3rd European Immersive Education Summit

London, 28-29 November 2013

King's College London, UK

Editors:

Michael Gardner
Mary Webb
Vic Callaghan
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Preface from the editors

This is the proceeding of the 3rd European Immersive Education Summit. It was held at King's College, London on the 28th and 29th November 2013 and was organized in conjunction with the School of Computer Science and Electronic Engineering at the University of Essex.

This is the third Summit organized by the European Chapter of the Immersive Education Initiative and followed the tradition of many other summits mainly organized in Boston, MA, USA. These summits bring together academia and industry to provide the latest innovations around 3D virtual worlds for education.

The theme for the 3rd European Immersive Education (iED) Summit is:

Immersive Education: What does the future hold?

The aim of the 3rd European iED summit is to look into the future as we move into a phase of more widespread adoption for immersive education and start to see exciting new possibilities. The early euphoria over virtual worlds has since become more realistic as the community starts to explore the opportunities afforded by this technology. It has been recognized that the industry until very recently was in the 'disillusionment trough' phase of the classic *Gartner hype cycle* and is now moving towards the 'enlightenment slope' with the promise of greater levels of usage and productivity. This status is also reflected by the *Rogers Innovation Adoption Curve*, as we move from purely engaging with 'early adopters' through to acceptance by the wider 'early majority' and the promise of more widespread adoption. This summit reflects on some of the recent changes in the technology and looks at examples of research and best practice from the wider community. It also explores what is actually meant by Immersive Education, and the opportunities and realities afforded by this exciting new technology.

To put together this programme an international committee was created with many experts from all around the world. Following the call for papers, forty submissions were received, which were reviewed by three reviewers on quality and appropriateness. The best papers from the summit will also be selected for publication in a forthcoming special issue of the Journal of Universal Computer Science (JUCS). The Easychair system was used for handling the organization of submitted papers. Apart from the paper presentations, the programme also includes poster presentations, speed-sharing papers and practical demos showing tools in action. Four keynotes represent a highlight in the program covering issues from the visual appearance of virtual avatars, how to capitalize on the competitive nature of gaming, how to better design augmented reality learning experiences, through to building the future for immersive education by looking at what it will be like in the year 2020. Finally, a panel session with representatives from academia and industry discusses the future of immersive education technologies. All these activities combine together to provide a varied and thought-provoking programme.

Also, new for this year, the summit combined with the Creative Science Foundation (CSF) to organize a separate workshop on predicting the future for immersive education. This workshop explores the use of science fiction as a means to motivate and direct research into new technologies for education (with a special emphasis on immersive reality technologies).

As editors of these proceedings and main organizers of the summit, we would like to thank the international Programme Committee members for doing an excellent job reviewing the papers, the local Organizing Committee for handling all the organizational issues that make a difference in the end, King's College London for providing an excellent location and infrastructure, and last but by no means least, the Immersive Education Initiative and in particular it's European Chapter for providing the support and encouragement to organize this event.

London, November 2013

Michael Gardner, Mary Webb, Vic Callaghan and Carlos Delgado Kloos (Editors)

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Keynotes

iED Europe Summit 2013 KEYNOTE: Prof. Mel Slater, ICREA, University of Barcelona & University College London

"Gaining New Experience by Self-Transformation in Immersive Virtual Reality"

Mel Slater (melslater@ub.edu) is an ICREA Research Professor at the University of Barcelona. He became Professor of Virtual Environments at University College London in 1997. He was a UK EPSRC Senior Research Fellow from 1999 to 2004, and has received substantial funding for virtual reality installations in both London and Barcelona. Twenty nine of his PhD students have obtained their PhDs since 1989. In 2005 he was awarded the Virtual Reality Career Award by IEEE Virtual Reality 'In Recognition of Seminal Achievements in Engineering Virtual Reality.' He leads the eventLab (www.event-lab.org) at UB. He is Coordinator of the EU 7th Framework Integrated Project VERE (www.vereproject.org), and scientific leader of the Integrated Project BEAMING (www.beaming-eu.org). He holds a European Research Council grant TRAVERSE (www.traverserc.org) on the specific topic virtual embodiment, and the general topic of a new area of application of virtual reality based on this theme.

Using immersive virtual reality it is possible to generate the strong illusion in people that their body has changed. We introduce the concept of 'body semantics' that is, where the visual appearance of the virtual body suggests particular personal attributes - for example, due to stereotyping. In this talk I will describe some experiments that show that a body ownership illusion with respect a transformed virtual body leads to changes in attitudes and behaviours that are appropriate to the semantics of that body. We conclude that adoption of a body type experienced from first person perspective carries with it behavioural correlates, that could be exploited in a number of applications perhaps making it easier to gain new experiences for facilitating learning. Moreover, virtual reality, typically used for the illusion of transfer to another place - the place depicted by the virtual reality displays - can be harnessed also to generate the illusion of being another ‘self’, with behavioural, attitudinal and possibly cognitive changes as a result.

iED Europe Summit 2013 KEYNOTE: Dr. Sylvester Arnab, Serious Games Institute, Coventry University

"How can we encourage the uptake of serious games within a formal setting? From a researcher's point of view"

Dr. Sylvester Arnab is a Senior Researcher at the Serious Games Institute, UK. He holds a PhD in Engineering from the University of Warwick, UK and his research interest is in the use of interactive and games technology in various domains. He is a founding member of the Serious Games Society (seriousgamessociety.org) and he is currently coordinating the R&D work package, leading delivery and acting as SGI representative at all partner and management meetings for the €5.65m Games and Learning Alliance (GALA – galanoe.eu)- a network of 31 partners. He has negotiated and/or project managed various development projects, such as the development of the £70K PR:EPARe game. Sylvester is a member of the steering group for Health 2.0 Birmingham (part of the Health 2.0 initiative) and Games for Health UK (SGI being the satellite hub for Games for Health). He has various publications within the area of virtual worlds, simulation and games, and he has edited a book: Serious Games for Healthcare- Applications and Implications.

The use of games as an educational tool capitalises on the engaging factor and the competitive nature of gaming. Even though there are existing studies suggesting that the use of games is more effective than traditional methods, the uptake of games in formal education is still restricted by the lack of comprehensive studies of efficacy. A multidisciplinary approach is essential to the success of serious games development and deployment. Not only should learners and teachers/instructors be included in the conceptual stage of serious games development, the consideration of validation measures as well as the deployment strategy should also be part of the design process. With the perspective of a pedagogy-driven approach, the use of 4-Dimensional Framework of Learning and a Game-based Learning Framework will be included in the talk. This talk will also include findings from the EU Funded Games and Learning Alliance – a network of excellence in Serious Games.

iED Europe Summit 2013 KEYNOTE: Dr. Jennifer B. Elliott - Senior Cognitive Research Scientist and Consultant at TiER1Performance Solutions (USA)

"Analog Thinking: Digital Times - Making pedagogical use of augmented reality affordances"

Dr. Jennifer B. Elliott holds a Ph.D. in Education from the University of Virginia, USA. She is a Senior Cognitive Research Scientist and Consultant at TiER1Performance Solutions, and former professor of instructional design and technology. She is the company lead for immersive learning environments and game design, integrating emerging technologies, learning sciences and instructional design for use in government and commercial markets.

With a background in neuropsychology, visual design, education and instructional technology, Dr. Elliott's passion is designing, developing, and studying immersive learning environments that harness the unique affordances of cutting edge technologies, while being grounded in sound cognitive and pedagogical design. Dr. Elliott's research has focused on learning within immersive participatory games and simulations. Most recently, she has worked on projects that include game development and research in neuroplasticity and foreign language learning, empathy development for pharmaceutical representatives, and professional development for economics educators. She has designed and taught courses in Game Design, Innovative Inquiry, STEM Education, Educational Technology, Social, Legal & Ethical Issues in Educational Technology, and Museums in Education.

This keynote presentation will focus on recent augmented reality applications in education and evaluate the underlying learning and pedagogical design,

assessing the extent to which these applications take advantage of distinguishing features and affordances of augmented reality. The function and purpose of the technology is examined and evaluated using a framework, developed by the author, that analyses the level of learning that is achieved (if any) through the use of the augmented reality. The purpose and function of the technology is described across levels from basic utility, content delivery, and assessment, to experience.

Keywords. Augmented reality, pedagogy, immersive learning, visualization, abstract concepts

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iED Europe Summit 2013 KEYNOTE: Mr. Brian David Johnson, Intel Corporation

"How to build the future?"

The future is Brian David Johnson's business. As a futurist at Intel Corporation, his charter is to develop an actionable 10 -15 year vision for the future of technology. His work is called "futurecasting"-using ethnographic field studies, technology research, trend data, and even science fiction to provide Intel with a pragmatic vision of consumers and computing. Along with reinventing TV, Johnson has been pioneering development in artificial intelligence, robotics, and using science fiction as a design tool. He speaks and writes extensively about future technologies in articles (The Wall Street Journal, Slate, IEEE Computer) and both science fiction and fact books (Vintage Tomorrows, Science Fiction Prototyping: Designing the Future with Science Fiction, Screen Future: The Future of Entertainment Computing and the Devices we Love, and Fake Plastic Love). Johnson lectures around the world and teaches as a professor at The University of Washington and The California College of the Arts MBA program. He appears regularly on Bloomberg TV, PBS, FOX News, and the Discovery Channel and has been featured in Scientific American, The Technology Review, Forbes, INC, and Popular Science. He has directed two feature films and is an illustrator and commissioned painter.

What kind of future do you want to live in? What futures should we avoid? What will it feel like to be a human in the year 2020 and beyond? Intel's Futurist Brian David Johnson explores his futurecasting work; using social science, technical research, statistical data and even science fiction to create pragmatic models for a future that we can start building today. In the next decade it will be possible to turn anything into a computer and participate in truly immersive education experiences. We will be living in a world where we are surrounded by computational intelligence. Join Johnson as he explores what that means for the future and how can we envision our tomorrows so that we can start building them today. It is possible to change the future and it's simpler than you might think.

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Demo Title: A Customisable Real-time Video and Audio Streaming Approach to Creating an Immersive Collaborative Distant Learning Environment.

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Overview. The intention of this demonstration is to present a novel immersive telepresence system that enables remote students to participate in seminars and lectures using online streaming video and audio connections. In this system, a virtualized video view is created using a 360° panoramic video projected onto a 180° curved projected screen (immersive shell). This recreates a more natural human-like perception of real environments and thereby stimulating the learning process. 3D audio is also collected and reproduced at the remote location adding to the realism. To accomplish this we us a 360° mirror situated in the classroom which we use with a camera to transmit a panoramic image to the remote users where they reconstruct the original image from spherical to Cartesian. To process the audio we use a small array of microphones at the classroom end. In addition, we provide various tools to allow the participants to control their position within the virtualized views, thereby creating an innovative technology and user experience. We will be demonstrating this system at the conference.

Keywords. Immersive Reality, Immersive Shell, Immersive Panoramic Audio and Video.

Introduction

Our aim is to present an immersive system within a learning environment which allows remote students to participate, either in synchronous (real-time) or asynchronous (video-on-demand) sessions. We will show that such a fully immersive video and audio experience is no longer a dream for the future, but is currently possible. This is a demonstration compliments a technical paper submitted to the same conference (iED Europe Summit London 2013) [2].

We are using an immersive shell manufactured by Immersive Displays Ltd which utilizes a semi-spherical 180° projection screen where the image presented is a partial view of a 360° panoramic video that is controlled by the end user. The image is transmitted through the internet by a Media Server with Real Time Messaging Protocol (RTMP) and reconstructed by the end user's browser where the view can be controlled either by a variety of HCI schemes such as ‘drag or drop’ (mouse/keyboard) or by a ‘head tracker’ or ‘ mouse camera’ scheme.

1. Demonstration set up

Our demo will present 2 concurrent scenarios:

1.1. Seminar room at a host location

Scenario 1 depicts a local scene where a seminar event is taking place with local students.

A spherical mirror is mounted on a tripod, with a webcam above the mirror which streams real-time video into a Media Server, which broadcasts it to the multiple connected clients.

The spherical mirror is located somewhere in the middle of the room between the attendees in order to simulate a seated student. The mirror can be adjusted to differing heights representing someone standing or seated. In this way, remote individuals can emulate being local subjects.

1.2. Student at a remote location

Scenario 2 illustrates the remote location where the distant student is located. The remote location consists of an immersive display shell together with an integrated projection and audio facility.

In this scenario the distant seminar room video (from scenario 1) is projected onto the semi-spherical 180° screen which the student stands or sits in front of. A wireless keyboard/mouse is used to control the system (or if we have one, we may use a head tracker to control the panoramic video view). Audio is presented using a Hypersonic audio system to provide a directional binaural experience. A headphone will also be available.

Users of the system will be able to ‘drag and drop’ the panoramic video in order to simulate moving freely around the 360° video scene streamed from the distant seminar room. As the user rotates through 360°, the binaural audio will follow the video to intensify the feeling of “being there”, not only visually but in an auditory sense too This will provide a selective directional audio approach which we have presented at another conference earlier this year [1].

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1.3. Live event streaming and VOD future work

The demonstration will show the system being used in a real time streaming mode but it could easily be adapted to a VOD system as the entire session could be recorded for a later access without losing any of the information either visually, with the panoramic facility or auditory, with the binaural experience.

2. Framework elements

This novel system makes use of the following third-part components:

- Media Server with RTMP, such as *Flash Media Server®* or *Red5®*, as a method of streaming from the lecturer to the student
- Immersive shell *ImmersaVue®* manufactured by Immersive Displays UK where the 180° image is projected
- Spherical mirror with an arm mounted HD Webcam for collecting the polar image
- *HHS Hypersonic®* loudspeaker system to provide the directional audio.

References

[1] A. Torrejon, V. Callaghan, H. Hagras. *"Selectable Directional Audio for Multiple Telepresence in Immersive Intelligent Environments"*, IE'13 - 9th International Conference on Intelligent Environment, 18-19 July 2013, Athens, Greece.

[2] A. Torrejon, V. Callaghan, H. Hagras. *"Immersive Audio and Video towards the Immersive Learning experience"*, Unpublished paper presented at iED Europe Summit 2013, 28-29th November 2013, London, UK.

Link and Learn™: The Learning Network

Dale Bradley[a], Robert Dragan[a], Toby Hughes[a] and Arun Wilson[a,1]
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Abstract. Link and Learn™ is a real-time, cloud-based social learning platform that enriches the interaction between students, educators and content. By uniquely combining elements of learning management systems with those of social networking sites and significantly improving communication and feedback mechanisms, Link and Learn™ enhances both the learning and teaching experience. Link and Learn™ simply enables academic institutions to both augment traditional teaching methods and deliver courses online with greater efficiency, at lower costs and with more effective outcomes.

Keywords. Learning, communication, social, platform, network

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UNITE: Collaborative Learning in a 3D Virtual World

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Abstract. This study found that the use of a 3D virtual world improved students' self-efficacy beliefs in relation to a number of activities undertaken as part of collaborative team-based projects. This paper describes a quantitative study of 80 university students enrolled in the Computer Games Design module at the University of the West of Scotland. The results indicate some significant improvements between students' pre-test and post-test self-efficacy ratings, with a medium effect size. The study forms the first tranche of a larger project which is currently being substantially extended to incorporate students from other institutions, education sectors and cognate areas.

Keywords. virtual worlds, Open Wonderland, virtual learning community, collaborative learning

Introduction

This paper describes the first tranche of the substantive empirical phase of a study that aims to implement and evaluate the use of a 3D virtual world for communication and collaboration by tertiary education students undertaking team-based project work.

The first phase of the study was a large-scale survey of university students [1], which suggested that participants in virtual world activities use online collaboration and communication as part of an informal learning process to increase mastery. This was followed by a pilot implementation of the UNITE virtual world on which this current paper is based [2]. Based on the successful conclusion of the pilot implementation, work has started on the final substantive empirical phase.

1. Virtual Worlds

The term "virtual world" is used by authors to mean different things. There is no broadly agreed definition of the term [3]. For example, the terms Massively Multiplayer Online Role-Playing Game (MMORPG), Collaborative Virtual Environment, virtual space, Multi-User Virtual Environment, metaverse and others have been used to describe virtual worlds. There are opposing views in the literature regarding a supposed ontological distinction between "games" and "virtual worlds". One paper [4] describes Second Life explicitly as an MMORPG, while another [5] states that *"Second Life is not a game"*. This study uses the Bainbridge [6] definition of virtual world, *viz. "an electronic environment that visually mimics complex physical spaces, where people can interact with each other and with virtual objects, and where people are represented by animated characters."* Specifically, this study relates only to three-dimensional (3D) virtual worlds.

For newcomers, gaining entry to and achieving success in these complex and challenging environments is dependent upon learning from and co-operating with others. This mirrors activity in communities of practice in the physical world, in which effective learning also has an essential social dimension [7, 8, 9, 10, 11]. It has been suggested that processes and philosophies in virtual worlds present interesting analogies to modern pedagogical thinking around communities of practice [12, 13].

Continuous interaction amongst members of a community of practice is essential if members are to deepen knowledge and gain further expertise [14, 15, 16]. There is a growing body of research relating to learning and instruction which suggests that the highly social and collaborative nature of the communities in virtual worlds makes them eminently suitable environments for cooperative learning, and that there is potential benefit to be gained by further investigation of the learning attributes of those communities [17, 18, 19, 20, 21, 22, 23, 24].

It has been suggested that further work should be undertaken in examining how learning takes place in informal virtual contexts, and whether positive attributes of this successful informal learning can be translated into formal learning environments [12, 25, 26, 27].

The importance of effective team working has been recognised by organisations and by researchers [28, 29, 30]. It has been suggested that the communication and collaboration that are essential for effective team working are optimised when participants are present in the same place at the same time [31, 32]. However, it has also been suggested that the features of virtual worlds offer a rich range of possibilities for virtual team collaboration and experiential learning [33, 34]. The ubiquities of virtual teams, and their effectiveness as a critical success factor for their parent organisations, are described in [35].

Although virtual worlds have existed for some time, and researchers have been actively investigating their educational potential, one of the primary problems associated with learning in virtual worlds is the dearth of strong empirical evidence to support the claims that have been made in the literature, and a need for greater understanding of the contexts and conditions upon which positive outcomes depend [36, 37, 38, 39].

The empirical work that has been done has tended to concentrate on the replication of physical world learning transposed to a virtual world. Teaching methods have largely been didactic and transmissive, rather than investigating the potential that virtual worlds offer for in-world student-to-student communication and collaboration [40].

2. Perceived Self-efficacy

Self-efficacy beliefs are defined as *''people's judgment of their capabilities to organise and execute courses of action required to attain designated types of performances''* [41, p31]. It is a form of self-evaluation that influences decisions individuals make, efforts they exert, and the mastery of behaviour [42]. This theory proposes that a student who believes he/she can successfully perform an activity is likely to exert more effort, spend more time, and master the required skills earlier than one who does not. Self-efficacy beliefs in a specific domain are positively linked with academic achievement in that domain [43].

3. Research Design

The virtual world used in this study was created using Open Wonderland http://openwonderland.org, an open source toolkit for building 3D virtual worlds [44]. A detailed description of the virtual world is given in [2]. A quasi-experimental research design using pre-test and post-test surveys was adopted. Online questionnaires were designed and administered using SurveyMonkey https://www.surveymonkey.com. The design of the questionnaires was based on the principles described by Bandura [45]. Access to the questionnaires was restricted by using the student's unique matriculation number to ensure that each respondent completed each survey once only.

3.1. Participants

University of the West of Scotland (UWS) students undertaking the module Computer Games Design (CGD) were invited to participate in this study. This module is in the second year of a Scottish four-year Honours degree programme. It was selected because its pedagogic foundations require collaborative team-based research, planning and creation of both written and practical courseworks. The module is delivered on three of the University's four geographically separate campuses: Ayr, Hamilton and Paisley using a blend of face-to-face and online learning materials. UWS makes extensive use of the Moodle virtual learning environment (VLE). The student cohort for CGD is made up of students from two undergraduate degree programmes: BSc (Hons) Computer Games Technology and BSc (Hons) Computer Games Development. The total number of enrolled students was 102. Of these, 80 completed the pre-test survey instrument during week 1 of the module delivery, and 63 completed the post-test survey instrument during week 12 of the module delivery. The survey results were imported into SPSS for data cleaning and analysis. After data cleaning, complete matching pre-test and post-test entries had been created for 61 participants.

3.2. Pre-test Survey

Participants were asked to provide their unique matriculation number, then the following demographic data: University campus (Ayr, Hamilton or Paisley); gender; age and full-time or part-time study.

3.2.1. Survey Themes

Prior experience of virtual worlds - Respondents were asked to indicate if they had prior experience of Massively Multiplayer Online Games (MMOG) or of social virtual worlds like Second Life. If they responded that they had, they were asked to indicate how many hours per week, on average, they spend in either activity using the following time bands: 0-1; 1-5; 6-10; 11-15; 16-25 and more than 25.

Can a 3D virtual world help student collaboration? – Respondents were asked to indicate on the following scale the extent to which they agree that having access to a 3D virtual world could help them to collaborate with other students working on a team-based University project: Strongly Disagree; Disagree; Agree; Strongly Agree and

Don't Know/No Opinion. They were also given the opportunity to add an optional freeform comment at this point.

Perceived Self-Efficacy – Respondents were asked to rate how certain they were that they could successfully carry out a range of activities by recording a number from 0 to 100 where: 0=Cannot do at all; 50=Moderately can do and 100=Highly certain can do. The activities listed were: Use a computer; Use an online virtual world or MMOG; Work well in a group; Contribute to discussion in a group; Take an active part in group problem solving; Participate in planning group activities; Contribute ideas for consideration by the group; Comment on ideas from other group me members and Make a presentation to a group.

