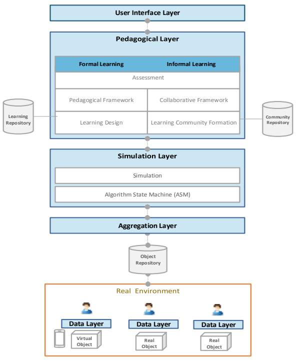

Figure 2. D-PVM Model.

5. Conclusion and Future Plan

Noticeably, this is a poster presentation for first year doctoral studies. The aim of this paper is to propose an extended PVM model by including new layers and sub-layers to support informal collaborative learning in MR spaces. Much research is still required to convert our proposed model to an implementation model, and we plan to present our work-in-progress in future publications.

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Publications of the Inaugural Immersive Learning Research Network Conference (iLRN 2015 Prague)

Full Papers

D. Preuveneers (Ed.): Workshop Proceedings of the 11th International Conference on Intelligent Environments. IOS Press, Volume 19.
ISBN: 978-1-61499-529-6 (print)
ISBN: 978-1-61499-530-2 (online)
http://www.iospress.nl/book/workshop-proceedings-of-the-11th-international-conference-on-intelligent-environments/

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ISBN (e-book) 978-3-85125-412-9
DOI 10.3217/978-3-85125-412-9