3.3. Post-test Survey

Participants were asked to provide their unique matriculation number, which allowed matching with the corresponding pre-test responses for that participant.

3.3.1. Survey Themes

Use of the UNITE virtual world - Respondents were asked to indicate if they had made use of the 3D virtual world provided as part of this research.

Did the UNITE 3D virtual world help collaboration? – Respondents who answered that they had used the UNITE virtual world were asked to indicate on the following scale the extent to which they agreed that having access to the UNITE 3D virtual world had helped them to collaborate with other students working on their team-based University project: Strongly Disagree; Disagree; Agree; Strongly Agree and Don't Know/No Opinion. They were also given the opportunity to add an optional freeform comment at this point.

Perceived Self-Efficacy – Respondents were asked to rate how certain they were that they could successfully carry out a range of activities by recording a number from 0 to 100 where: 0=Cannot do at all; 50=Moderately can do and 100=Highly certain can do. The activities listed were: Use a computer; Use an online virtual world or MMOG; Work well in a group; Contribute to discussion in a group; Take an active part in group problem solving; Participate in planning group activities; Contribute ideas for consideration by the group; Comment on ideas from other group members and Make a presentation to a group.

4. Results

4.1. Pre-test

Of the 80 participants who completed the pre-test survey, 68.8% (n=55) were located at the Paisley campus, 18.8% (n=15) were located at the Hamilton campus and 12.5% (n=10) were located at the Ayr campus. 90% (n=72) were male and 10% (n=8) were female. The mean age of respondents was 20.81 (SD=3.21), with a range between 17 and 34. All respondents were full-time students.

90% (n=72) indicated that they had prior experience of MMOG or of virtual worlds. In order to calculate the mean time spent in these activities the time bands used as responses were recoded with their mean value (e.g. 1-5 hours was recoded as 3). 0-1 was recoded as 1 and more than 25 was recoded as 25. Considering only those respondents with prior experience of MMOG (n=54), the mean time spent on MMOG activity per week is 9.89 hours (SD=7.63). A breakdown of these figures is shown in table 1 below.

Table 1. Hours per week spent on MMOG activity

Code	Frequency	Percent	Valid Percent	Cumulative Percent
1	8	14.8	14.8	14.8
3	11	20.4	20.4	35.2
8	14	25.9	25.9	61.1
13	9	16.7	16.7	77.8
21	9	16.7	16.7	94.4
25	3	5.6	5.6	100
Total	54	100	100	

Considering only those respondents with prior experience of virtual worlds (n=18), the mean time spent on virtual world activity per week is 4.11 hours (SD=5.36). A breakdown of these figures is shown in table 2 below.

Table 2. Hours per week spent on virtual world activity

Code	Frequency	Percent	Valid Percent	Cumulative Percent
1	9	50	50	50
3	5	27.8	27.8	77.8
8	2	11.1	11.1	88.9
13	1	5.6	5.6	94.4
21	1	5.6	5.6	100
Total	18	100	100	

Inclusive of all respondents, 67.5% (n=68) agreed or strongly agreed that having access to a 3D virtual world could help them to collaborate with other students working on a team-based University project. 3.8% (n=3) disagreed or strongly disagreed. 11.3% (n=9) did not know or had no opinion. A detailed breakdown of the responses is shown in table 3 below.

Table 3. Agreement on whether access to a 3D virtual world could help collaboration

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly agree	14	17.5	17.5	17.5
agree	54	67.5	67.5	85.0
don't know/no opinion	9	11.3	11.3	96.3
disagree	2	2.5	2.5	98.8
strongly disagree	1	1.3	1.3	100.0
Total	80	100.0	100.0	

15% of respondents (n=12) opted to make freeform comments as part of their response to this question. No thematic or other formal analysis of this qualitative data has been undertaken. The comments are shown *verbatim* below:

- It could help but seems mostly unncessary.
- Slightly. Seems like a bit of a hassle to set up just to communicate, when its much easier just to text or facebook.
- I believe it's a good option to have in general. But I prefer meeting in person when possible as when on-line I feel to procrastinate more and work speed isn't as efficient. But on occasion I have found it very helpful when meeting in person isn't an option for whatever reason.
- I agree that this could really help however only if everyone on the team feels comfortable with it
- I believe this is a good idea however from the software I have seen I think there are slight improvements that could be made to make it into more of a professional tool as opposed to a game-like program.
- It would make things easier for people who arent very good at talking in person to be able to talk through a virtual character and allow them to feel better about it
- I belive this will make it alot easier to meet new people
- It would be easier than travelling.
- It would depend on the willingness of the other students to use the 3D virtual world to collaborate.
- I struggle to how it can be a useful tool, its seems unnessesary to me to have a virtual world, with virual furniature over other more tradional video conferencing methods.
- I have never used a 3D virtual world for studying but I can definitely see the benefits of it, and will be using it extensively for this module.
- Options such as Google hangouts seem to be better for group work.

The tasks for which respondents indicated they had the highest perceived self-efficacy were “Use a computer” (Mean =96.86 SD=6.021) and “Use a virtual world or MMOG” (Mean=86.01 SD=18.803). The tasks for which respondents indicated they had the lowest perceived self-efficacy were “Make a presentation to a group” (Mean =68.9 SD=23.498) and “Participate in planning group activities” (Mean=78.71 SD=14.612). A detailed breakdown of these responses is shown in table 4 below.

Table 4. Breakdown of perceived self-efficacy ratings

Task	Minimum	Maximum	Mean	Std. Deviation
Use a computer	75	100	96.86	6.021
Use an online virtual world or MMOG	15	100	86.01	18.803
Work well in a group	30	100	80.88	14.791
Contribute to discussion in a group	30	100	81.19	14.213
Take an active part in group problem solving	45	100	83.59	14.024
Participate in planning group activities	20	100	78.71	14.612
Contribute ideas for consideration by the group	30	100	83.50	15.095
Comment on ideas from other group me member	30	100	82.61	16.297
Make a presentation to a group	10	100	68.90	23.498

4.2. Post-test

Following data cleaning and matching, 61 participants had fully completed both the pre-test and post-test surveys. 68.9% (n=42) were located at the Paisley campus, 14.8% (n=10) were located at the Hamilton campus and 15.0% (n=9) were located at the Ayr campus. 93.4% (n=57) were male and 6.6% (n=4) were female. The mean age of respondents was 21.11 (SD=3.30), with a range between 18 and 34. All respondents were full-time students. 80.3% (n=49) used the UNITE virtual world and 19.7% (n=12) did not.

Considering only those respondents who used the UNITE virtual world, 85.7% (n=42) agreed or strongly agreed that having access to a 3D virtual world helped them to collaborate with other students working on a team-based University project. 4.1% (n=2) disagreed or strongly disagreed. 10.2% (n=5) did not know or had no opinion. A detailed breakdown of the responses is shown in table 5 below.

Table 5. Agreement on whether access to a 3D virtual world helped collaboration

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly agree	13	21.3	26.5	26.5
agree	29	47.5	59.2	85.7
don't know/no opinion	5	8.2	10.2	95.9
disagree	1	1.6	2.0	98.0
strongly disgaree	1	1.6	2.0	100.0
Total	49	80.3	100.0	

8.2% of respondents (n=4) opted to make freeform comments as part of their response to this question. No thematic or other formal analysis of this qualitative data has been undertaken. The comments are shown *verbatim* below:

- I think it has strong potential, more geared for bigger groups (at least 4+ members) my group was a group of 2, so much of the sharing was only two way and because of this we unfortunately found using a virtual world platform became time consuming for only a small group.
- I do think that it helps although it does depend on the members of the group as some are unwilling to use it.
- Other team members had problems at home with Open Wonderland but I personally found it ran fine for me and enjoyed using it
- Didn't actually use it for project. Just messed around with it. We found it much better too meet in person and as a result rarely used it

4.3. Comparison of pre-test and post-test

The difference in mean scores between the pre-test question "Do you think that having access to a 3D virtual world can help you to collaborate with other students working on a team-based University project?" and the post-test question "Do you think that having access to a 3D virtual world helped you to collaborate with other students working on a team-based University project?" was examined using a paired *t*-test procedure. There was a decrease from pre-test (M=2.02, SD=.803) to post-test (M=1.94, SD=.801) which was not statistically significant ($t(48)$=.573, p=.569).

Differences in mean scores for self-efficacy between the pre-test and post-test surveys were examined using a paired *t*-test procedure. The results are shown in table 6 below.

Table 6. Effect of UNITE virtual world use on self-efficacy – paired samples test

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
(a) Used UNITE virtual world						
Use a computer	-0.980	4.706	.672	-1.457	48	.152
Use an online virtual world or MMOG	-2.551	11.093	1.585	-1.610	48	.114
Work well in a group	-5.429	15.868	2.267	-2.395	48	.021
Contribute to discussion in a group	-5.939	17.846	2.549	-2.329	48	.024
Take an active part in group problem solving	-2.816	18.149	2.593	-1.086	48	.283
Participate in planning group activities	-7.694	17.052	2.436	-3.158	48	.003
Contribute ideas for consideration by the group	-5.102	19.019	2.717	-1.878	48	.066
Comment on ideas from other group members	-3.959	15.298	2.185	-1.812	48	.076
Make a presentation to a group	-12.449	26.051	3.722	-3.345	48	.002
(b) Did not use UNITE virtual world						
Use a computer	-.333	11.965	3.454	-.097	11	.925
Use an online virtual world or MMOG	-2.250	22.499	6.495	-.346	11	.736
Work well in a group	-6.750	16.934	4.888	-1.381	11	.195
Contribute to discussion in a group	-7.333	19.542	5.641	-1.300	11	.220
Take an active part in group problem solving	-4.750	14.046	4.055	-1.171	11	.266
Participate in planning group activities	2.417	30.183	8.713	.277	11	.787
Contribute ideas for consideration by the group	-4.667	11.742	3.390	-1.377	11	.196
Comment on ideas from other group members	-5.750	9.855	2.845	-2.021	11	.068
Make a presentation to a group	-10.667	17.629	5.089	-2.096	11	.060

For the respondents who did not use the UNITE virtual world, there were no statistically significant ($p<.05$) differences between pre-test and post-test scores for any of the activities used for assessing self-efficacy. For the respondents who did use the UNITE virtual world there were statistically significant differences ($p<.05$) between pre-test and post-test scores for "Work well in a group", "Contribute to discussion in a group", "Participate in planning group activities" and" Make a presentation to a group". Table 7 shows descriptive statistics and the r statistic for the four activities. The r statistic indicates a medium effect size for all four activities.

Table 7. Descriptive statistics and effect size

Activity	M pre-test	SD pre-test	M post-test	SD post-test	r
Work well in a group	79.67	12.504	85.10	14.234	0.33
Contribute to discussion in a group	79.16	14.513	85.10	14.160	0.32
Participate in planning group activities	76.27	15.205	83.96	15.797	0.41
Make a presentation to a group	65.27	23.356	77.71	19.042	0.43

5. Discussion and Conclusions

The responses to the pre-test survey indicate that 90% of respondents had prior experience of virtual worlds or MMOG. This is in keeping with the findings reported in [1]. On average, more time per week is spent on MMOG activities (9.89 hours) than on virtual world activities (4.11 hours). The pre-test survey indicated that 67.5% of respondents considered that a virtual world could help them to collaborate with other students working on a team-based University project. Of the pre-test respondents, 80.3% made use of the UNITE virtual world. Of these, 85.7% considered that the UNITE virtual world had helped them to collaborate with other students working on a team-based University project. Comparison of pre-test to post-test responses in relation to whether a virtual world could or did help team-based collaboration showed a slight decrease which is not statistically significant.

For respondents who did not use the UNITE virtual world almost all tasks showed an increase in self-efficacy ratings between pre-test and post-test. One activity showed a decrease. None of the differences are statistically significant.

For respondents who used the UNITE virtual world, all activities showed an increase between pre-test and post-test. Of these, four were statistically significant: "Work well in a group", "Contribute to discussion in a group", "Participate in planning group activities" and" Make a presentation to a group". The *r* statistic indicates a medium effect size for all four activities.

These results suggest that using a 3D virtual world can improve students' self-efficacy beliefs in relation to a number of activities undertaken as part of collaborative team-based projects. The larger project, of which this study forms a part, is currently being extended to incorporate students from other institutions, education sectors and cognate areas. It is intended that the inclusion of cognate areas other than Computing will help to address the lack of gender balance that is evident in this study.

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Integrating a Facebook Group with the Open Wonderland Environment

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Abstract. Although broad research has been done on virtual learning environments and the role of communities in social networks, few studies exist which sufficiently support the relationship between these two domains. In this paper, the authors demonstrate the effectiveness of integrating these two environments by creating a novel prototype and conducting a preliminary pilot evaluation session. For the prototype system, a Facebook Group was utilised as a repository for learning content and the Open Wonderland platform was selected as a mixed reality intelligent environment for 3D virtual collaborative activities. Finally, this prototype was evaluated by means of a two-hour task-based assessment and user-satisfaction questionnaire.

Keywords. Social Networks; 3D Virtual Collaborative learning Environment; HCI

Introduction

Nowadays, Web 2.0 applications are part of many people's lives. Online Social Networks for communication purposes such as Facebook, Twitter and Google+ are well-known examples of Web 2.0 technology. At the center of Web 2.0 technology is the *Interactions*. E-learning 2.0 is derived from the combination of Web 2.0, legacy learning system and human factors [1]. Stephen Downes was apparently the first to use the term e-learning 2.0 [2]. Therefore, one of the most significant discussions in learning systems involves the design of a web-based collaborative learning environment to support learners' needs. Many kinds of these systems have been implemented and assessed by users in terms of usability and effectiveness. In this paper, the authors aim to propose a model of collaborative learning system to support both aspects of knowledge transfer. The proposed model is composed of a 3D collaborative learning environment and a Social Network.

The primary goal of this study is to evaluate the features and effectiveness of a Social Networking community within a 3D collaborative learning environment to discover the role of community-based activities in the learning process. The remainder of this paper is organised as follows. Section 1 will present a literature review. Section 2 will suggest a hypothesis and a methodology based on the gap in the existing literatures. Section 3 will briefly outline the requirements and design decisions of the prototype. Section 4 will describe the evaluation steps. The final Section will offer the conclusion and suggestions for future work.

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1. Literature Study

1.1. 3D Collaborative Learning Environment

On the one hand is a 3D collaborative learning environment which has been widely investigated by the researchers. A 3D collaborative learning environment is generally known as an intelligent game-based environment with academic goals. Dafoulas stated that students who play video games can navigate in most virtual environments [3]. The Federation of American Scientists argued that some skills can be gained through the gaming environment [4]. For instance, there are many games that require strategic thinking as well as problem solving abilities, or maybe they need convincing interpretative analysis. Liarokapis et al. suggested a game-based learning model for e-learning systems, however, they proposed a classroom-based learning system which was dependent upon the video games [5]. Bronack et al. criticised the model that Liarokapis et al. had suggested from their findings [6]. They believed that the 3D virtual learning environment is not comparable to the traditional class-based learning system because it can make more opportunities for learners to explore the virtual world and likewise allows them to choose their own path through the 3D space.

Since collaborative virtual learning systems strongly support user interaction, the idea of using this method as an experiential learning environment was offered by Jarmon et al. in [7]. In his study, Second Life was considered as an instance of a virtual learning environment. Bedford et al. suggested Second Life as a virtual learning platform in which real-time interaction is possible and they identified three groups based on real-time interaction: experiential activities, project-based activities and community-based activities [8].

In summary, the 3D collaborative learning environment with its special features such as voice chat and avatar can be a good choice for the learning system since it provides some opportunities for interaction among its users.

1.2. Role of Social Networks in Education

On the other hand is Social Networking, which is known as one of the most important applications of Web 2.0. In recent years, there has been an increasing interest in this field and a considerable amount of literature has been published on this subject. Liccardi et al defined Social Networks as a social construction of nodes which have isolated and organizational characteristics and there are some relationships among them in the specified domain [9]. A Social Network Service is an online community which specifically represents the structure of nodes and their connections [10]. Throughout this paper, the term Social Network will be used to refer to the Social Network Service.

So far, however there have been some discussions about the effect of Social Networking on students' lives, a few individual investigations have been found in the integration of a content-based community in a Social Network with a 3D collaborative learning environment. This paper seeks to address the gap between explicit and tacit knowledge in the 3D collaborative learning environment by introducing the abovementioned integrated system. Breslin described some functionalities of Social Networks such as: network of friends, profile, sending a private/public message, forums, managing events, writing a blog and sharing media [11] which are required to have a comprehensive learning system. Rodrigues et al. proposed a model for illustrating the interaction between a learning system and Social Network [12].

To summarise the discussion, it is concluded that Social Networks are applications for communication that can be used in the education system. A strong relationship between Social Networks and the Collaborative Learning Environment has been reported in the literature.

2. Research Approach

First, in reviewing the literature, a little investigation was found in the association between a social network and an intelligent virtual learning environment. However, a strong relationship between these two has been reported. Social Networks were defined as online platforms illustrating the relationship between their members introduced as one the most important applications of the Web 2.0 technology.

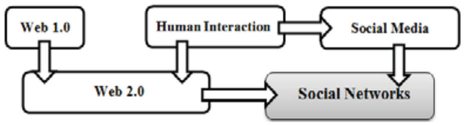

Figure 1. The Social Network's Factors

In the other side, Web 2.0 technology causes a huge improvement in learning systems. The second version of e-learning was introduced to consider the human factors as one of the most significant aspects of such systems. In addition, video games were presented as one of the most widely used tools for the students. Surprisingly, these kinds of tools were found to increase the rate of thinking among their users since they force the users to discover a certain solution to achieve their goals. Therefore, using the virtual environment as a learning system could have a number of attractive advantages including increased interaction among the users, which raises enthusiasm and motivation, and the provision of a more attractive environment for students and teachers alike.

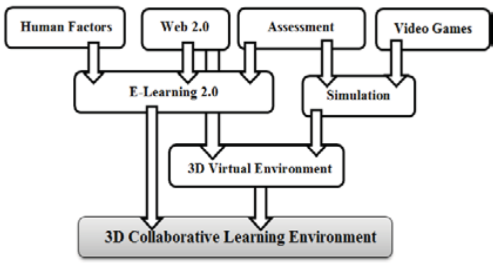

Figure 2. The 3D Collaborative Learning Environment's Factors

There are many common factors in the two figures above, such as Web 2.0 and human effects including human factors and human interaction. If the intermediate levels in figures 1 and 2 are ignored and these two diagrams are merged, the figure 4 can be arrived at.

Hence, it could conceivably be hypothesised that: The integration of a Social Network Group or Community into 3D Collaborative Learning Environment can better meet the learners' need for collaborative tasks such as discussions.

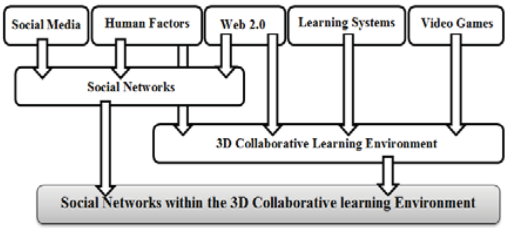

Figure 3. The Gap between Social Networks and 3D Collaborative Learning Environment

In this research, one of the variables is a Facebook group of students studying at the University of Essex and the instance of 3D collaborative environment is Open Wonderland. In addition, some evaluation methodologies employed to assess the effectiveness of the proposed system. The *usability evaluation* applied via a *user-satisfaction* questionnaire as well as *Think-Aloud protocol* and *Focus Group*.

3. Prototype

The proposed system has four major functionalities: (i) authenticate users based on their Facebook profile; (ii) retrieve data from a Facebook group to show in 3D environment, (iii) create a new discussion from 3D environment into a Facebook group; and (iv) add a new comment from 3D environment into a Facebook group.

The Open Wonderland platform is formed on the client-server architecture. From the high level view, it is possible to divide the wonderland platform into three layers. The *virtual world browser* concept, brings up in the highest level, connect to the different Wonderland servers and download the contents. The *rendering engine (MT Game)* is applied to this browser to add the multi-processing capability. Below the first level, server layer consists of many different services to make a specific world. Finally, the lowest level is mainly the connection between the client and darkstar server. It is made of the objects with the specific position in the world and some set of shared-properties which can be seen by all the users. This synchronisation is carried out by the *darkstar* messaging mechanism. For instance, avatars, buildings, mountains, chairs and all of the other objects are grouped in this level. In addition, a developed 2D application is used to generate an access token and create a new discussion or new comment. This application acts as a controller module between 3D environment and Facebook.

The new proposed Wonderland module has three main packages including: *Client*, *Server*, and *Common* package. Common package was required for the common classes between client and server. Furthermore, the current state of client and server was held in this package.

4. Evaluation

Usability evaluations of the proposed prototype conducted during a role-play session based on the *think-aloud* protocol. In this method, however users were not the actual clients of the system, they pretended to be and thought about their requirements. It is worth mentioning that all the volunteer users were MSc and PhD students at the Universities of Essex and Manchester who had previous experienced of a traditional learning environment. Furthermore, a *focus group* methodology applied to assess the effectiveness of discussion in the collaborative learning environment within a group of people in terms of explicit/tacit knowledge. This method helped the evaluator to gain better feedback from the users' perception of the proposed system. Finally, users filled in a five-point Likert scale questionnaire designed with regard to Jakob Nielsen's *Framework of System Acceptability* and Ben Shneiderman's *criteria* for usability of a digital system. The figure 3 captured during this trial session.

Figure 4. User Trial Session

It seems the experiment has confirmed that, learning outcomes are associated with rate of high-fidelity interaction among the participants in the 3D spaces. Therefore, each component in a learning environment which can help to increase this type of interactions may be suggested as a positive factor for such systems. For instance, since the *avatar* employed to express the users' emotions as well their reactions, it may be a beneficial element for the virtual worlds. Upon completion of the evaluation process, the statistical information from the questionnaire reviewed and analysed. In the following, some remarks from the results are collected.

- The low rating in technological infrastructure (high-speed connection, high graphic requirement …) was predictable.
- Before this session, all of the participants believed that Social Networks can distract students from concentrating on learning purposes. After the evaluation, surprisingly, 90% changed their mind and agreed with the potential of using a group of Social Networks for learning purposes.
- Astonishingly, an unexpected result occurred on the proposed system, where 70% believed that this system could be beneficial for learning systems. Just 10% of the participants strongly disagreed with using a virtual 3D environment for learning.

5. Conclusion and Future Works

This paper investigated the potential of using a Social Network group or community in developing a 3D virtual collaborative learning environment. The challenge was to find a novel innovative approach to support learners' requirements, such as accessibility for learning collaboratively. A 'group' within a Social Network was assigned as a research variable since its members usually have a common goal.

In this research a new Wonderland module was implemented to integrate the 3D environment to a Facebook group. The implemented module communicates with the Facebook Group via an Access Token which is used for privacy, authentication and authorisation purposes. To generate an Access Token, a new 2D Controller Application was developed. Moreover, this application was applied to create a new post or add a new comment from the 3D world to the Facebook Group.

The initial results of the questionnaire illustrated that the prototype was accepted among the trial-session users and it encouraged them to participate in the discussion and interact with other group members more effectively. Overall, returning to the hypothesis, it seems that using a Social Network Group or Community within a 3D virtual collaborative learning can improve the ability to meet learners' requirements for collaborative learning tasks. One implication of these findings is that both social group interaction and the concept of accessibility should be taken into account for a 3D collaborative learning environment.

Considerably more study is required in order to develop a comprehensive integrated module. For instance, one of the most attractive features for the learners can be recording the voice conversation among the students and saving it to the Facebook group as file content. The other important functional requirement can be checking the popularity of content. This functionality may be more important for teachers than learners. They can understand which content is more attractive for the learners and which content does not motivate them enough to initiate discussion.

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xReality objects Demonstration – Collaborative laboratory interactions in Immersive Reality

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Abstract. Laboratory activities for distance learners have been always a challenge for teachers and instructors. Many of the available options are limited to simulations in a Virtual Learning Environment (VLE). Our research focuses on a novel implementation for the aforementioned situation, using immersive technology and mixed reality. In this demonstration we will present the use of real objects coupled to its virtual representation (xReality objects) in order to create a collaborative mixed reality laboratory activity, complementing the paper, "*xReality interactions within an immersive mixed reality learning environment*" [1] submitted by the authors to EiED'13 summit .

Keywords. Ubiquitous virtual reality, mixed reality, dual reality, virtual laboratory, blended reality, xReality objects, interreality, human-machine interface (HMI), internet-of-things, tangible user interface (TUI), Multi-user virtual environment (MUVE).

Introduction

Nowadays, the internet has opened a door to innovation in distance learning, giving more opportunities for geographically disseminated students in an - everyday more - globalised world. Massive Open Online Courses (MOOCs), Multi-User Virtual Environments (MUVEs), Learning Management Systems (LMS), Virtual Learning Environments (VLEs) among other options are some of the possibilities for complement teaching and learning, particularly in the case of distance learners. However, in the case of laboratory activities for distance learners, current available options are focused on the use of simulations within a VLE. This demonstration proposal presents an innovative learning scenario, using mixed reality in an immersive learning environment, complementing the paper [1] submitted to this summit (EiED'13). The test bed scenario proposed is the creation and participation within a mixed reality collaborative laboratory activity between geographically dispersed learners to produce Internet-of-Things (IoT) applications emphasising computing fundamentals.

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1. Current project

Our project implementation uses the so-called *xReality objects* [1], smart networked objects coupled to a virtual representation of them in a 3D virtual environment; updated and maintained in real time creating a mirrored reality. These objects are developed using a Raspberry Pi[2] (a low cost small computer), as a main component; and a collection of pluggable components. These were implemented using Fortito's BuzzBoard Educational Toolkit[3], a collection of pluggable hardware boards for rapid prototyping, which can be interconnected in diverse combinations to create a variety of quick Internet-of-Things (IoT) prototypes.

1.1. Demonstration description

Our demonstration is based on the following scenarios:

- <u>Single session (Virtual objects)</u>: This scenario is analogous to simulations that currently exist for virtual laboratory activities. The user can connect virtual representations of BuzzBoards within the immersive learning environment to create the proposed desktop robot.
- <u>Single session (xReality object)</u>: In this scenario the user can interact with the virtual simulation of the robot connected with the real desktop robot using the services available for the device (e.g. movement of the robot, sensors, etc.)
- <u>Collaborative session (single xReality object)</u>: This scenario allows two users to communicate within the 3D virtual environment interacting with just one xReality object (desktop robot).

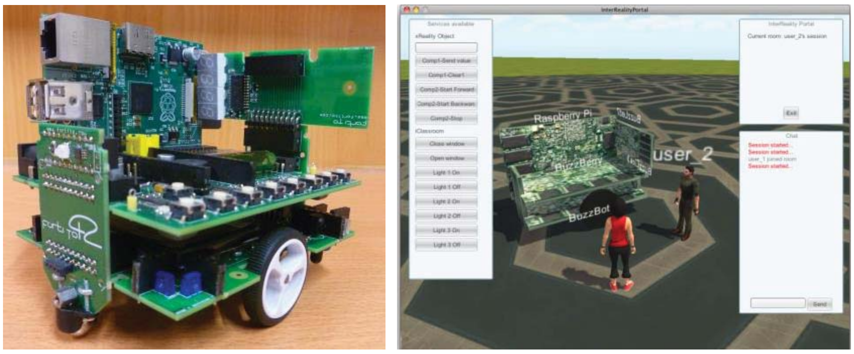

Figure 1. BuzzBoard Desktop Robot & screenshot of 3D Virtual interface.

Future work will include the creation of collaborative sessions using multiple xReality objects: a) when both users have exactly the same hardware mashup and b) when users have different hardware configuration, allowing them to complement each

[2] Raspberry Pi Foundation – http://www.raspberrypi.org
[3] Fortito Ltd – http://www.fortito.mx/en

other with the available pieces. A different scenario to consider will be the creation of sequences of services that can be designed by the learners on real time.

1.2. Technical details and requirements

The immersive environment is formed by Immersive Display's ImmersaVu[4], a composite moulded 160° panoramic dome screen, which allows a free-range of head movement. Due to the size of the ImmersaVu (2 mts. length) we will need a suitable space for the device. Along with this we will need access to electric power for the following components: a) the ImmersaVu (1 projector & 1 server), b) 2 PCs, c) the BuzzBoard Desktop robot (1 Raspberry Pi) and d) a network switch. Internet access is not essential but it might be needed for showing videos of other demos.

Figure 2. Immersive Displays' ImmersaVu

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xReality interactions within an immersive blended reality learning space

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Abstract. Multi-user virtual environments (MUVEs), used in training, entertainment and education, had been a reality for several years now, allowing users to perform collaborative activities using virtual settings and virtual objects. Nowadays, technological advances are opening the possibility of integrating multiuser virtual environments with so-called ubiquitous virtual reality (U-VR); extending and complementing real and virtual worlds in a blended reality space. In this work-in-progress paper we describe our efforts towards the implementation of a blended reality distributed system, to achieve integration between real and virtual objects, using smart objects (*xReality objects)* and immersive technology in a mixed reality learning environment, extending our previous work towards the creation of a holistic option to enable geographically dispersed learners to collaborate on laboratory activities.

Keywords. Ubiquitous virtual reality, mixed reality, dual reality, virtual laboratory, blended reality, xReality objects, interreality, human-machine interface (HMI), internet-of-things, tangible user interface (TUI), Multi-user virtual environment (MUVE).

Introduction

Traditionally virtual worlds have been regarded as a standalone entities separated from the real world, where users can create their fantasy worlds which could follow realistic physical laws and rules (e.g. gravity) or differ from reality (e.g. flying, non-human avatars, etc.). Multi-user virtual environments (MUVEs) provide a 3D virtual canvas for users to populate with 3D representations of the real world, extending human capabilities into a computer-generated space. However, new research in this field is moving towards the integration and correlation between virtual worlds and real worlds using ubiquitous computing to create different technologies and possibilities for users. Suh et al. [1] defined Ubiquitous Virtual Reality (U-VR) as the possibility to "*make VR pervasive into our daily lives and ubiquitous by allowing VR to meet a new infrastructure, i.e. ubiquitous computing*". Lee et al. [2] complemented this concept by stating that ubiquitous virtual reality produces intelligent spaces combining real and virtual worlds to create seamless connections, with the advantage of each world complementing the other. This encourages the concept of *interreality* as defined by

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Van Kokswijk [3] "*a hybrid total experience between reality and virtuality*", generating on the user the illusion of the so-called Blended Reality [4], a "*switch context between real-local and virtual-distant environments and blend traces of one into the other in a socially unconscious manner (often seemingly simultaneously)*". To achieve this, Lifton et al. [5] proposed the creation of a cross reality (xReality) environment, a ubiquitously networked sensor/actuator infrastructure mirrored in real-time with a 3D virtual environment to complement both, virtual and real worlds, in real time bidirectional process.

But how do end users can interact with this sophisticated architecture, where real and virtual objects can host a complete bidirectional conference without talking a single word to the end user? Several gaming platforms had been using tangible user interfaces (TUI) to connect end-user to real objects and virtual worlds. Ishii et al. [6] defined a TUI as a user interface that "*augments the real physical world by coupling digital information to everyday physical objects and environments*". Video games industry has many examples: traditional game controllers, dance pads, sophisticated on-body gesture recognition controls (e.g. Nintendo Wii [2]), etc. A particular example we would like to cite is Ubisoft's Rocksmith[3] which connects a real electric guitar to a virtual interface in order to teach the end user to play the guitar in an individual learning session (or collaborative if the other user has an extra electric guitar/bass). Here the user can perform an action over the real object updating a state in the virtual world (e.g. a string pressed is reflected on the virtual fret board and playing the sound). However, this is a unidirectional communication, as actions performed over the virtual world cannot be reflected in the real world, and each real object (e.g. electric guitar) is tied to a single user at a time. In [7] Ibáñez et al. used a mobile device to interact in a learning activity, maintaining a bidirectional communication between real and virtual worlds. Although the activities described in both examples were collaborative learning activities, real world objects were designed to be used by a single user at a time.

In our previous works [8] [9], we proposed the use of *xReality objects* to achieve collaborative bi-directional communications between real and virtual objects, with the particularity to allow sharing both, real and virtual objects. *xReality objects* are smart networked objects coupled to their virtual representation, updated and maintained in real time to create a mirrored state (dual reality). The test bed scenario suggested is to use a collaborative laboratory activity to produce Internet-of-Things (IoT) applications emphasising computing fundamentals.

In the following sections of this work-in-progress paper we introduce some of the concepts presented in [8] [9], and we describe the conceptual model and architecture of our blended reality distributed system, present the implementation and discuss future work. The first phase of our research involved the creation of a single *dual reality* state as described in [10]; in this paper we have moved on to include the creation of collaborative learning sessions, incorporating two users, and the management of multiple *dual reality* states, mirroring two or more *xReality objects* on a single virtual environment in synchronous time in different scenarios.

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[2] Nintendo Wii - http://www.nintendo.com/wii

[3] Rocksmith - http://rocksmith.ubi.com/rocksmith/en-GB/home/index.aspx

1. A blended reality distributed system

1.1. Architecture

In [10] we described a conceptual model and implementation of an *xReality object* using two different components: a main module, which communicates and identifies other components connecting them to the interreality system; and a group of interchangeable pluggable sensors and actuators providing multiple services, and enabling the creation of diverse physical mashups.

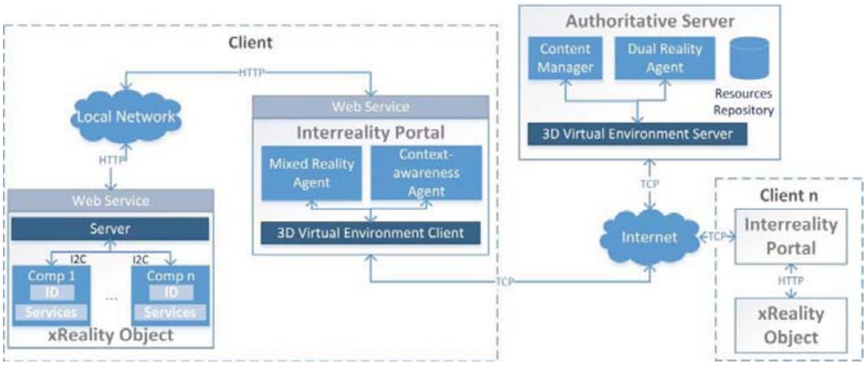

Figure 1. Blended Reality Distributed System architecture [10]

Figure 1 shows the architecture proposed. In this architecture we define three software agents to coordinate actions/responses and maintain mirroring between the virtual and real world. The Context Awareness agent (CAag) captures any changes in real or virtual world and sends the information to the Mixed Reality agent (MRag). MRag sends this data to the Dual Reality agent (DRag) and receives instructions from it to execute within the local virtual environment, representing/executing any change in either the virtual or real world. The DRag manages the multiple dual reality states, synchronising client environments using these predefined rules [10]:

a) *A change in any Virtual object of a given Interreality Portal results in identical changes to all subscribing Interreality portals*.
b) *A change in an xReality object of a given Interreality Portal results in changes in the representation of the real device on all subscribing Interreality portals*.

In figure 2 we describe concurrent state transitions between the three main elements of our Blended Reality Distributed System: the *xReality object*, the *Interreality Portal* and the server. The process starts when the *Interreality Portal* client connects to the server for validation. Once validated by the server the learner can choose to enrol in a learning session. At this moment the server sends an individual inquiry to all the *Interreality Portals* enrolled in the session asking for information on all the *xReality objects* available. The *Interreality Portal* connects to the local *xReality object* and sends a list of available services to the server. The server lists them, making them available for execution by any of the *Interreality Portals* active in the learning session. If a user chooses to execute a particular service (local or remote) the

Interreality Portal sends the information to the server which locates the selected service and sends an execution call to the *Interreality Portal* that owns the *xReality object*. The *Interreality Portal* sends the RPC to the *xReality object* and waits for the result. At this point the service is marked as locked for both, the server (to deny any subsequent call for a different client) and the *xReality object*, until the latter finishes execution and sends data to the *Interreality Portal*, which conveys the data to the server. Finally before unlocking the service, the server updates its data and synchronises all subscribing *Interreality Portals*.

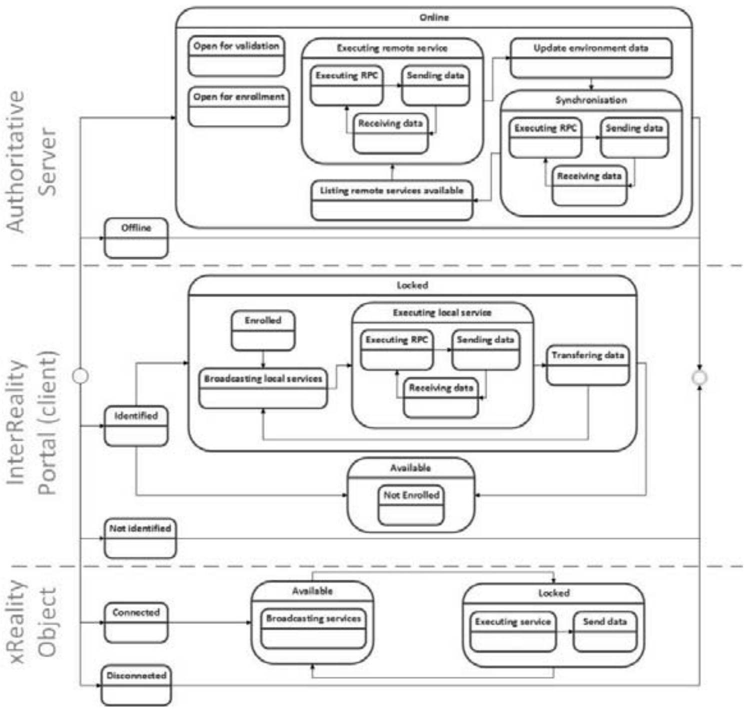

Figure 2. Blended Reality Distributed System states diagram

1.2. Implementation and usage

Figure 3 shows a 3D virtual representation of an *xReality object* being explored by two learners within a learning session. These virtual representations were created using Unity3D[4], a cross-platform game engine for creating interactive 3D content. To create collaborative sessions and maintain the dual reality states we implemented an authoritative server using SmartFoxServer X2 [5] (SFS2X), a middleware platform optimized for real-time multiplayer games, MMOs, virtual communities, etc. SFS2X API connects the clients to the central server via a persistent connection (using the TCP

[4] Unity3D Game Engine - www.unity3d.com

[5] SmartFoxServer 2X - www.smartfoxserver.com

protocol), while the central server is responsible for maintaining object states and sending back synchronisation messages to every client.

Figure 3. 3D Virtual Interface – Interreality Portal.

To start a learning lesson, the user sets up an *xReality object* (fig. 4) by turning on the main component and connecting it to the local network. The *xReality object*'s main component was implemented using a Raspberry Pi[6] (RPi), a small low-cost computer with a linux-based operating system. At this point the learner can connect one or more interchangeable pluggable physical components (BuzzBoards) on RPi's general purpose I/O pins, which communicate using a python library via the Inter-Integrated Circuit bus (I^2C). I^2C is a multi-master serial single-ended computer bus created by Philips in 1982 for attaching low-speed peripherals [11]. Once a BuzzBoard is detected by the RPi, its available services are broadcasted to the network via a RESTful web service (WS). This WS was implemented using Bottle[7], a distributed python-based Web Server Gateway Interface (WSGI) micro web-framework. Pluggable components were implemented using Fortito's BuzzBoard Educational Toolkit[8], a collection of pluggable network-aware hardware boards which can be interconnected to create a variety of Internet-of-Things (IoT) prototypes by using combinations of modules plugged together. For example, if the learner connects the BuzzBot module, formed by a bot servo motor, light sensors and IR Rangers, the RPi will advertise the

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[6] Raspberry Pi Foundation – http://www.raspberrypi.org
[7] Bottle: Python Web Framework - http://bottlepy.org/docs/dev/
[8] Fortito Ltd – http://www.fortito.mx/en

movement/direction options for the servo motor (forward, backward and stop) and the "read" service for all the sensors (fig. 4) [9].

To use the system a learner starts the 3D learning environment and, once he is authenticated the 3D virtual environment, it will display the "lobby" space, where he can chat with other learners and arrange a learning session. To create these learning sessions we used SFS2X's Room object, allowing it to create and destroy sessions at runtime from either the client or the server. As soon as the learners join one session from the list located on the left side of the "lobby" space, they enter into a shared virtual world where they can see each other as avatar representations, and they can see the virtual representation of the xReality object(s) linked to any of the users of the current learning session. These where detected using the broadcasted list of services available, which is located on the left side of the main screen (fig. 3). A chat window is located on the right side of the screen to allow the users to communicate during the learning session.

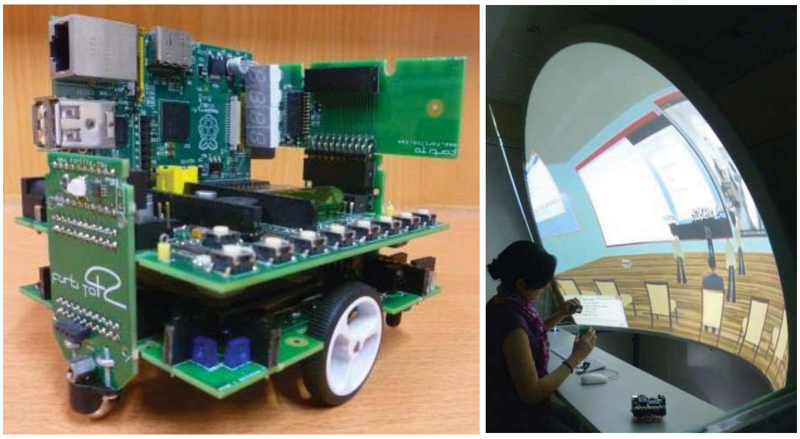

Figure 4. Fortito's BuzzBoard Educational Toolkit (left). ImmersaVu (right).

In [12] Fowler points that research on 3D virtual learning environments (VLEs) cannot truly be considered as 3D from a sensory point of view, as visually these environments are accommodated in a 2D desktop computer. Therefore our testbed was deployed on an immersive environment using Immersive Display's ImmersaVu [10] platform (fig. 4), a composite moulded panoramic dome screen, which allows a free-range of head movement without the need of any special instrumentation such as glasses or other devices that can interfere with the learning session.

2. Learning scenarios based on xReality interactions

In [13], Alrashidi et al. proposed a 4-Dimensional Learning Activity Framework (4DLAT) (fig. 6), where they classified the learning activities by the elements that

[9] In [9] we presented a detailed description of the implementation of an xReality object.

[10] Immersive Display - www.immersivedisplay.co.uk/pdf/immersavu.pdf

compose the activity: number of learners and complexity of the task. In a previous work [14] we proposed a classification of activities based on its nature and characteristics (fig. 7). Similarly Lee at al. [2] identified three key dimensions in the creation of Ubiquitous Virtual Reality (U-VR) implementations:

- Reality; which refers to the point where the implementation is located in relation with Milgram's virtuality continuum [15].
- Context; which refers to the flexibility to change and adapt according to time and space. Context can be presented as a static-dynamic continuum.
- Activity; which refers to the number of people that will execute an activity within the implementation, going from a single user to large community.

All these classifications explore learning activities from a technological point of view, based on the nature and complexity of the task. It is necessary to consider pedagogical challenges in the implementation of these activities, evaluating the learning benefits. Elliot et al. [16] argue that "technical components are part of the learning environment, and as such should not be treated as separate, but interconnected constructs". From this perspective, we integrate these classifications to define the learning scenarios described in figure 8.

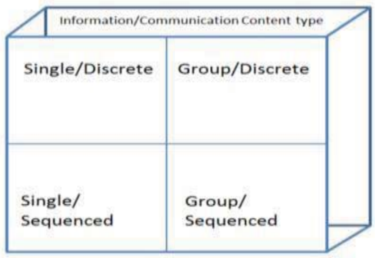

Figure 6. 4-Dimensional Learning Activity Framework (4DLAT) [13]

Figure 7. Classification of Activities in Mixed Reality Learning Environments [14]

Figure 8 illustrates the possible scenarios for learning activities using a combination of virtual objects and *xReality objects* in an individual or collaborative session. In this first implementation we only consider the possibility of using single services through the 3D virtual world. Future research will include the creation of sequences of services designed by the learners, similar to Chin's virtual appliances approach [17], therefore 4DLAT's sequenced activities (Single-Sequenced / Group-Sequenced) were not considered on this preliminary learning scenarios.

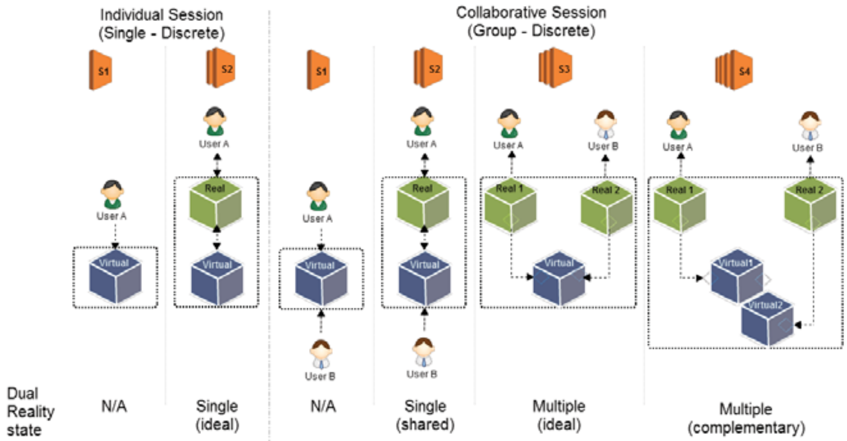

Figure 8. Possible scenarios for virtual and xReality objects

Scenario 1 (S1) examines the use of only virtual objects, either in an individual or collaborative session, similar to virtual laboratories where simulation is the key to performing an action; in this case although there is synchronisation between virtual representations within a collaborative session, there is no dual reality state. A dual reality state involves the coupling of a real object to their virtual representation, updated and maintained in real time [10].

Scenario 2 (S2) describes the use of virtual objects and an xReality objects in a learning activity; the individual session represents the ideal case of dual reality state. In the case of a collaborative activity it shows the possibility of having just one xReality object shared by the users; in this case both, the remote and the local user, have access to the services available for the physical mashup, and both can control it using its virtual representation. Although only one the local user will see the result of the activity in the physical object, the remote user can follow the execution via the 3D virtual environment, as the xReality object keeps updating its virtual representation in real time.

Scenario 3 (S3) exemplifies the synchronisation of two (or more) xReality objects with the same hardware configuration (e.g. two identical desktop robots) within a collaborative session, creating real-time multiple dual reality states. This could be considered as the ideal scenario for multiple dual realities.

Finally, Scenario 4 (S4) describes a collaborative session where users do not share the same xReality object hardware configuration. In this scenario User A could have a part of the final mashup (e.g. a led display) and User B in a remote location could have a different device (e.g. a bot servo motor) that complements the one in possession of User A. Both objects have a mirrored virtual representation within the virtual world, therefore both are xReality objects but the mashup is only configured in the virtual world, creating multiple complementary dual reality states. In our example this will happen when User A and User B create the desktop robot using a combination of their virtual pieces. Once the mashup is created in the virtual world, both users could execute the available services. Both can follow the result in the virtual world, although only the user with the respective physical device will see the result of the activity reflected in the physical object.

Summary and future work

In this work-in-progress paper we briefly explained the fundamental concepts and rationale of our research. We reviewed our previous work towards the creation of a Blended Reality Distributed System, explaining how this paper extends our research from the creation of a single dual reality state, available to a single user, to the creation and management of a multiple dual reality states in a collaborative session, by 1) proposing an architectural model and 2) exploring different learning scenarios, including the possibility of having collaborative sessions with a real world object shared by multiple users at a time (single shared dual reality) and completing mashups within the virtual environment (multiple complementary dual realities).

Our current implementation manages single dual reality states (ideal and shared), the first one in an individual session and second one within a collaborative activity. However the architecture proposed allows the implementation of multiple dual reality states. This opens a possibility for learning sessions in places where laboratory resources might not be available due to place or money constraints. Future work advances towards implementation of multiple dual realities (ideal and complementary) using two or more *xReality objects*; and the integration of sequenced groups of services to be executed within our *Interreality Portal*, encouraging teamwork, creativity and innovation. Our main contribution from this paper is the proposed Blended Reality Distributed system architectural model and the implementation that enables geographically dispersed learners to control a single *xReality object*. In particular we introduced the possible interactions within real and virtual objects, and classifications for each type of associated dual reality. We look forward to presenting further outcomes of this research, as our work progresses, in subsequent workshops and conferences.

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.

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Narrative, Metaphor and Gesture: Embodied Quests in Virtual Worlds

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Abstract. This paper reviews the role of narrative as a tool to make sense of the world and reality. This tool can also be used in the design of coherent virtual spaces. More specifically, the extensive use of metaphor in language is also addressed here. Metaphors are not exclusive of speech and are considered to be externalized by gestures, that is, they are embodied. Furthermore, studies show that gestures not only reflect but can also influence thought. It is argued here that this view of metaphors and gestures has important implications for the design of gesture-based immersive worlds for instruction. A design framework for exploratory games is extended to include these considerations and a short example is provided.

Keywords. narrative, metaphor, gestures, natural user interfaces, embodied cognition

Introduction

When learning about quantum physics, it is usual to spend long hours in a classroom going through different equations and solving several problems. Facts are presented in compartmentalized sections according to an organized plan. Graphics are included on textbook pages to help understand certain concepts but in general the content can be dry and abstract. Students sit still for long hours because it is assumed that the mind is doing all the work. In many cases we view education as a process that reminds us of the industrial revolution.

Alternatively, we can talk about multidimensional universes where *"each universe is linked to every other through the network of forks in the road. Or, as the Argentinian writer Jorge Luis Borges wrote in The Garden of Forking Paths, 'time forks perpetually toward innumerable futures'"* [1]. Misho Kaku explains physics in the context of our understanding of the universe we live in, how science views our role in this universe and not just as a set of equations that have to be understood only within that specific area. The result is a fascinating tale that leaves the reader wanting to know more about the field and each of the different contributions. It connects with our deepest interests and emotions. The presentation of facts is not bad per se but it does not reach the same level of connection. "*Although non-narrative discourse may be informative, only narratives can be gripping. Stories seize the mind.*" [2].

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Even though we are actively making sense of a story when we read a book or watch a film, new technologies now allow us to leave the role of a relatively passive spectator and instead immerse ourselves into fantasy worlds and be part of the tale. Microsoft's Kinect allows our bodies to be represented in the virtual world, the Leap Motion tracks our gestures, Neurosky's Mindwave transforms our brainwaves into commands, and the Occulus Rift device puts us right in the middle of it all.

So what does this mean for the design of immersive worlds in instruction? This paper reviews narrative as a tool to make sense of the world and it highlights the role of metaphor. Narrative and metaphor are not considered here purely mental processes. Instead they are strongly linked to sensory-motor processes. It is argued that gestures embody metaphors and are important components of what we commonly consider 'thinking'. Gestures are viewed not only as externalizations of thought, but also as tools to influence it. This becomes relevant in immersive worlds controlled by gestures.

Narrative is then revisited as a guiding framework to design interactive spaces that are coherent and that can be understood in several ways, allowing the learner to build an understanding of a domain, in line with constructivist approaches. A review of a design framework for educational exploratory games is presented. This framework views immersive worlds as knowledge landscapes made of conflict nodes that users visit in order to get an understanding of the whole domain. It is largely based on Cognitive Flexibility Theory. This framework however does not say anything about the three-dimensional conceptual structure of the knowledge field or how navigation takes place. Research on orientational metaphors and gestures is used to extend the design framework, suggesting that gestures may help the user understand the hierarchical and spatial relationship between concepts, and improve comprehension.

The final part of this paper presents a gesture-controlled world, The Witch of Eichstätt, which applies these principles to digital storytelling. By using the Leap Motion device, the reader is no longer passive but is part of the story and acts by using gestures that are congruent with both the role and context.

1. Narrative and Metaphor: Making Sense of Reality

Stories are indeed very attractive to people but beyond their appeal, several researchers suggest that they play a more important role in our lives. Newman [3] suggests that our brains evolved to handle complex stories, with certain fundamental narrative scripts being genetically embedded. Scripts are mental templates made out of events that take place in a sequence. Some of them are present across cultures as the study of myths reveal.

In his book The Hero With a Thousand Faces [4], Joseph Campbell analyzes different elements of myths present in different cultures geographically dispersed across the five continents. For Campbell, mythical narratives deal with the mysteries of human nature, deeper truths that transcend cultural and geographical boundaries. By acting as signposts that guide us in our interactions, myths become clues to the potentialities of human life. In Campbell's opinion, myths have informed policies and religion throughout the centuries, acting as an invisible plane that supports reality. Without them we would have to find the way on our own.

Bruner [5] considers that we see our own lives as narratives but the argument does not stop there. He suggests that our cognitive and linguistic processes are culturally influenced, and they in turn influence what we perceive, how we act and how we build our lives. We don't just tell our story, we live it as well. At a neurophysiological level, studies show that we do indeed seem to make meaning with stories, and we also tend to believe our stories as long as they explain the environment and our behaviour, even if those explanations are not true [6].

1.1. Embodied Narratives

Narratives are not static. They model life as it is at this moment. New meaning is found every time they are experienced again through rituals. Rituals are considered to be the reenactment of mythical narratives, and part of their purpose is to take us out of the mundane. Carolyn Handler-Miller, speaking of interactivity, mentions the completely new perspective she obtained from a religious ritual in Mexico. Rather than remaining a passive spectator, she became involved in the procession and was able to fully experience the profound meaning of the nativity [7]. "Now, in myth and ritual the great instinctive forces of civilized life have their origin: law and order, commerce and profit, craft and art, poetry, wisdom and science." [8].

What this means is that narrative quests cannot be undertaken from a purely intellectual perspective. We re-experience the transformational power of the quest through rituals (reenactments) that shock us and bring us out of our programmed routine. An important issue here is that contrary to what one would expect, this deep understanding is reached out of a connection with one's own centre from which all action emanates, not exclusively from the mind. "*The mind cannot take control, it must submit and serve the humanity of the body. When it puts itself in control you go to the intellectual side, like Darth Vader. (...) When the mind takes control we have the danger of living programmatically and refuse to hear our own bodies, we become off-centre*" [9]. Action is essential and it naturally takes place through the body.

Behind the standard and most prevalent teaching systems is the belief that our thinking and learning take place exclusively in our minds. We somehow take for granted that our thoughts belong to a realm different from the one inhabited by our bodies. When we read a book, we believe we are engaging in a purely intellectual exercise while we sit comfortably and flip the pages.

Nevertheless, recent theories and research studies are beginning to challenge the Cartesian view of the world, where the body's role is limited to that of carrier of the mind [10, 11, 12]. It seems that the way we interact with the world and make sense of our surroundings is a process that involves our entire being.

Stories are at the centre of meaning-making in humans, and our bodies play a central role in this process, a role more prominent than previously believed. How does this process take place? Embodied cognition sees thinking not as an exclusive internal process but actively involving the body in the process of knowing. Gibson's ecological view sees the world as made of affordances or opportunities for action. Perception is there to identify these opportunities and reach goals [13]. We are equipped, through our bodies, to take advantage of those affordances. Interaction takes place as we identify those possibilities, and act upon them. This creates a cycle of perception and action between the knower and the object of knowledge. Body and mind are active participants in this cycle. Cognitive processes are influenced by the affordances we perceive in the environment, how we can act on them, and if we choose do so, what effect that has in turn.

1.2. Metaphor in Language

When we tell our stories of everyday events or of our own lives, we make heavy use of metaphor, according to Lakoff and Johnson [14]. Metaphors are a way of understanding a certain concept in terms of another, which is called conceptual mapping. They can be structural in nature, where we structure a domain in terms of another. For example, in the majority of cultures we use the metaphor ARGUMENT IS WAR to describe the fact that in our minds debating has strong parallels with fighting. We attack or defend our position, we win an argument, etc. This has an impact on how we approach debating. A metaphor such as ARGUMENT IS DANCE would generate a different set of behaviours. Orientational metaphors organize concepts in terms of spatial relationships. Metaphors such as HAPPY IS UP, SAD IS DOWN, MORE IS UP, LESS IS DOWN, etc. belong to this group. Lakoff and Johnson suggest that these metaphors are based on cultural and physical experiences. Orientational metaphors are important when considering tangible interfaces, as will be considered later.

Researchers suggest that metaphors are not exclusive to language but are multimodal [15]. It is argued that they are not only part of speech but also present at sensory and motor level, that is, they are embodied [16]. In particular, researchers believe that gestures are an expression of metaphorical thought. Hostetter and Alibali [17] note that speech produces a set of mental images, which are based on perceptual and action simulations of the process. These processes are in turn expressed through gestures. Communication systems are made of cognitive as well as perception-action processes, which is in line with embodied cognition.

1.3. Gestures and Learning

If gestures are accepted as externalizations of thought, then the next question is whether they can be used to foster learning. There are several research studies that look into gestures and instruction. However, from the point of view of designing virtual worlds, there are two approaches that are particularly interesting.

The first one is proposed by Segal [18] and is an extension of conceptual mapping. Previously we saw that the use of metaphor is a form of conceptual mapping, or using elements of one domain to understand another. For Segal this is insufficient for learning with tangible interfaces and instead the idea of Gestural Conceptual Mapping is presented. Segal convincingly argues that any kind of gesture used to teach something must map directly to the learned concept. Other authors [19] have suggested that in general, any embodied lesson must apply this mapping between instructional content and action. For example, if a person is learning bowling, the Nintendo Wii motion is a direct mapping between action (throwing the ball) and the gesture used (grabbing the Wiimote and performing the same motion). In contrast, there would be no direct mapping if throwing the ball was represented by a push motion. In cases where direct mapping exists, Segal shows that gesture-based interfaces do promote thinking.

The second approach is somewhat the expanded version of many gesture studies in an educational context. These studies focus on the way gestures reflect knowledge and internal cognitive states, the way those gestures are interpreted by students and the way they foster learning [20]. Gestures are not only seen as externalized thought processes but also as tools that can "feed back and alter that thinking" [21]. This effect on thought is not achieved by only looking at gestures but also producing them. The gestures produced do have to relate to the motion required by the physical action. Goldin-Meadow and Bellock experiments go as far as suggesting that gesture has a more powerful effect on thinking processes than action itself. This has the important implication that rather than seeing gesture only as an embodiment of mental processes, they can be tools to influence those same processes.

2. Narrative, Metaphor and Gesture in Immersive Worlds

The previous section covered a significant amount of theories with the objective of presenting narrative as a sense-making tool that makes heavy use of metaphors. The process of understanding reality in this way is externalized, at least in part, through gestures. What is the significance of these ideas in the design of immersive virtual worlds?

The first is that narrative is advocated as a design tool to create meaning in interactive worlds. The second is that based on the use of metaphor and its embodiment through gestures, it is possible to design tangible navigation systems that map directly to learning, at least to some degree.

2.1. Narrative as Design Framework

Several authors propose that narrative is an important tool in creating interactive worlds that make sense to the user [22, 23, 24]. Making sense is also a challenge for digital storytelling authors who face the conflict between authorial power and the interaction possibilities they offer to their readers/users. The final product has to be coherent regardless of the path.

Brenda Laurel has drawn parallels between six elements in the Aristotelian view of drama and computer interaction [22]. These six elements are action, character, thought, language, melody (pattern) and spectacle (enactment). Understanding virtual spaces such as computer games as interactive drama allows one to see the contributions of human-controlled and computer controlled elements. It also suggests that highly interactive spaces should, as in any good story, have exposition, rising action, climax and conclusion. This familiar order is present in books and films.

As mentioned above this is easier in traditional media because the author has full control. It is much more difficult to achieve in interactive spaces [25]. In Crawford's opinion an interactive storyworld is a universe that offers the possibility of multiple paths. Each path will allow the user to experience one story. The content can then be appreciated from multiple angles. These different paths do pose a challenge in that sometimes they bring repetition into play. There are also significant computational barriers to implementing these non-linear worlds. Understanding all the facets of a storyworld can be equated to learning, an issue that will be further addressed when discussing Cognitive Flexibility Theory.

Laurillard sees the teacher as a storyteller, who is unfortunately not always present in the digital space [23]. She correctly points out that although experts might find easy to traverse interactive spaces, novices will likely struggle because of their lack of previous knowledge. Narrative then has to be made explicit by other means such as a series of objectives. In addition, the user can be given the possibility of more in-depth exploration of a specific topic by using hyperlinks or other affordances specific to digital media.

Plowman et al. [24] see the elements included in the software, such as graphics and text, as narrative guidance. The process of meaning-making in which each user engages is called narrative construction. Both of them interact and become a cycle, and both help in constructing meaning.

Eck [26] suggests that stories bring about a state of relaxed alertness suitable for learning by providing context and helping to create meaning. In addition these narratives require active processing of information, engage people at an emotional level and bring about immersion which leads to higher levels of retention.

In summary, elements of narrative can inform the structure of immersive worlds in a way that the user can make sense of the path chosen and construct meaning, which is naturally quite important in learning.

2.2. Gestures in Immersive Worlds

This paper has briefly addressed research on gestures and how they are not only considered externalizations of thought but also tools to influence thought. The concept of Gestural Conceptual Mapping, which argues for a direct mapping between the gestures that make part of the interface and the concept that has to be learned, was also introduced.

It is tempting to think that tangible or natural user interfaces will replace the keyboard and mouse. However, these interfaces have challenges of their own and not everybody believes they are so 'natural'. Norman's [27] analysis of these interfaces follows the embodied view of human-computer interaction.

It was thought that users built an internal functional model of a system, for example an application, and used that model to complete the necessary tasks to reach a goal. We were supposed to create a mini-world that informed our decisions and actions. Nevertheless, some studies challenged this view. Norman considered these mental models unstable and parsimonious [28]. Mayes et al. also showed that expert computer users do not remember the exact location of commands and rely on visual cues to locate them while working on a task [29]. Larkin went further to suggest that when interacting with a digital environment, expert users simply understand the visual codes that lead to the next correct action [30].

This perspective fits into the ecological view offered by Gibson. Rather than having a little functional system in our heads that directs our behaviour, it has been shown instead that a cycle of information takes place between the perceptual cues of the environment (interface information on the computer display, for example) and the cognitive and motor strategies used to act on the system.

Chris Crawford's definition of interactive storytelling provides an excellent match with what has been observed in human-computer interaction. Crawford [25] defines interactivity as:

"*A cyclic process between two or more active agents in which each agent alternately listens, thinks and speaks - a conversation of sorts*." (p. 26)

As the previous definition specifies, interactivity is considered a conversation or bidirectional process. When we talk to somebody, we do not do so with just our heads but with all our bodies and minds. The same thing applies to our interaction with the world, with knowledge and with virtual spaces. This cycle of information engages body and mind.

In this conversation, natural user interfaces pose some challenges as Norman points out [27]. Gestures are difficult to detect sometimes and a simple hand motion might be interpreted by the system as a command to do something. Unexpected use can have negative outcomes. As an example, Norman describes the issues some players had with Wiimotes while playing bowling. The motion to throw the ball is very similar to the one made in actual bowling. However, instead of throwing the 'virtual' ball, users push a button. Some players let go of the control and smashed their TV screens.

The conventions on how to design these interfaces are still being written. Norman believes that gestures and body-motion are an important addition to the way we interact with computer systems, but those systems need to be refined to work as the designer intends. From the point of view of instruction, Marshall [41] notes that even though there is much interest in natural user interfaces, we still need more research in order to determine their impact on learning.

Nevertheless, several studies have shown the benefits of gesture-based manipulation in three-dimensional space [31]. The use of orientational metaphors in language also suggests that mappings between the 3D space and certain concepts would make sense in the design of an immersive world.

3. Building Gesture-Based Immersive Worlds

Before we discuss how to integrate narrative and gestures into immersive virtual worlds, it is important to note that there is an instructional theory that deals with similar issues of traversing a coherent path among different options.

We can see interactive worlds as networks of potential paths. We engage in quests in order to live different experiences and appreciate the landscape from different perspectives. This is similar to Wittgenstein's view on understanding a concept [32]. In his Philosophical Investigations he suggests that this understanding cannot be achieved through a single linear path. Instead, we imagine this concept to be a landscape that has to be criss-crossed in order to fully understand its complexity.

3.1. Cognitive Flexibility Theory

The idea of criss-crossing a 'knowledge' landscape is the essence of Cognitive Flexibility Theory (CFT) [33]. It is an instructional theory but its framework can provide insights into storyworld design for all purposes. It has a broad range and has been applied to diverse fields such as film studies and medicine.

The key idea is that in the real world formulas rarely work. The circumstances that a person normally faces at work and in life in general, are not repetitive but change frequently. To be successful and effective, an individual is required to have a deep understanding that will allow him to adapt what he knows to the situation at hand. Cognitive Flexibility Theory's solution is a 'knowledge' landscape with many different paths that will lead to mastering different concepts under different contexts. It is not surprising that CBT found in hypertext the perfect tool to implement this instructional model [34]. In a sample application each node that the student could visit was a mini-case, indexed under one or many themes, representing alternative ways to understand a subject, in this case a film.

Different paths are in essence different narratives with underlying themes. The paths must make sense and provide a coherent experience for the user, be it entertainment or instruction. Creating a world where than can take place is a significant challenge. It requires a carefully structured network of nodes that provide relevant content, independent from the route selected.

Important points in CFT are that content must have multiple representations, concepts must be interconnected in different ways that foster the construction of schema, and content should be presented at least in part in the form of cases. Notice that this last part, cases, refers mostly to ill-structured domains, the main objective of CFT.

Cognitive Flexibility Theory does not offer specific rules to create these kinds of networks. Interactive storytellers face the same challenge: how to create a network of dramatically solid possibilities that can be chosen in different ways producing a unified experience? Here we refer to the previous discussion on narrative as a design framework. Also notice that multiple representations allow for the use of metaphors, which as we have seen are not only linguistic but multimodal. This is a factor that allows us to include text, speech, graphics and of course tangible interfaces. Even though initially conceived for educational games, one framework has been proposed in the instructional technology literature for the creation of these networks [35].

3.2. Tangible Immersive Space – Design Framework

The field of game design has also dealt with these issues of creating spaces that players can explore. Although narratologists argue that games would benefit from being included along with other storytelling media such as books or films, ludologists consider that narrative principles would only diverse attention from the most important mechanics of the game, that is the pure experience of fun [36]. According to Jenkins, environmental narrative can "create the preconditions for an immersive narrative experience in at least one of four ways: spatial stories can evoke pre-existing narrative associations; they can provide a staging ground where narrative events are enacted; they may embed narrative information within their mise-en-scene; or they provide resources for emergent narratives."

Based on Cognitive Flexibility and game theory, a framework has been proposed to create exploratory instructional games. The suggested solution is to create a network of 'conflict' nodes (Figure 1).

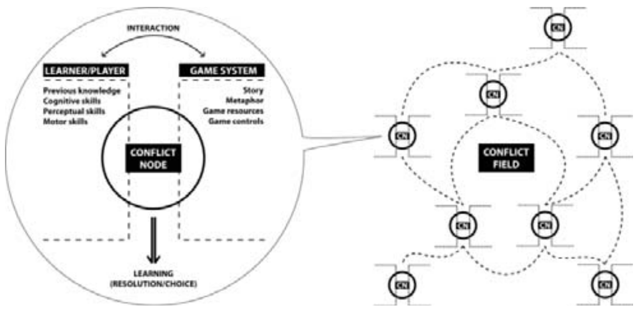

Fig. 1. Conflict node and conflict field (Reproduced with permission)

Conflict in education is viewed as the trigger of cognitive dissonance, a situation that challenges our preconceptions and allows us to learn something new as a result. Of course, conflict can also have its more traditional meaning as it does in a literary work. In this framework, the level of conflict can range from simple to highly complex at each point of decision.

Due to space considerations only a summary of the framework is provided here. Each node is a dramatic, decision or learning point. From the educational point of view, for each node the instructional designer considers on one side what the player or user brings to the equation, such as previous knowledge and level of cognitive, perceptual, motor and social skills. On the other side, the designer also considers the narrative used to create themes along paths, the metaphors used to present concepts, the resources made available by the game space, the possibilities for collaboration and the types of physical controls used. Both sides must complement each other in order for learning to take place.

Each node has an input level of information that can come from several other nodes, and an output leading to new paths. Each node is also the point where users can take decisions in order to move forward in the virtual world. Each of them can contain the same concept viewed at different levels, from the practical all the way up to the most conceptual one. The key decision point can be presented at different levels of abstraction depending on the path taken and the purpose. The design process ends up with a graph of dramatic or decision points that include level of conflict, possible goals, input information, output information, and interaction mechanisms.

The problem with this framework is that it says nothing about the spatial arrangement of these nodes. Even though nodes have different conflict levels, that is not evident in the network which is depicted as flat. An additional third dimension that shows the hierarchical and spatial relationships between nodes could be superimposed on a three-dimensional virtual world. It is here that considerations such as orientational metaphors become important and can be mapped to the digital space. For example, metaphors such as GOOD IS UP and BAD IS DOWN could help locate ethical conflict. This is consistent with Lakoff and Johnson's [14] observation that "*most of our fundamental concepts are organized in terms of one or more spatialization metaphors*". They also note that scientific concepts are frequently based on metaphors that have their root in physical and cultural experience, and are congruent with orientational metaphors.

The keyboard or mouse might not be the ideal devices to navigate this conceptual three-dimensional space, although they may be used within nodes. Gestures have been shown to be closely linked to spatial visualization [31]. Chu and Kita suggest that people are more successful at completing visualization tasks if their hands move in a manner that relates to what they need to visualize. In order to understand the hierarchical and spatial relationships between concepts, hand motion would be a more appropriate interaction mechanism. If understanding comes from manipulating an object, then teleoperation (manipulating an object at a distance through some mechanism) will also be a more suitable interaction method as opposed to left-clicking and moving the mouse to rotate the object. More specific application of these ideas is the topic covered in the next section.

3.3. The Witch of Eichstätt – A Three-Dimensional Story

Although not initially designed for instructional purposes, The Witch of Eichstätt is an experimental digital story that uses many of the ideas proposed here. Before describing the project it is important to consider why metaphor, gestures, embodiment and natural interfaces could be applied to literature.

Cognitive literary studies are not new, and there are many academics who are interested in the specific relationship between embodiment and literature. On one side, there are studies that focus on how our bodies respond to narrative, metaphors, etc. In her book The Style of Gestures [37], Guillemette Bolens addresses embodied cognition as a framework to analyze literature and presents the concepts of kinesthesia and kinesic intelligence. Kinesthesia is our awareness of our body parts and how they interact together, although we are not necessarily aware of every minute adaptation the body goes through as it interacts with the environment. Kinesic intelligence refers to our ability to interpret other's movements. It opens the door to a sort of empathy that allows us to understand the implications of body states. In one example, it is easy to see how one understands the difference between clutching a pair of gloves and holding them in a relaxed manner. This difference is not only understood mentally but at a corporeal and emotional level.

Bolens argument appears to be supported by work on neuroscience that shows that when we hear or read a narrative we dynamically build a mental, perceptual and kinetic simulation of that situation [38]. This meaning we create is largely built on the experiences our own bodies have gone through before, but we are even able to simulate situations that we have not experienced at all.

As Gallese and Wojciehowski [39] quote from writer Siri Hustvedt: "Writing fiction, creating an imaginary world, is, it seems, rather like remembering what never happened". This discussion has implications both for the author and the reader. Gallese and Wojciehowski suggest that the author may encode experiences in his text, at an embodied level, to be simulated by the reader.

From an instructional point of view, Glenberg [40] showed that reading comprehension is greatly improved by simulating written language, in particular through the imagined or physical manipulation of objects. Reading comprehension is seen by Glenberg as an embodied activity.

The Witch of Eichstätt is a three-dimensional book in the sense that the main purpose is not to play but to read a story loosely based on the witch hunts that took place in the prince-bishopric of Eichstätt during the middle ages. It is a fiction tale that tells the story of a woman, Erika Riehel, who has a mental illness but who is thought to be a witch. It is entirely gesture-controlled thanks to the Leap Motion sensor which accurately captures hand and finger motion, as well as gestures.

The reader flies over Eichstätt looking for information on the case by traversing different nodes that are available throughout the 3D space. Flying is done by moving the hand relative to the Leap Motion device. If the hand is to the left of the device, then the camera moves left. If the hand tilts, then the camera tilts, and so on.

In this case, the spatial location of the nodes is based on dramatic and metaphorical considerations. For example, the user must fly up in order to know more about Erika (GOOD IS UP) but must 'dive' in order to reach the witches' lair (BAD IS DOWN). The order in which the nodes are visited is determined by narrative themes.

Some nodes only provide a fragment of the story whereas others allow the reader to manipulate objects in 3D, also using the Leap Motion technology. Manipulation of objects or teleoperation is an interesting additional dimension that plays an important role in reading comprehension and visualization tasks. At the time of writing this paper, the application has not been released yet. Even though its intended purpose is to entertain in a different way, it will also be used as a research tool in the future.

4. Conclusion

Technology offers unprecedented possibilities of interaction with virtual worlds, mechanisms that almost look like magic and stimulate our imagination. However, we are still exploring how to best use all these options in ways that have a strong and measurable impact on learning.

This paper has emphasized the role of narrative as a way to make sense of our environment, be it real or digital. More specifically, it has been shown that metaphors are heavily used in those stories and they are multimodal, externalized in part by gestures. Furthermore, gestures are not only externalizations of thought but can also influence mental processes. This has important implications in the design of tangible interfaces for educational purposes.

Narrative can be used to unify and make an immersive space coherent. Gestures, and other interaction mechanisms, must be carefully introduced in order to have the expected effect on the learning process and the instructional goals.

This paper has visualized immersive worlds as networks of conflict, dramatic or decision nodes that can be organized based on narrative themes. It has extended a design framework for exploratory games, based on Cognitive Flexibility Theory, to include the spatial and hierarchical organization of nodes based on orientational metaphors. It has also introduced support for the use of gesture-based interfaces to traverse the network space.

Even though reference has been made to an educational theory, and the proposed framework is an extension of an instructional approach, the paper provides only a limited connection to the pedagogical impact of these ideas because more research is required to support specific findings. These are only the first steps in a field that is extremely promising but that requires more work, particularly into the specific effects on thinking and learning. This involves cognitive, perceptual and motor levels. The future is indeed a mix of technology and art since building the gestural conceptual mappings necessary for learning not only requires the skills of a programmer but also of a good storyteller, one that can bring all the disjointed uninteresting facts together into a riveting tale.

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The Witch of Eichstätt: Digital Storytelling in Gesture-Controlled Virtual Worlds

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Abstract. Digital storytelling has become part of the educator's toolbox as a way to create meaning through narrative. Video games have opened the door for participation in complex stories which can be experienced individually or collaboratively. Virtual worlds offer the possibility of immersion, which is not present in other digital storytelling media such as video, social networks or text-based tools. Through advances in technology, this immersion goes beyond the presence of an avatar. Users are invited to participate in these worlds using their bodies. This new embodied dimension is explored in a fiction story based on historical data of medieval times, when magic played a central role in society at all levels. The user becomes one of the deciding actors in a world controlled exclusively through gestures. Embodiment through the use of gestures is in line with the reader's role: a member of the Sorcerer's Council exploring, through the use of spells, the details of a witchcraft trial.

Keywords. narrative, metaphor, gestures, natural user interfaces, embodied cognition

Introduction

Digital storytelling has become an interesting tool for educational purposes. Robin sees digital storytelling from different angles: as an instructional tool for teachers to present content in an engaging manner, and also as a way to allow students to build their own and develop their digital, global, technology, visual and information literacy skills [1]. The Centre for Digital Storytelling case studies reflect that student-created content can capture social, political and cultural issues in a more powerful way than fact presentation [2].

There are several inexpensive options to create digital stories, and they range from the use of web-based tools such as blogs, personal websites and social media, all the way up to open-source 3D options such as Second Life, Open Sim and Open Wonderland. Web-based solutions have the advantage of being available to everybody that has an internet connection. 3D tools are more complex to use and require a learning curve. In between, we find applications such as Inform 7 which can produce interactive stories similar to old text-based adventure games such as Zork. More recently, researchers at the University of Ottawa have created a Drupal-based template that allows users to quickly build their own interactive stories for educational purposes [3].

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Even though open source tools are quite tempting because they are freely available, more sophisticated software can create stunning 3D worlds with advanced levels and functionality. In this field, some applications such as Unity 3D and Shiva 3D are offering affordable options that can produce quality products for different platforms. These software applications, coupled with new technologies that allow the user to control computer environments with their bodies, add a new dimension to immersive worlds.

Among new interaction technologies that bring a new level of embodiment we have the Neurosky MindWave that reads brainwaves, Microsoft Kinect which detects body motion, and the Leap Motion device which very accurately detects finger and hand motion and which has been used in this project.

This additional embodied dimension is important in storytelling for various reasons. The first is that we have a new way of interacting with a story that can be innovative and engaging. The second goes beyond the novelty and relates to the application of embodied cognition to literature studies. Embodied cognition suggests that thinking processes are not merely internal but are tightly linked to perception and motor processes [4]. In other words, our bodies play a central role in thinking and knowing. Several authors have studied the role of embodied cognition as a framework in literature, suggesting that reading involves the body and that there is an important impact on comprehension [5, 6, 7]. In addition, it has been shown that embodiment through gestures also plays a central role in learning [8].

1. The Witch of Eichstätt – The Middle Ages, Magic, Politics and Culture

This project was initially conceived as an experiment in digital storytelling. The main idea was to explore the perception of madness in medieval times along with the role of magic at different levels of society. Magic was widely used in the middle ages by the clergy, doctors, lay people who claimed to have magical powers and even those who did not make such claims. It was related to many fields such as religion, medicine, politics, art, literature and science. It can be said that the study of magic allows for a better understanding of the underlying dynamics of the middle ages [9]. Its development from something that was commonly used to something that was to be eradicated also explains in part the witch hunts that took place from the 14th to the 18th century.

It was important in this project to align the role of the reader with the kind of gestures required to advance the story. In some games there is some degree of plot and user interactions advance it. These interactions, which are normally done through the mouse, keyboard or game controller, do not always directly map to the same action in real live. For example, pushing a button on a game controller to make the character spin and jump to deliver a kick does not map to the real spin and jump motion.

In popular culture and stories, wizards gesture with their hands when casting spells. Since the tale is in great part about magic, performing gestures typical of those we imagine a sorcerer would make created alignment. There are several ways to interact with the story depending on the objective. The design of interactions was guided by research on navigation and spatial thinking. More specifically, studies that showed that navigation in three-dimensional space works well if accompanied by body motion replicating the direction of navigation were considered. Also research suggesting that spatial thinking is improved when manipulating objects in 3D space was included [10].

At this point, the application is close to completion and will be released shortly. The first goal is to wait for the initial feedback from users in order to determine if the design supports the story and engages readers. In particular, it is important to determine whether or not users find the gesture-based controls engaging and easy to use. User feedback will be used to improve the application from the storytelling and interaction point of view.

The second objective is to explore possible instructional uses. It is believed that this type of environment can foster the exploration of different periods in history and allow students to better understand the dynamics of society and culture through narrative and interaction. An additional feature that will be added in the near feature is the opportunity to experience the storyworld with other people, but before the social dimension is explored, the individual experience needs to work well.

Conclusion

Natural interfaces are starting to be more available across software applications. The effects of these types of interfaces in education are not clear yet [11]. We do not know how they impact thought or if they help learning. More research is currently being done and that will contribute to better instructional design frameworks in the future. The objective of showing this application as part of the European Immersive Education Summit is to demonstrate the use of gesture within an immersive environment as well as receiving feedback and opinions form the community.

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Panoramic Audio and Video: towards an Immersive Learning experience

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Abstract. Historically, learning has been seen as part of the human process to achieve a status, income and a better future. Traditionally students travel to attend lectures or participate in brainstorming and training sessions benefiting from the interaction afforded by the physical learning environment, the classroom, and the wider University facilities. However, financial pressures arising from national and global competition are putting pressure on Universities to find more cost-effective ways of delivering education. While distant learning has been always there, it is clear that this approach needs substantial improvements in order to deliver a similar learning experience to physically attending a university. To these end, this paper presents a novel immersive telepresence system that allows remote or distant students to customize their virtual presence at seminars and lectures based on a 360° panoramic video projected onto a 180° curved projected screen (an immersive shell). Audio is also collected with 3D information in order to be reproduced more naturally at the remote location. The arrangement is intended to provide online learners with a more faithful replication of human perception, akin to what they would experience in a real learning environment. Technically, to do this we use a 360° mirror to capture the lecture room scene and transmit it to remote locations where it is reconstructed the original image from spherical to Cartesian coordinates providing a novel but natural immersive experience. This paper describes the motivation, model, computational architecture and our main findings.

Keywords. Telepresence, Immersive environment, Panoramic audio, Panoramic video.

Introduction

Financial pressure are putting pressures on Universities to look for more cost-effective ways to deliver education.. At the same time there is a new generation of students that are more comfortable with online systems which, together with advances in online technology has driven our motivation for this work.

Beyond education, another market and technology driver is the gaming industry which seems to grow at an exponential rate. As a result, numerous educationalists are looking at games technology to understand the core of values that attract users, so the ideas could be applied to education. Having studies these areas, in this paper we propose a new model combining traditional teaching methods with immersive media, taking advantage of the gaming interfaces and workflow to produce an effective interaction between remote and local attendees.

The term "Telepresence" was coined back to 1980 by Marvin Minsky, a Massachusetts Institute of Technology professor, who described it as "*the ability to present and manipulate objects in the real world through remote access technology*" [1]. Later the term has come to refer to remote manipulation paired with a high quality sensory feedback where the end-user "perceives" the remote space as "local" in order to perform the task more effectively.

Following this definition, Bill Buxton redefined Telepresence to include telecommunication, as "*telepresence is the use of technology to establish a sense of shared presence or shared space among geographically separated members of a group*" [2], where presence is considered in terms of two spaces: that of the person and that of the task.

Traditional videoconferencing is a good attempt to establish this shared personal space. However, as technology advances, videoconferencing is increasingly focusing on achieving the sensory feeling of "being there".

Towards those ends we have created an immersive telepresence system that facilitates physically dispersed students, or groups, to collaborate around a shared task with a sense of shared presence. At one end of the link, the local space (e.g. a lecture theatre), a 360° mirror lens is placed in the room, from where a spherical image is captured and then transmitted to a remote location in real time. Once this stream is delivered, it is converted from polar to Cartesian coordinates to create a panoramic video that is projected onto a 180° screen. 3D audio is also collected in order to reconstruct a more natural sound image at the remote learner end by using binaural techniques and directional speakers or headphones.

This setup allows remote viewers to participate in events as though they were local participants, enjoying much greater control over their visual and audio context.

This work was inspired by other immersive projects such as the *"Mixed Reality Teaching and Learning Environment"* (MiRTLE), an Open Wonderland platform [3] which uses virtual reality in the form of avatars to bring geographically dispersed learners together [4]. The work described in this paper advances this field in two important respects; first it replaces avatars with video of real people and secondly it collects panoramic audio at 2 different levels; one for pure audio transmission to the remote user, and a second to calculate the dimensional position of the source, thereby enabling the audio to be recreated and spatially controlled by the end user.

1. Distance learning

Distance learning in its most basic form (e.g. sending materials by post) has been around for more than a century. While traditionally it has been accepted as a method to get on to the education ladder when resources such as time, money and commitment are not fully available nowadays, in addition, it is evolving as a way to provide an extra-curriculum option for people with busy lives . Some Universities have found that distant delivery of lectures has allowed them to have multiple campuses on different locations. This enables them to project their cultural and academic values to other cities, countries and even continents or societies, making better use of their best resources, their individuals, and at a lower cost. Other Universities have used online learning to massively expand their student numbers, for example Shanghai Jiao Tong in China has 40,000 distant learners taking the same examinations as those in their real campus [4].

Some of the issues in the past, with relation to distant learning, has been addressing the quality of the educational experience as compared to that experienced by students in traditional programs. It has been found that the format of delivering the content has little effect on student achievement, as long as the technology is appropriate for the content and all participants have access to the same technology and resources. [5]. The use of online content has been extended from remote learners to local students who want to review a lecture that has ended. Digital lecture recording and capturing has flourished in recent years.

Recent statistics from the High Education Statistic Agency (HESA) [6] have shown that over 10% of the students enrolled at UK Universities during 2010-2011 were studying through distance learning, while another 10% undertook some kind of distance module during their university studies. All of them have used some remote presence tools for collaborative work, such as Skype®, Facebook® groups, Moodle® forum, course message boards, YouTube® videos and similar tools.

Traditional method for distance learning originally involved sending books, tests and videos by post to registered students but have now been replaced by more modern methods. For example, some institutions created their own radio and TV programs to support learning. Videos were introduced and later the internet, the largest repository of learning material to-date. Some Universities have produced a number of courses with more up-to-date resources such as screen capture, RSS audio recording, web pages often centralising learning resources, via systems such as Moodle®, offering message boards and resources available 24/7 to suite the student needs. Social tools such as Tweeter®, Facebook®, YouTube®, Second Life®, etc, have also been added by many universities as part of the student experience, communication and marketing.

2. Social Interaction and Social Presence

What make students engage in an online learning? Beyond the chosen subject itself there is a social view that emerges in support of online learning as the individual join a community group [7][8]. There are 3 interrelated elements that have to be considered:

A. Social Presence

Social presence is defined as the degree to which the student feel socially and emotionally connected to others in the group, projecting themselves as “real” people, independent of the communication medium used [9][10], and should extend beyond geographic boundaries to allow the remote individual to belong to the group [11]. Socio-cognitive theorists describe learning as an interactive group process in which learners actively construct knowledge and then build upon that knowledge through the exchange of ideas with others [12].

Studies on social presence [13][14]determined that social presence was composed of three subjective elements: co-presence, intimacy, and immediacy. None of them naturally available at distance learning, so the need to build a model that takes those into consideration is a paramount for the success of any distant education program. In this “value social interaction“ and ”learning interaction” are the key factors needed to achieve learner satisfaction and goal achievement, which is basically the final goal of any teaching institution.

B. Cognitive Presence

Describes the extent to which the student is able to construct meaning through sustained communication, reflection and discourse or, as Garrison defined:"The exploration, construction, resolution and confirmation of understanding through collaboration and reflection in a community of inquiry" [15].

C. Teaching Presence

The glue element to bring all these together is the teaching presence, by designing, facilitating and providing direction to cognitive and social presence, thereby allowing students to achieve their full potentials. In this way the educator is responsible for providing emotional presence that will lure and engage the student into being inquisitive in order to better progress [16].

2.1. Emotions

Emotions are universal phenomena that people experience in everyday events throughout their lives, and obviously are present in online learning communities [16]. Online objects, such as emoticons, have been created in order to communicate emotions while socialising online [17]. Research on emotional presence within online communities demonstrates the salience of emotion in online learning. Thus, as Harasim stated "emotion must be considered, if not a central factor, at least as a ubiquitous, influential part of learning" [18].

Interaction in any traditional classroom is far more complex than the interaction that occurs in any online course. While the two instructional environments are different, the main asset in a traditional classroom is the pedagogical value of synchronous interactive communication. The student "feels" part of the process and the event, not as external observer but at the pedagogical core. The importance of interaction in distance education has been acknowledged and researched [19][20]. In a traditional classroom the lecture and the scenario will provide visual cues that the student will add into the learning process to reinforce their experience. Because the lack of this connection, remote students may fall into the feeling of isolation and lack of connection toward the lecturer and fellow students. Thurmond et al. reported that students who responded more positively to knowing their instructors also tended to believe that there were a variety of ways to assess their learning, reporting more timely feedback from the instructor; and participating more actively in course discussions [21]. Their research also found that students were more satisfied with their courses and reported greater learning when more of their course grading was based on participating in live discussions [22] and they believed that their participation in discussions enhanced their learning. These findings revealed a positive relationship between high levels of group activity in the courses and their learning. But how is it possible to use distance learning technology to promote discussion with remote students and to engender timely feedback?

3. Sense of Community

In a seminal 1986 study, McMillan and Chavis [23] sought to describe a sense of community and offered four criteria necessary for an acceptable definition. Their model to define sense of community applies equally to both place-based and non-place-based communities, and their elements equally apply. *Membership* is concerned with boundary issues, often represented by feelings of belonging to or sharing something in special. *Influence* looks at an individual's sense of mattering, being shaped by the group, and able to make a difference. *Needs*, more specifically the integration and *fulfillment of needs,* deals with reinforcement and distribution of common resources.

Emotional connection speaks to a community's shared history, similar experiences, and common world-view. The ability to identify other members of the community allows people to determine how to spend resources and time and with whom they feel comfortable. The feeling that the individual can influence or add value to a group will increase the social value, in a bidirectional way. In order to be attracted to the group, an individual must have the potential of influencing the group otherwise he will see it as a burden. The individual association must be rewarding to members and successes relating to the group should bring them closer together.

In conclusion, a group of people with shared values and membership, with similar goals and priorities, will be easily able to focus on specific tasks in a consistent and mutually beneficial way. Sharing emotional events is crucial in creating sense of connection between those members, and in order to provide this emotional connection there is a requirement for some kind of direct interaction between them, based around common task and goals.

It is also evident that people who expend time and energy on projects will feel more emotionally involved in the outcome than those that don't. In addition, providing support, identity and emotional connection can offer the attraction needed for people to progress towards their personal goals.

4. Gaming applied to Learning

Games illustrate the importance of the points made in the preceding section. In multi-participant online games, individuals are given a task, shared with other members in two ways, one as contender to achieve the best individual score and a second as a collaborator helping a team to achieve its goal.

Research has shown that Multiplayer Online Games (or Massively Multiplayer Online Role-Playing Games - MMORPG), like 'World of Warcraft', teaches online players very important life skills such as teambuilding, communication and leadership. Those skills can be combined and be extended to more traditional learning subjects such as economics, sociology, math and science, taking advantage of the learning culture created around MMORP [24].

According to Slater [25] an *Interactive Animated Pedagogical Agent* consists of Adaptation, Motivation, Engagement and Evolvement. The two first agents are easily understood:

A. Adaptation: evaluates the learner's understanding throughout the interaction, adapts the lesson plan accordingly. It also ensures a learner has a good understanding of the basics before progressing to more sophisticated concepts

B. Motivation: this prompts students to interact by asking questions, offering encouragement and providing feedback;

But how can teachers engage and evolve with distant learners through the course of a lesson? Games create engagement, which is one of the cornerstones of any positive learning experience. According to Karl M. Kapp, a learning expert, game-based mechanisms can help to create a meaningful learning experience [26]. The paper we cite [26] shows how to create and design games that are effective and meaningful for learners. Gamification is the use of game thinking and mechanism to engage audiences and solve problems. This term comes from the videogame industry and the development of the internet. Zicherman [27] introduce the concept of a flow zone and illustrate a boredom area to where the player loses interest, and the anxiety area, where the player will probably shutdown the system.

Inspired by Self-Determination Theory (SDT), Deci et al [28] determined that the more control someone has in choosing what to do, the better the chance the person will be internally motivated to do it. People who want to do something because it is fun are more likely to succeed with their intentions than those who are doing something for a reward or to "learn something." When someone is taken into a playful space then the flow of learning will come naturally, with disregard of age, background or any other characteristic. Many of those examples in real-world include museums, libraries, zoos, and botanical gardens [29]. Many of these leisure's settings employ game elements to help users find personal connections with the non-game setting and their cultural value behind the scene. The phrase "*Ludic learning space*" was coined by Kolb and Kolb to define a space where play is used to help someone explore and learn about a topic or, to use his words; "free and safe space that provides the opportunity for individuals to play with their potentials and ultimately commit themselves to learn, develop, and grow" [30]. Those spaces are designed in such way that individuals can choose to enter, "leave themself behind" and engage in play. In conclusion, if opportunities are created then individuals will explore the given space, discover that is meaningful to them and then engage, reflect, participate and allow themselves to be transformed by the system [31].

5. Panoramic Model for Telepresence

The concepts described in the preceding sections led us to design a novel 360° panoramic video and audio telepresence system. We took on board the findings of earlier research that the environment should be as close to a real classroom as possible and that the participants should feed social and emotionally engage, and in control.

We therefor specified and built the system described in the proceeding sections. Using this system we gave gathered measurements and recommendations in which we present in this paper. We have solicited a number of healthy subjects without visual or auditory impairment to assist us in this experimental work. It is important to remember that this project does not aim to provide a 3D image that can deceive the brain into a false belief of contextual presence [4] but rather to provide a 3D immersive experience where the users can directly manipulate the direction of view and its field of view without affecting others' field of view (FOV).

5.1. Human Stereoscopic Field of View

5.1.1. Horizontal Field of View

For most people, the central field of vision, where both eyes observe an object simultaneously, covers an angle between 50° to 60°, depending the visual ability of the individual. This area is called “binocular field” and any object within this field provides a sharp representation, with a precise depth perception where colour and spatial discrimination is possible. Any work on visual reconstruction, to present an item as “real”, needs to be focussed within this area. There is a 30° preferred angle (15° per eye from the centre of the axis), and a 70° of immediate field of view (35° per eye).

Outside those angles our peripheral vision resides, where the information collected is treated in a different manner but may be as important as the central one. Although our peripheral vision is not as good as central for performing detailed work, but it is especially important and good at detecting motion and pre-fetching tasks [32].

A very small eye movement can provide a large set of new data on the horizontal axis, up to 200°. See Figure 2.

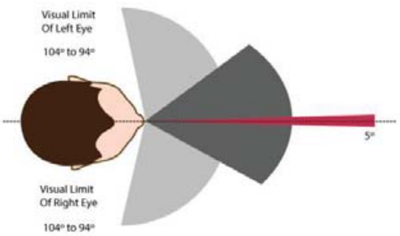

Figure 1. Horizontal Field of View.

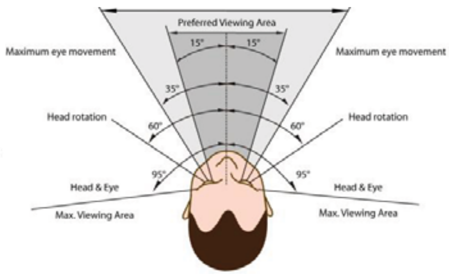

Figure 2. Horizontal field of view and head rotation.

5.1.2. Vertical Field of View

In relation with the vertical field of view, people have developed a different way of perceiving the surrounding space, probably more related to walking and hunting activities. The upper limit is 50° from the normal line of sight, while it is 70° from the same axis for the lower area. It differs if the subject is seated or standing by up to 5° at the preferred viewing area, and same for the area where colour, space and shapes can be discriminated, amounting to 55° in total [33]. See Figure 3 for more information.

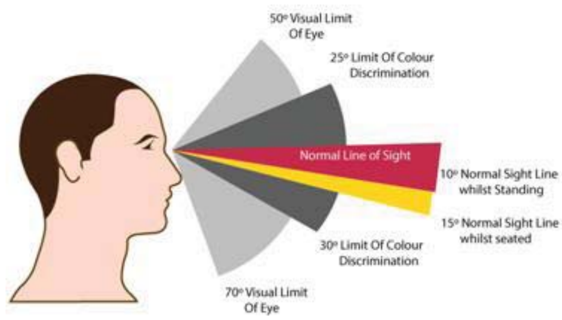

Figure 3. Vertical Field of View.

For optimal viewing on any projected image, the field of view should be larger than 36° per eye, a total FOV of 72°, with an upper bound of 70°, a total FOV of 140° including the peripheral vision, before the viewer begins to feel uncomfortable and will be induced to nausea and disorientation.

6. Proposed System Architecture

6.1. Spatial Video Capturing and Reconstruction

Images are collected from the main location (where the event takes place), such as lecture or seminar room, via a spherical mirror setup in the middle of the room, at a specific height to emulate a seated subject attending the event. This is a 360° mirror supported on a tripod, and with a webcam pointing down toward the center of the mirror. The resulting image is a polar coordinated image (Figure 4 and 5).

Figure 4. Spherical mirror and camera in room setup.

Figure 5. Polar image transmitted

This image is captured by the local *Flash®* application embedded into the website responsible for broadcasting the event, before being transmitted via the internet using a Media Server, using the RTMP protocol.

At the remote end (e.g. a solitary student) the image is received through a standard web browser using a *Flash®* application embedded into a webpage for portability reasons. This remote application performs the image conversion from polar to Cartesian coordinates, and then presents it to the end-user as a 360° panoramic real-time video where the user can use the mouse to move the visibility window left or right to meet their own needs. We provide a system called 'Camera Mouse' to allow hands-free mouse control, via a camera pointing toward the user's face and recognizing any intention of movement.

Figure 6. Polar to Cartesian conversion

Once the image is converted at the receiving end, it is projected onto a specially manufactured 180° screen *"immersive shell"* (Figure 7), produced by Immersive Displays UK and named *ImmersaVu*®. This immersive shell is adaptive, and can be set to different heights to accommodate events that need standing or seating for greater realism. Distant students at home can use their standard web browser and screens.

Figure 7. Immersive shell

6.2. Spatial Audio Capturing and Reconstruction

The audio is collected through an anechoic mono microphone and transmitted along with the video signal.

At the same time 3 other micro systems, made of a single board computers, with an USB microphone attached to each, stream the signal onto the internet, together with a spatial reference in relation to the panoramic video. Therefore a 3D map of the audio source location can be reproduced. These 3 systems are located equidistant from each other to facilitate triangulation. See Figure 8.

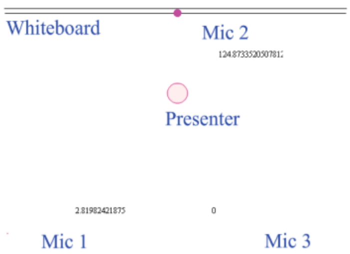

Figure 8. Audio triangulation

Figure 9. Audio capturing system – Mic 3

These microsystems are *Raspberry Pi®* devices driving a *Samson®* USB microphone chosen for its high gain and quality. The audio source location stream is transmitted by using *ffmpeg®* engine producing 3 different streams, one per microsystem. If more precise location algorithm is needed then a number of microsystems can be added to the overall system. The main audio, used during reproduction, is sent together with the RMTP video signal, through the Media Server.

For the audio reconstruction, the end-user receives the audio file as standard audio, with the RMTP video signal, through the *Flash®* application. This signal is combined with an Impulse Response from a HRTF database (Head-Related Transfer Function) . With the IR of the original room so the end-user is able, by convolution reverb, to reconstruct the original sound into a binaural output from a mono anechoic audio stream.

The values for the HRTF database are provided for each 5° angle of the 360° location. So every time an end-user drags and drops a panoramic video 5°, either to the left or to the right, then a new binaural output will be played [34].

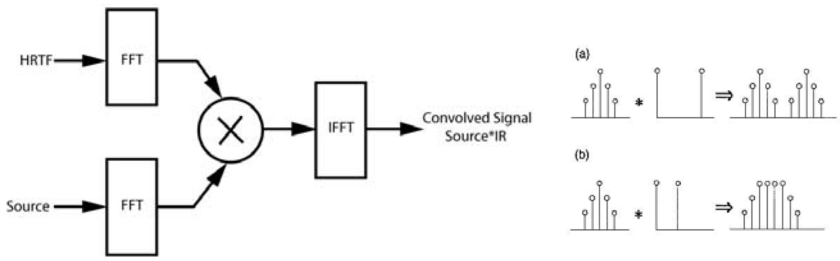

Figure 10. Convolution and output signal

Once the audio signal has been convolved with the related IR (Figure 10), it is then played either though the directional loudspeakers or by headphones. We have used a HHS-3000 Hypersonic directional loudspeakers® for this setup. These directional loudspeakers point directly to where the subject's head should be located.

For binaural reproduction, a set of standard loudspeakers won't work due to the nature of the binaural audio that needs precise ITDs (inter-aural time differences) and ILDs (inter-aural level differences). Because loudspeaker-crosstalk from conventional stereo loudspeakers interferes with binaural reproduction, either a set of headphones are required, or a specific and complex crosstalk cancellation system is needed. In this case we have found that hypersonic directional speakers deliver the narrow beam of audio required to avoid crosstalk, which provides a similar level of performance to headphones [35].

7. Evaluation

The system has been evaluated at different intervals with different users, in an ongoing process when new versions have been created plus it has been presented in numerous demonstrations. Feedback from those people has been gathered and incorporated into the project.

From a technical viewpoint, the system can be regarded as being composed of two distinct sides; the collection and transmission of local video and audio, and the reception and reconstruction at the remote end. A very important strength of the system is that it has flexibility built-in as one of the requirements, allowing users to interact in multiple ways and thereby providing the ability for it to evolve as new technologies emerge. Adobe Flash® ActionScript 3 (AS3) is used as the current platform because of its portability and ability to support rapid prototyping but, in the future, any other platform, such as Java could be used. There are some limitations with AS3 and its library that could be overcome by Java and need to be researched in future work. The process of video reconstruction is a memory and processor intensive task and so we have added elements to the transmission interface in order to regulate quality *vs*. speed during transmission, but need to conduct further investigation to avoid unwanted pixilation and distortions. Also, further work is needed to perform workbench tests to confirm if Bitmap Data handling should take place on the server side, instead of the client.

From a user viewpoint while we have yet to undertake a formal user evaluation, we have through the development of the system involved users. A, common view of all those who have experienced the system is that it opens a new range of possibilities, not just for remote lone learners but also for local classroom based users.

Part of this feedback has led to the development of a browser-only version for those people accessing the system without an immersive shell. Now that we have completed the technical work on the platform, we plan to conduct a more formal user-study but in the meantime, we hope these less formal insights prove helpful.

8. Conclusions

For any distant learning model to succeed is necessary to consider the needs of the individual and the relation with their environment and group; that is y the way that they perceive it. When modeling a group, a priority is to allocate a space where the learners can grow and fulfill their intentions. Being part of a group is an important key to improving the relationship between the distant learner, the teacher and other peers. The success of each participant will be manifested in the success of the group.

We have presented a model, based on panoramic immersive media system, capable of deconstructing and reconstructing remote spaces to give access and additional information to distant learners and local groups. This model provides key elements for the success of online activities such as learning, by providing communication and engagement, and creating a ludic space that is not limited to the academic activity but to any life learning scenario. Thus, we hope that this work provides a new perspective for online education that go beyond the current state of the art by offering panoramic real-time video and audio connections that are controllable and more engaging to users.

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Stories of the virtual mind

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Abstract. The use of virtual worlds and immersive technologies have brought many possibilities for experiencing alternative realities, as some has been used in gaming, medicine or learning. We used this Science Fiction Prototype (SFP) to present a fictitious use of immersive technologies and virtual reality, exploring a futuristic method to learn, described in the story as the concept of "programming information directly into the brain". In the story the main character explores the idea of using the human senses as input/output devices to exchange information with the world, collecting information from our everyday life (life logging); preserving knowledge and creating a way for accelerated learning through programmed physical experiences created within a mixed reality environment.

Keywords. Science fiction prototype, ubiquitous virtual reality, mixed reality, blended reality, human-machine interface (HMI), experiential learning.

Introduction

Imagine the possibility of learning a different language within minutes or the opportunity of becoming an expert in one subject by loading the information directly into the brain, (similarly to what happens to the protagonist in the film *The Matrix* [1]); or the possibility to capture and preserve all the invaluable untransferable knowledge obtained by experience that specialised professionals, such as surgeons, researchers, etc., possess. This Science Fiction Prototype (SFP) delves into an imaginary world were all the information that goes through the senses is captured by an implant and then it can be recreated using virtual reality and immersive technologies.

1. Background

In this paper we incorporate diverse technologies extending them to a future vision of their possible implementations for learning, using the method of science fiction prototyping [2]. We explore the use of immersive technologies and virtual worlds to propose an unusual method of accelerated learning based on Kolb's ideas on experiential learning [3]. He suggested that learning can be acquired from grasping concrete experiences in real-world and by creating abstract conceptualization of new

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information, and then transforming this experience using reflective observation and active experimentation. This develops a preferred way of learning, following patterns defined as “learning styles” [4]. Fleming's VARK model extended learning styles based on the channels for input/output information, targeting learning as the final objective. These categories are: visual learners, auditory learners, reading-writing preference learners and kinaesthetic or tactile learners [5]. Based on this, the SFP proposes the use of external stimuli as a way to create physical experiences which accelerate learning by implanting information on the learner’s brain. Shibata et al. [6] used “decoded functional magnetic resonance imaging (fMRI) to induce brain activity patterns to match a previously known target state improving performance on visual tasks” [7], inducing “highly selective activity patterns within a brain region, thus allowing the investigator to influence specific functions”. According to them this method “can ‘incept’ one to acquire new learning, skills or memory, or possibly to restore skills or knowledge, which has been damaged through accident, disease or aging, without one’s awareness of what is learned or memorized.” [6]. This research explores plasticity in visual areas of the brain generating visual perceptual learning. In our story we extend this to a hypothetical situation where learning can be obtained not only through visual stimulus but using auditory, olfactory and haptic stimuli simultaneously within an immersive environment to acquire learning.

The use of mixed reality virtual environments in education has been implemented in many projects, e.g. [8] [9]. These examples use virtual worlds as an extension of traditional physical classrooms, motivating visual or auditory learners and enabling geographically dispersed students to attend and participate in lectures. In previous works [10] we proposed the use of a blended reality learning environment to perform laboratory activities, using a mixture between tangible user interfaces embodied in real-world objects and virtual devices, enhancing the learning process for kinaesthetic learners. This SFP explores the illusion that virtual worlds can deceive the mind using different stimuli and immersive technology (as presented in videos such as [11]); having as an outcome an enhanced accelerated learning process. Murray et al. [12] presented the use of immersive virtual reality to treat pain, in an experiment similar to the ‘rubber hand illusion’ [13]. They used a virtual world, a Kinect camera and a sensor to track user’s head movements to create a virtual image of the patient’s amputated arm which was causing him chronic pain. Reportedly, when the user visualized and moved both of his arms in the virtual world using immersive glasses, the pain was reduced [12] [14]. This shows just one of the possibilities of the use of virtual reality and immersive technologies to change brain behaviour and deceive the senses. Some other uses of virtual reality have been related to the treatment of mental disorders such as schizophrenia [15], where avatars used as virtual representations of the voices heard by schizophrenic patients might help them to take control over the hallucinations [16].

Our story delves not only with the possibility of implanting information onto the brain but also with the possibility of recollect information captured by an individual through its senses to then recompose all the elements with the intention of “relive” experiences; capturing valuable information that then could be reused in other persons to transmit and preserve knowledge. A problem described in the story is that people’s memory tends to edit, forget or rewrite specific (maybe vital!) details of the lived experiences, in order to reinforce their values and beliefs. To solve these issues in our futuristic world, population have implanted a life logging device which captures every detail of the life on an individual, similar as the idea showed on the film *The Final Cut* [17]. Life logging is the process that captures every event in a person's life, generally using sensors and wearable devices such as mobile devices [18] or cameras [19] that get information automatically every certain period of time [20]. Besides the many issues on privacy, an interesting challenge is the management and organisation of all the data recollected to provide meaningful information that can be used in diverse applications such as medical monitoring. In [21] the authors proposed a framework to create a story-based visualization of all the recorded data. In our SFP the main character uses a similar organisation system with the information collected not just to preserve certain memories but to reconstruct the experience captured as it was happening again, using immersive technology.

2. Creative Science Prototype (CSP)

"Most people die before they are fully born.
Creativeness means to be born before one die" - Erich Fromm

2.1. Sophia

- "What is reality? Reality, like time is just a concept for human beings. Certain situation could be real for you, but not real for everyone else. I mean, you can believe that something is real, like the existence of God, but for others it can be just a concept, an idea. But, when does it become real? When everyone can feel it with their senses?" With these ideas Sophia always started her talk on 'What is reality?'

Figure 1. Sophia working on her virtual environments

She was a neuroscientist and owner of a company focused on creating virtual experiences for people. The company started with multiplayer videogames, and then, with the boom of augmented reality (AR) - thanks to devices like AR glasses, AR contact lenses, AR helmets, etc.-, just like many other companies it moved to virtual experiences. In these experiences engineers could create almost anything, and then implemented in immersive devices with special audio, video, haptics and even olfactory devices, they could deceive the senses and the mind. Because of the degree of 'reality' in these experiences, some people had been driven to a point really close to madness, especially when they asked for things like to recreate a dead person, or create the perfect partner. To prevent these cases, the government implemented laws classifying the type of experiences, banning most of the direct human-avatar interaction, and limiting the use of these experiences to 20 hours a month. However, in case of using this as a medical treatment for disabled people, the number of hours could be increased, (filling the appropriated forms!). Due to these restrictions, people usually just asked travelling to real or imaginary places in their immersive experiences; the Caribbean, the Mediterranean, even a different planet or imaginary locations described in a book or movie. Sophia always thought that these laws restricted creativity; still she fortunately could find one or two clients willing to try different experiences.

"Imagination is the beginning of creation. You imagine what you desire, you will what you imagine, and at last, you create what you will" – George Bernard Shaw

2.2. Hank

Hank was a rich septuagenarian widower, obsessed with the possibility to live again the happiest moments of his life, rejoicing again with his childhood, memories of his mother –gone long time ago– and the remembrance of his late wife. This was similar to the idea that people can see their life in a flashback when they have near-death experiences; but with the bonus of choosing which memories they wanted to bring back. This was possible because in this era all the memories were recorded from the beginning of the life of an individual. In older times, people did this voluntarily, uploading their photos, achievements, activities and thoughts to social media. But those methods were primitive, people could select what things to upload, creating a different digital persona from the one they really were. This resulted on people looking successful and popular on the recorded data, but with a reality completely different from what they have declared. Early experiments on memory transfer of information from digital media to the brain, ended up with a person completely different from the one scientists were trying to create. Sophia recalled a very unfortunate incident, when a person completely lost his memory in an accident. The family asked Sophia's company to upload into his memory all the data they recollected from the social media. Obviously as it was previously censored by the patient, when they put this data into the memory it resulted in a completely different persona. The family couldn't recognise their relative.

Nowadays to keep a better record of a person's life, hospitals implant a microscopic chip to new-borns, to record everything from the beginning until the end of their lives. The problem with Hank was that because of a human mistake (it seems that humans will never surpass this characteristic!) he got a faulty implant (or maybe is the technology the one that will never surpass this!). Sophia and her team had been working for several months trying to create a virtual experience based only on digital photos, old emails, digital voice records, etc. This project had been a nightmare to Sophia, because Hank was never satisfied with the quality of the experience. These kinds of projects were difficult even using real data captured with the implanted device. Sophia discovered that people also perform an unconscious selective mechanism to erase memories and some of them, with the time, get mixed with other experiences, own or borrowed, like movies or someone else's stories. Therefore even when she and her colleagues worked with real data obtained from the microchip, people always surprised when they re-experience a particular memory as they didn't recalled as it was. It is an entirely different feeling to experience your born when you are a baby than re-experience it later when you are an adult!

"*Creativity involves breaking out of established patterns*
in order to look at things in a different way" - *Edward de Bono*

2.3. Clem

Clem was Hank's second child. She grew up in the middle of a successful business family. As far as she remembers, most of her relatives were involved in the family business since the beginning of the company. This company was the largest chain of food pills in the world. Food pills became a successful business a few decades ago, when people were so busy that they didn't had time to do regular stuff, i.e. for shopping, online commerce appeared; for reading, audio books and immersive books appeared; for food, Clem's family created special pills which can transform in a whole meal and send to your brain the best tasting experience ever (even if you repeat the same pill for all your meals!). Clem was in charge of the company's business planning, for that reason she had to travel almost every week to different parts of the world. She was fluent in four languages, and being a very sociable young woman, she had a good relationship with everyone. But she had a secret that lately was giving her many headaches: she always felt as an impostor, as if she was watching all her life through a monitor; a woman looking like her but living, acting, speaking and interacting different with the outside world. Inside her brain she always had contradictory thoughts, and she needed to translate not only her words to different languages, she always felt as if she was also translating her life. But why does she need to translate each word, each action, and each movement before doing it in the 'real' world? She felt like if there were two persons inside her brain. One with the original intentions, thoughts that had different ways and different goals, which were not appropriate to her; and other showing her the behaviour she was expected to do. She always followed the latter, but the original intentions, before the 'translations' were the things she really wanted to do.

Clem's problem was that her brain carried out two types of memories; she could remember what she did but she could also remember her original thoughts, her original intentions, her original words, even the original experiences inside her mind before the translation she performed every time that she acted in the 'real' world. Sophia's company diagnostic was: "The individual records two different memories; one for the acts that she did in the 'real' life and other for the intentions displayed into her mind". She always had control on her acts, she could always differentiate between what she did and what she thought… until now.

Sophia's team found two implants into her brain: one was an old model containing Clem's unreal experiences; the other one was the one that contained 'real' memories, but the team could not remove any of the implants without losing Clem's personality. They didn't know why her brain was always translating all her thoughts and actions, and recording both, 'real' and 'unreal' experiences. Clem wanted to keep the 'unreal' content and remove the other, but this could collapse her 'real' life. The only way to feed those internal 'unreal' experiences was living and acting in the real world, and therefore keep registering real life events, otherwise she could not feed this second life. It was a vicious circle.

"You see things; and you say, 'Why?'
But I dream things that never were; and I say, 'Why not'?" – George Bernard Shaw

2.4. Paulo

But besides her everyday work at the company, Sophia was doing some research on her own. She was obsessed trying to find a way to program a human brain without using an implant, based on the idea that human anatomy had already all the chips required for almost any programming goal. She was always avid to learn, and her maxim goal when she was younger was to be able to hold all human knowledge in her brain, in other words to be a 'know-it-all' literally. On her first experiments she tried to create a method to upload the information to the brain. She thought that if a computer can hold immense quantity of information on a hard drive, well, the brain seemed to do the same on humans. She tried first this method, but the result was something like a humanoid robot, he had memories and information in his head but he didn't know how to use it. This resulted in just a method to implant information in the brain, just like the old practices of hypnosis and subliminal advertising.

Then she discovered that the key to program a brain was the experiences that the person feels when a particular event happens. She read many theories of learning (Pavlov, Skinner, Piaget, Papert, etc.) and she agreed with Fleming's VARK model [5]; in which a person can learn through his/her input devices: the senses (visual, auditory, kinaesthetic, etc.) and this happens when learners are willing to digest and accept the information provided by the senses. This was the moment when she thought of reusing experiences from her clients, preserving memories and specialised knowledge, and transferring it to a different individual. Imagine that you could transfer the experience of a skilled surgeon, or the genius of a musician, or… well the possibilities could be unlimited! This was her main motivation to work every day at the company; she wanted to focus on constructing immersive environments where all the senses could be deceived, allowing users to enter in a different reality, and experience virtual as real to transfer and collect information. She started with visual environments and augmented reality; in these initial environments people were deceived only on their sight but the experience although very realistic wasn't described by her users as complete. The next step was to include more senses to create a real immersive experience. She realised that the mind can be completely abstracted and focus on one environment at a time (what Lifton [22] defined as 'vacancy problem'), just like when people concentrate on their screens watching a movie or having a videoconference and forget time or situations happening around.

Then the first step was to create an environment able to provide external stimulus to human I/O devices (aka senses). She knew that certain sounds change human behaviour, like music, since a tune can change people's mood and make them feel better… or worst. And what is music after all? Is it just a sequence of sounds? Almost all music is written under mathematic measures and certain combinations of volume, timbre, and harmonic patterns which might lead people to a certain mood [23]. For example she recalled reading about the work of John Sloboda [24], which analysed human reaction to certain musical constructions. For example, he discovered that a particular construction called 'appogiatura' creates sadness on listeners. She also knew about the so-called 'Mozart effect', which seemed to show short-term improvement on the performance of spatial-temporal reasoning [25] as a consequence of arousal or mood [26]. Levitin [27] says that 'musical memories intermingle with events, emotions and other information about the context of the experience of the music' giving it an evocative capacity. For the stimulus of the other senses she studied colour psychology and its relation with human behaviour, physical reactions and its influence on learning [28] [29]; she also studied olfactory memory [30] and stimulus over anthropological comportment as it was reflected on Patrick Süskind's book 'The perfume' [31]; one of her favourite novels.

After years and years of research she created a test environment, but the simple suggestion of the experimentation was a very big problem for the authorities. How could they know that she would not harm the subjects on the test? And also what kind of programed information she could insert into their 'guinea pigs'? Finally after many paperwork and many problems, she was ready to try her environment in a volunteer: Paulo. He was a middle-aged gamer who spent most of his time (and money) betting on illegal 3D casinos, where people can only play if they bet huge amounts of electronic money, and if they do not have money then the owner can lend it to them with the highest rates. In many countries it was illegal of course, as in those cases lender's gains are higher and the probability of win is low (e-money tracking in this business is a real challenge for authorities). Paulo just loved the excitement and intensity of these games and as an optimist at heart; he always thought the next game would be his lucky game. Sometimes he gained enough money to pay the bills, buy food pills and holographic clothes, but most of the time he was in bankrupt. Sophia had chosen Paulo because as an experienced 3D gambler, he had many hours of training using virtual worlds and particularly immersive videogames where the gamer participate on mixed reality tasks to achieve a goal. Paulo accepted because he really needed the money, he had many debts and due to this he had been suffering of anxiety. He just wanted to end this problem and then go to a gambler's rehabilitation clinic.

The test was designed to program Paulo's brain to understand Spanish, (he only knew English and some words in German as he used to have a German girlfriend in college). She collected the data from the chip of many Spanish speaker subjects; creating a repository of the language an educated 30-years-old would possess. She turned on the machine, and set the knowledge to a B2 level, which represents an intermediate level (around 500-600 hours of study [32]); she was calculating a feasible amount of information in order not to overcharge Paulo's brain. After a moment of doubt she started the process. The machine started to recreate an incredible cocktail of sounds, visual images and colours and olfactory inducements along with other electrical stimuli for skin. Paulo had many sensors attached to his skin to measure his heart rate and body temperature. The machine went on for the first hour, and she felt confident about the process, Paulo's sensors indicated that he was having an experience similar to deep sleep (REM frequency). By the second hour she started to get nervous but she tried to calm down and think that everything was calculated thoroughly. The third and fourth hours were a really painful process for her; Paulo's heart rate had increased as if he was running on maximum speed. She was not sure if she wanted to continue with the process but she was even more afraid of stopping the process and leaving Paulo in the middle. As she didn't know what could be the consequences she decided to wait. The machine stopped at the fifth hour. To be more precise, it took 5 hours 19 minutes and 27 seconds according to Sophia's chronometer. Her heartbeat was so fast that she took a minute to breathe. She checked Paulo's vital signals. They looked fine; his heart rate was decreasing slowly, but he was still, with his eyes closed...

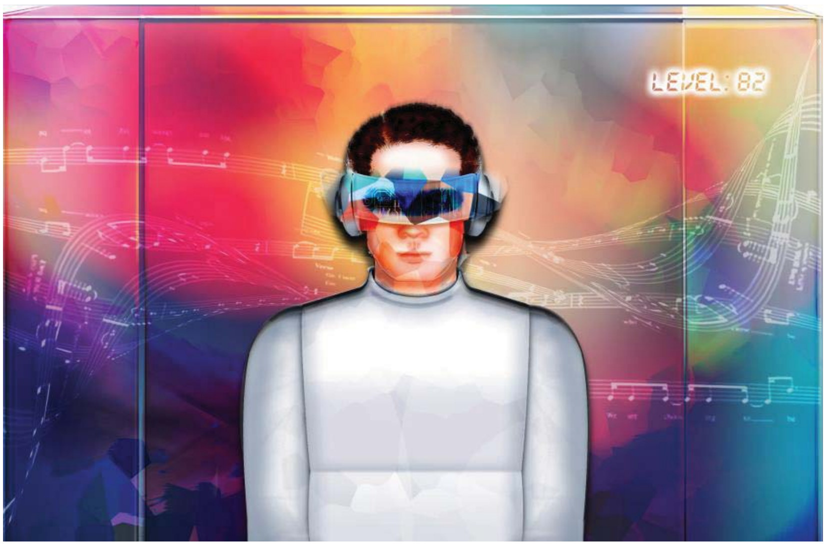

Figure 2. Paulo inside the environment.

3. Reflections

In this CSP we proposed the use of technology to capture, preserve and transfer knowledge, in the form of experiences, from one individual to another. In particular, our stories proposed a fictional scenario using virtual worlds and immersive technology as key elements in the learning process. We described a relation between collecting and storing data using devices implanted in the human brain and transferring this information to a different individual, enabling an imaginary possibility of programming human brains in an accelerated manner using mixed reality environments.

The story superficially touches issues such as free will and human ambition, the role of life logging in an individual's life, and some risks and ethical problems of capturing, managing, classifying and preserving information. We left our story without a defined end in purpose; with the intention of generate discussion about the benefits and problems of these methods, having in mind all the elements described in the story. What could it be the positive and negative effects on people's lives if everyone could have access through this sort of learning to any subject they would want to learn? Has the human brain the capacity to hold unlimited knowledge? Would it be any side effects? What kind of laws would be necessary to implement in order to regulate this imaginary scenario? What impact would that cause in the world? Would that completely modify for good the present educational model?

We are aware that this SFP do not offer answers to these questions but we hope that it will raise ideas that might identify solutions towards the construction of a new enhanced learning era.

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A Comparision of the use of Gestures to Control Computer Games

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Abstract. This poster presentation will present some preliminary work carried out to investigate the design and comparison of a range of gestures to control computer games using a Microsoft Kinect device. This poster will compare the use of five gesture types when used to play two different types of game with experienced and non- experienced players.

Introduction

The aim of this work was to compare different types of gestures and determine which were best suited for different types of game. The detailed objectives were:

- Comparison of different gesture types
- Investigate how to design different games to support gesture control
- Comparison of gesture control compared with normal controllers such as the keyboard and mouse.
- Determine whether different gesture types were more suited to particular types of game.

Discussion

Many computer games make use of virtual worlds and avatars in which the user can do things which they cannot do in real life. For example street racing, playing football with their favorite team, exploring a warzone and shooting enemies.

In a virtual world we have a visual representation of ourselves which is called an avatar. In order to control these avatars and the virtual environment the game will provide a number of different controls options. These can include:

- Keyboard and mouse
- Joy stick
- Gestures

This poster presentation will demonstrate:

- A comparison between five different types of gesture controls.

- A comparison between the use of gestures and normal controls (keyboard & mouse).
- An analysis between which type of gesture is most suited for which type of game.
- Five types of gestures selected for comparison are Beats Gesture, Deictic Gesture, Iconic gesture, Metaphoric gesture, Spontaneous gesture.

The main purpose of this research is to find which type of gesture is best suited for which type of game, keeping in mind the user's requirements. The main reason for selecting the above five mentioned gesture's was that humans use those kinds of gesture in daily life and that way they can use them to play games along with doing their daily tasks like physical exercise and at the same time it is comfortable and entertaining to play the game. For this, I have used Microsoft Kinect sensor to detect the gestures. First, the necessary hardware and software were setup that was necessary to capture gestures. Then two game types were used for this research. These were:

- Racing Game (Need for Speed Carbon(predesigned games not for gesture) & Kodu (designed game for gesture by me))
- Shooting Game (Counter Strike – Condition Zero)

The open source Flexible Action and Articulated Skeleton Toolkit (FAAST) was used to create gestures and controls for each game. 5 different types of gestures were designed for each game.

Evaluation

Once all the gestures were created and mapped to the games an evaluation was carried out. For this research, this was done in two phases:

1. Formative evaluation. In the first phase, the gestures were tested with a small sample group and the results were used to further refine the different gesture controls.
2. Summative evaluation. In the second phase, the gestures based on the outcomes from first phase, were tested with a larger group of users.

I have completed both the phases of evaluation. Results obtained are quite similar from what I was expecting but I got to some more new conclusion after this, which are shocking.

Poster summary

The poster presentation will provide an overview of the work done on this research. This will include the use of gestures to control computer games, the issues found when designing different gesture types for the different games, and the results obtained after the evaluation.

Storyweavers

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Abstract. This Creative Science paper reviews critical thinking and suggests that rather than a purely mental construct, good thinking is embodied and situational. The concept of embodied expertise is presented, followed by a story in a not so distant future when nanobots implanted in people's bodies will allow us to modify brain and body signals, creating virtual worlds that will blend with or entirely replace reality. This paper argues that the challenges that we currently face require educators not only to teach skills but also to help people find their path in life. Beyond delivering information, it is speculated that teachers will be asked to translate knowledge, experience and expertise into fully immersive stories.

Keywords. Science fiction, critical thinking, embodied cognition, embodied expertise, immersive worlds, storytelling

Introduction

Our society faces difficult challenges, with a growing number of individuals suffering from depression, neurosis, alcoholism, and drug addiction. Suicide rates at global level have increased by 60% in the last 45 years, according to Suicide.org. We are seeing a considerable number of teenagers who are victims of bullying and harassment and reach the unfortunate conclusion that death is better than life. We are also witnessing increased violence and rage in young people that have lost hope in the future.

The educational system spends considerable time delivering information but in many cases, as young students, we are not taught how to face deeper issues. In school we learn mathematics, chemistry and physics, but we receive little help regarding how to go about life, which is what most of us focus on throughout the rest of our existence.

After decades of promoting rote learning and unquestioned premises, we have arrived to a point where we may have to conclude that our model is not working. As Facione mentions, "the eighties witnessed a growing accord that the heart of education lies exactly where traditional advocates of a liberal education always said it was – in the processes of inquiry, learning and thinking rather that in the accumulation of disjoined skills and senescent information" [1]. The eighties are long gone, but education has kept the desire to help people think better.

How feasible is it to teach critical thinking? Imagine for a moment that you are a prisoner in a cave where the rays of the sun can never reach you. You, however, lead an unquestioned existence, since you have never been aware that you are a prisoner. You know there are others like you, because you can hear their voices and you can talk to them. All of you spend your time pondering the shapes that are projected on the wall by a fire you cannot see, shadows to which you give different names, like

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"mountain" and "tree". That constitutes "reality" for you and your fellow prisoners, even though it's just a reflection. Suddenly one day you manage to escape from the cave following a rough and steep path. Reaching the outside world you are able to see for the first time the real mountains and trees, the lakes and oceans. Thrilled with your new understanding, you pity those you left behind in the cave, for what they consider reality is not more than a shadow of the world. So you decide to go back and 'enlighten' those who are still in the cave, but what you say sounds incoherent to them, and finally they conclude you must be mad, a menace to their well-preserved status-quo, and kill you.

You probably recognized in this previous tale a short unorthodox summary of Plato's Myth of the Cave. In my opinion, it summarizes how difficult it is to change thinking patterns in individuals. We resist change and anyone who tries to change us. We normally go about our business unaware of our beliefs, content with our realities, until a crisis forces us to check our assumptions. Can we teach how to think better before we reach a crisis? Could the solution to teaching critical thinking skills be the words of Cicero? "If you wish to persuade me, you must think my thoughts, feel my feelings, and speak my words." This Creative Science paper explores this possibility.

1. Thinking Critically

What is critical thinking? Since critical thinking is commonly confused with problem-solving and decision-making, the American Psychological Association decided to create a panel of experts, their objective to systematically arrive to a definition [1]. The consensus was that critical thinking is a "purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based. As such, critical thinking is a liberating force in education and a powerful resource in one's personal and civic life." The definition goes on to describe the critical thinker, cognitive skills and sub-skills involved, and affective dispositions. Even though this definition is certainly valid and encompasses the many variations of critical thinking, I would like to focus on more practical versions, which are essential for everyday living.

In educational gerontology and adult education, critical thinking is related to challenging long-held beliefs and judging how efficient they are in the context of a new reality. In this situation, critical thinking (CT) can be considered a tool to find the meaning of one's existence [2].

In a ground-breaking work in the field of adult education, Brookfield proposed that critical thinking involves two processes: identifying assumptions, and exploring and imagining alternatives [3]. The purpose of identifying one's assumptions is to uncover strategies that were acquired in childhood without much evaluation, and challenging their validity and applicability to one's current situation. Usually, though not always, a difficult situation or crisis triggers this process. The second part of CT takes care of producing new alternative paths or ways of thinking that will agree more with reality.

In the same line, Mezirow's perspective transformation deals with the process of reflecting on perspectives culturally acquired, and how they impact us and our relationships [4]. Mezirow agrees with Brookfield in identifying 'life dilemmas' as the triggering events of transformation, and also in that this process cannot be carried out in an individual vacuum but requires a social dimension that will allow discussion and validation of new paradigms.

The emancipatory nature of CT is shared by Paul, who divided the construct into macro-logical skills (of emancipatory nature) and micro-skills (technical) [5]. As a guiding force, it is seen by Ennis as "reasonable reflective thinking focused on deciding what to believe or do" [6]. CT as a means to free oneself from unchallenged paradigms is the process that underlies the search for meaning in a specific situation –and at a larger scale of one's existence– in order to efficiently deal with it.

In this emancipatory definition of critical thinking the underlying assumption is that thinking is a purely mental process, disconnected from our bodies. However, there has been a relatively recent shift in the way we view cognition, from considering it a purely internal process to being situated, distributed and embodied.

2. Critical Embodiment

Cognitive, perceptual, and motor operations cannot be seen as separate as it is frequently the case. Memory-based and perceptual-motor strategies act together to influence the way the individual interacts with the environment. It can be said that cognition encompasses not only formal operations 'in-the-head' but also the situation the individual is in, the physical properties of the environment he/she is acting on and the body used to act upon the environment. The environmental context provides opportunities for action (affordances) which our bodies are designed to detect and act upon, creating a cycle of action and feedback [7]. Learning is defined then as the "education of intention and attention" [8].

Embodied cognition is not a clear-cut construct. Simple embodiment sees the body as a constraint on the internal processes and representations [9]. The flow of information from the environment through the body and to the mind is what Clark considers cognition. A more radical approach is that of Chemero which directly stems from Gibson's ecological psychology and abandons mental representations entirely, what Chemero calls 'cognitive science without mental gymnastics' [10].

If we adopt an embodied perspective, then rather than using logic and other purely rational tools to teach critical thinking, we need to make the individual aware of the possibilities for action afforded by the current situation, mindful of how the body is reacting and how it is influencing, and how in turn it is influenced by thoughts and mental images. I suggest that critical thinking goes beyond mental models and is more in line with what Suwa calls 'embodied expertise' [11]. I would summarize embodied expertise as the optimal balance between mental processes, sensory and perceptual information, body skills and the surrounding environment.

Embodied expertise would be applicable to all levels of what we define as critical thinking, from the skills required to play an instrument or dance, all the way up to the process of giving direction and meaning to our lives. Immersive technologies are starting to offer us the possibility of 'living' knowledge rather than understanding it at a purely conceptual level.

3. Storyweavers

3.1. Zara

Zara was not looking at the vast ocean in front of her. Her eyes were focusing on empty space while in her mind she revisited the path she had followed to reach the top floor of the Observatorium, the massive structure on the artificial island of Miura. The memory of sneaking through forbidden corridors and doors made her fair skin redden slightly. Her hands were still shaking and her heart was beating fast. She bit her lower lip and raising her hands to the top of her head, she undid her ponytail and run her fingers through her hair. Her silky black hair framed her delicate features and contrasted with her big turquoise eyes. Gently she massaged the stiff neck and shoulders.

She sat on the wide fence bordering the building's roof. Was there any way to fix this mess? She thought about this old song from years ago. Immediately the nanobots inside her body lit up and began sending neural impulses that resulted in a high-definition three-dimensional hologram of a song retrieved from her memory right in front of her eyes. The sound enveloped her entire body.

"Whenever something is too unpleasant, too shameful for us to entertain, we reject it. We erase it from our memories. But the imprint is always there", said the face in front of her.

Her thoughts switched to the days and hours that had led to that moment. The holographic image in front of her eyes receded in space and was replaced by images of her body and her most inner thoughts and desires paraded all over the global stream for everyone to see. Her profile holograms were all vandalized with obscene drawings and hurtful insults. Some went as far as encouraging her to 'just die'. However, she realized that being physically naked in front of everybody was not as painful as being ridiculed for her adolescent dreams. Because she fell in love, she was accused of being easy. Because she dared to explore, she was accused of being an ugly whore. Everything she had thought of becoming was trampled on viciously. Even her music.

Music moved her and took her to places she could not reach any other way. Shyness turned into wizardry when she played the violin. Before she had to carry the instrument wherever she wanted to play it, but all that changed when she met Iain. She did not know where he came from but she was fascinated by him. It was her birthday and she received this strange card from him: "Open me and what you love will always be close to your heart". She thought he was referring to himself, except for the use of 'what'. She opened the file and felt a strange tingling sensation. She recognized that her system had installed something that modified her nanobots. After a few seconds the centuries-old Alard violin, one of Stradivarius' finest creations, materialized in front of her eyes. She had smiled thinking it was a common hologram but then he heard Iain's voice saying: "Come on, play it!"

First generation nanobots, like the ones she used to carry, were only allowed to modify an individual's perception system up to a certain point, for fear that their capacity to influence sensory and neural signals could be misused. Humans could interact with holograms and they could feel almost like the real thing but playing a holographic instrument had remained a challenge because it required modifying brain and body signals in a way that was strictly forbidden. It was not just about touching the instrument. It was about the precise texture, its response, the acoustics, even how it felt in one's hands and how it influenced one's body. Iain had told her about second generation nanobots that could emulate these experiences and more, but he had been very secretive about it.

She felt silly but grasped the bow with her left hand and with her right hand rotated the instrument to place it on her collarbone, finally resting her jaw on the chin rest. She propelled the bow and music flowed as if she were playing the real thing. She felt a strange sensation, as if someone was driving her execution, but she was soon carried away by the sounds of the instruments and her own mind.

After that day she started feeling music in a completely new way. Her body moved as if she were a different person, in a manner that she could not understand but felt just right. After that day she could not say no to Iain.

“We can be connected now, you and me. We can share our thoughts and desires. We can be one, never mind where we are!” Back on the roof of the Observatorium she remembered she had indeed shared everything, much more than she should have.

She thought of the violin and the nanobots created the illusion of the playable instrument in front of her once again. She stood on the edge of the fence, two kilometers away from the ground, and started playing. The sound of the violin followed the ethereal voice of the song she was listening to.

“Can't fight it all away, Can't hope it all away, Can't scream it all away, It just won't fade away.”

Tears fell down her face, her eyes closed. The nanobots, still reacting to her thoughts, surrounded her with holograms of her parents listening to her play, and her sister that used to tease her calling her ‘creepy ghost’ because of her pale complexion. Completely immersed in the music she felt weightless. She played for a long time not noticing the cold wind against her skin. Suddenly she stopped, breathed deeply and opened her eyes.

“God, please don’t hate me.”

3.2. Ailsa

“I hope I won’t get into trouble”, thought Ailsa. The web of messages danced in a three-dimensional mesh in front of her eyes, reconfiguring themselves according to the way she wanted to search. She found the one she was looking for and isolated it with her mind. After struggling with herself for a while, she unwrapped the content: the MeridianMod in all its glory, and a modified dance environment to go with it –courtesy of Zara’s mystery boyfriend– were ready for her.

She held the files and opened her hands. She felt the code modifying her nanobots and once the process was over, she checked her body to see if she felt any different. Nothing. She opened the dance mod and chose a song. A hologram appeared in front of her, ready to demonstrate the routine. Ailsa started moving her body slowly following the music. She knew this routine well. Suddenly, she felt a gentle twist of her leg moving it in a slightly different manner from the way she normally did.

“You’ve got to be kidding me…”

Great dancing did not come just from the brain but from the understanding of the music piece and the interpretation the dancer created about what that music meant emotionally. It naturally depended on the motion of different body parts and where those movements where taking place. The environment, other dancers, the energy of the music and audience, delivered cues that the expert was able to decode but the novice overlooked. Of great importance was the dancer’s awareness of his/her own body through the proprioceptive system. Apart from augmenting all these elements and delivering real-time information to the prospective dancer, as first generation nanobots did, second generation nanobots went further by modifying the information between the brain, the body and the holographic and real environments around the individual.

So with first-generation nanobots, a person could see a holographic teacher, imitate its form and superimpose his or her own hologram to see where the differences were in real time, striving to match the correct technique. Color codes, plan-like lines and highlighted symbols quickly indicated the areas where everything was working well and those that needed improvement.

In contrast, second-generation nanobots, which were created by Professor Ethan Suk to enhance learning, added emotion and embodiment. They modified sensory and perceptual information in order to reach the perfect level of training. Thinking about moving a hand in a specific way was not the same as actually moving it that way. The dancer could attempt to do the exact motion of the model, but lack of training or physiological constraints could result in the wrong movement. Or the technique would be perfect but performed without emotion or expression.

Here is where the new nanobots would kick in. Coded within the example offered by the experienced dancer were the levels of emotion translated into brain chemicals, and the exact muscle and joint motions that were necessary to achieve that specific level of proficiency. Nanobots would induce the same emotional states by modifying the levels of brain chemicals and would send signals to muscles and joints to replicate the exact same motion.

The trainee would at the beginning be almost like a puppet, but as the dancer's body became closer to the target, nanobots reduced their influence. Dancers would no longer go through long hours of training without having a clue about what it really felt to be a great dancer.

Second generation nanobots were at research stage and faced a steep path to being approved because of the potential control nanobots could have over physical and emotional states. What Ailsa was experiencing was a modified version created by hackers.

Ailsa quickly chose a difficult song, one that she called her 'nemesis'. Whenever she danced that routine, the teacher's hologram and her own would engage in what tended to look more like a Sumo wrestling match than a coordinated dance. Watching the reviews made her sometimes wonder if she should have been better off doing something else.

She was ready. A sudden energy flow went through her body. She felt the nanobots gently sending sensory information to her muscles and joints. She felt a bit like invisible hands twisted her limbs gently correcting her moves and getting them closer to the expert's. Her skin felt almost like touched by the music, her face reacting to every single nuance in the musical piece. She thought of visualizing herself and she appeared as a hologram right next to the trainer. But this time it was different, she moved gracefully and for the first time she really felt that song and understood what it meant to move her body to that tune. She continued dancing with herself, her body sensually flowing as carried by invisible guides. Nanobots released the right chemical soup to reach a state of pure emotional flow with the music.

Suddenly, one of the nanobots' state changed and started to release an increased dose of epinephrine. Ailsa started feeling a sense of exhilaration and her heart started pounding. A few seconds later, the nanobot induced the release of phenylethylamine, which in turn triggered dopamine. She felt attractive and sexual. She smiled at her holographic self, flirting a bit like she would with a real partner. It was then that the nanobot started to broadcast an encrypted holographic signal of her sensual dancing. She was enjoying herself very much. And so was Iain.

3.3. Chief Inspector Kinlan

Chief Inspector Cerys Kinlan sat in front of a long table. Rather than each individual being physically present in the room, each chair was filled by a hologram, an immediate transmission of the actual person located somewhere else on the planet. The table and chairs, except for hers, were of course the product of her own nanobots recreating the necessary space for the meeting.

The Web 4.0 was now standard across the entire globe. People could access information and get it directly delivered to their brains. Humans did not just visualize information. They were immersed in streams of data. Advanced artificial intelligence delivered the right content at the right moment. Anyone could access any information resource and learn anything they wanted. Education had become widespread even in the poorest areas of the world. Nevertheless, depression had become the number one global disease followed closely by other mental diseases. Stress and anxiety dominated a society of overpopulated cities with hundreds of millions of people and scarce resources.

"Where is she?", asked Cerys.

"We don't know, ma'am. The last satellite transmission of her position indicated that she was moving towards the outskirts of the city but we lost her after a while. She has activated her firewall and we have not been able to trace her."

The hologram in front of them showed a 3d map of the city with an orange path glowing through the transparent-blue buildings and stopping in the Nova district.

"We are the police department and we cannot track a teenager, is that what I am hearing?"

"Ma'am, we have 300 million people in this city, almost 100 artificial islands surround it with roughly the same population. Also, she is not a regular teenager. She is highly intelligent and she has upgraded her nanobots to second generation. We are only experimenting with them so far. She has applied the MeridianMod patch to her system."

Second generation nanobots were not available to the public but hackers had been quick to create a patch, the MeridianMod 1.0, its name based on the autonomous sensory meridian response, which was defined on the global stream as a "perceptual phenomenon characterized as a distinct, pleasurable tingling sensation in the head, scalp, back, or peripheral regions of the body in response to visual, auditory, olfactory, and/or cognitive stimuli." The patch was a modification of Professor Ethan Suk's work.

The mod allowed direct sensory and perceptual information in the brain and body to be modified. It made possible to mix the virtual world with the real one in an almost indistinguishable manner. It also allowed full access to the individual's system.

"And where is he?"

"He is under custody, ma'am".

"Good, we are not as ineffective as certain people claim. And what do we know about him?"

"He is a sort of regular kid, relatively social. He moved out of his parent's place a couple of months ago, because according to him they were just too stupid to understand him."

Cerys nodded and a new hologram materialized in the centre of the room. She carefully observed the athletic man staring directly into her eyes. She did not expect him to have glowing glyphs tattooed on his scalp and his neck. Cerys' younger sister was considering getting them but she thought they looked weird on a man. She noticed Iain kept one eyebrow raised and his lips slightly pursed as if he was the one analyzing her.

"I want you to hack into her system and stop her from doing something stupid. Now."

"She gave me access to all the information I posted. Now she is making a big deal out of it."

"She trusted you and you took advantage of her."

"She was the one complaining about not being able to play her stupid violin everywhere."

"You accessed private thoughts and sensory information that did not belong to you, and made them public. You broke the law and you could be held responsible if anything happens to her".

"She should have read the fine print", answered Iain with a grin.

Cerys wished at that moment she also had second generation nanobots so she could slap him and make him feel at least some degree of pain.

"I will make sure you don't enjoy one more day of freedom if you don't help us."

"What freedom?", he yelled back. "You mean the freedom to roam the streets? The freedom to see people starve to death? I don't care about your stupid freedom. People die every day. She will be just one more."

Chief Inspector Kinlan stayed quiet for a moment and then, using the same tone of voice she had used all along, said: "You will help me find my sister or I will make you suffer beyond anything your mind considers possible in this world".

3.4. Ethan Suk

From the messy white hair, unshaved face and wrinkled clothes one could conclude that Ethan Suk had been hiding in some dark corner of the planet, alone with his computer, for the past two centuries. An emeritus professor at one of the leading global universities, he had created the original code on which the MeridianMod was based.

"As you well know, Chief Inspector Kinlan, I created this code with the idea of going one step further. Just sharing information is not enough for humanity. For far too long we have lived in our heads. Our bodies need to be incorporated into the equation. Our mental, sensory and perceptual systems are important parts of what makes us human, and they are involved in how we apprehend knowledge, in how we interact with the world. My idea was simply to take human learning to the next level. I have conceived a way where essentially you can perceive what I perceive and interpret it in the way I do, generate your own concepts or share mine, and follow my body response or chose your own. So far we have augmented all physical places on Earth. I can go to Stonehenge and see with my own eyes what happened there centuries ago, explore and even play a role in that society. But this is still purely a mental exercise. I have no idea about how they perceived their world, or why they reacted the way they did, or how their bodies behaved in that world in response to that specific environment."

"That's all very good, but your code allowed this hacker to steal images, thoughts and sensations from my sister and post them all over the stream. I need to find her before she does something foolish. And you will help me".

Professor Suk took a deep breath. “I would not call Iain a hacker. Old school hackers have ethics. For them, the goal is to create art and beauty using a computer. We may disagree with their concept of art and beauty, but they do believe computers can change life for the better, even though they reject authority.”

“Iain seems to be the destructive type”, he continued. “Highly intelligent, he gets easily bored with what regular people term ‘education’.”

“Spare me the psychological profiling. Can you get into his system?”

“He has a solid firewall but I am confident I can see what he is up to”. Professor Suk proceeded to work with his holographic computer. He did not need to type code as his thoughts were transcribed directly into the compiling console. Eye-motion determined the steps he wished to follow. After a couple of minutes he stopped.

“Ok, I am in. But you will not like what he is doing.”

With a swift gesture, he shared his holographic display with Cerys. Ailsa was dancing almost naked in front of them. “I have severed the communication, she will be ok now. I think I have an idea. Maybe now is time to test my theories, if you allow me to do so. We might need permission to run this procedure.”

“Forget permissions, I will deal with that later”, Cerys said. “Just get my sister back.”

3.5. Iain

“Hello, Iain. I am Ethan Suk.” Professor Suk’s hologram appeared in front of Iain’s field of vision.

“How did you bypass my firewall?”

“Let’s say I have a more refined version of your mod. Like a 1.5 sort of thing”.

“Your code was junk. I just made it better”, replied Iain.

“I am a messy coder, you are right, but I learned from my mistakes. But you know I am not here to talk code. I severed your communication link with Ailsa because it was active. You have cut all communication with Zara, why?”

“I could not stand her whining. So people have seen her naked. Big deal!”

”I think you went further than that. You stole her thoughts and desires, a whole bunch of private information that was not yours to share.” Suk paused for a moment and then added in a calm voice: “Iain, a girl is about to die if you don’t stop her.”

Iain looked at Suk for a moment and then asked: “What kind of upgrades have you made?”. Suk looked puzzled for a moment but answered the question. “My nanobots are able to control lower versions of nanobots at all levels. I can present myself at will, like I just did. I can create illusions for other people. I can write their realities if so I wish.”

“Is it even legal?”

“Coming from you, Iain, that is a very strange question to ask.”

A second later Suk knew his strategy had succeeded. By taking advantage of a vulnerability planted in the code, Iain was hacking Suk’s system and had downloaded the upgrade.

“As I said, your code is still junk. Now let’s see what this can do”, said Iain with a proud face.

Professor Suk’s holographic projection appeared to be affected by static. “You see, Iain, it is time for me to try a little trick of mine. I designed this program to help people understand anything at a very profound level, not just in their heads. I lied when I told you that I could create any reality I wanted. In fact, I needed a tiny piece of code in your system, the one that you have just kindly installed. I have written a new reality for you."

Iain was no longer in his cell with Suk. He was in a black and white world, one step beyond redemption. He saw the crumbling roofs and towers of gothic cathedrals, ruins of magnificent buildings hidden by a dense forest of dead trees. He tried to scream and cursed Suk but the only sound was that of death. He felt the cold wind burning his skin. Following the dry bed of a river covered with ice, he run for what seemed like hours, falling again and again. Out of breath, dark gray blood covering his face, he reached a cliff and fell to his knees. He faced distant colorless memories, broken promises, and unlived dreams, creating a phantasmagoria of emotions he could barely handle. All of a sudden everything stopped and what he saw in front of him was the view from the Observaturium. He then heard his own voice: "Zara, stop!"

4. Conclusion

While the literary merit of the previous somewhat dark story is highly questionable, I wanted to present a perhaps naïve view of what technology might one day enable us to do with respect to what we currently call teaching and learning.

If we conceive experience as embodied, then better thinking will really mean better perceiving, feeling and acting, within the specific reality we face. In general, the tools we use in educational institutions, at least beyond a certain age, teach the mind only. We sit for hours and listen, when perhaps we should be moving, talking and acting.

As educators we are in charge of teaching different kinds of skills but I believe that as our world changes, we will also be more in charge of helping people live. Whenever someone says the word 'education', images of formality, boredom and stillness fill people's minds. Nevertheless, in essence what we do in life is to learn and most of us don't find that particularly dull.

Immersive technology can bring a level of embodiment to learning beyond anything we have seen so far. Naturally there will be risks, and we will have to debate how far we can go. In this new environment, we will be asked to move beyond the delivery of information and create realities that will help us learn and safely make mistakes. We will no longer be able to compartmentalize knowledge. Instead we will be required to string together skills, domain-specific facts, competencies, attitudes, motivations, emotions and all the components that allow us to apprehend reality, be it playing an instrument, building a rocket or understanding the reason why we are here. Through technology, educators will create immersive stories where people will experience and appropriate our collective wisdom.

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Fostering Learners' Interdependency Relationships in MUVEs

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Abstract. Multi-user virtual worlds can be used to model authentic learning environments in which knowledge can be created collaboratively on its context. However, collaboration cannot be considered a given and careful consideration of the design of learning activities and organizational support must be provided to foster collaboration. In this work, we present an interdependency pattern that promotes the collaboration of students. The pattern is deployed in a multi-user virtual environment where synthetic characters guide participants in a situated learning experience. Preliminary results of the pilot study suggest that participants were able to perform required activities by establishing interdependency relationships stated by the proposed pattern.

Keywords. Collaborative learning environments, distance education and telelearning, interactive learning environments, virtual reality.

Introduction

The growing popularity of multi-user virtual environments (MUVEs) has drawn attention from educationists due to many benefits or affordances for learners. Researchers have found that representational fidelity and interactive possibilities of MUVEs [1] have a great potential in the educational context as they engage learners and to explore, manipulate and modify the virtual world by means of their avatars in a collaborative way [2], [4], [7], [14]. However, just as in face-to-face environments, productive learning interactions among participants are not guaranteed and some mechanisms must be provided to foster collaboration [5], [13].

This paper describes an interdependency pattern (see Section 1) that fosters collaboration among participants by controlling the information that the environment provide them. The paper also introduces different ways to deploy the pattern within a MUVE taking advantage of the unique elements of these environments (see Section 2). In Section 3, a case study uses the interdependency pattern in a MUVE to enact a situated learning activity. Synthetic characters invite participants to play a plot with them while learners try to accomplish a mission; learners' efforts intend to improve their communication skills. Preliminary results of a pilot experience are presented in Section 4. Finally, in Section 5 we present the conclusion of our work.

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1. Interdependency pattern

Knowledge acquisition within a community requires from its members not only the ability of acquiring information effectively, but also the ability of transmitting information. The information might be either received passively or acquired inquiring to other community members. In the last case, effective communication feedback is necessary to eliminate any possible noise introduced in the communication process. These communication skills are not easy to promote in courses due to the difficulty to isolate and organize pieces of information in a controlled environment and the problems tied with the transmission of messages within a community.

In this work, we propose an interdependency pattern that promotes learners' knowledge acquisition through interactions with peers. The pattern consists of the following steps:

1. Preparation. Instructor identifies the self-sustaining units of information ($u_1,\ldots,u_m$) to transmit to the learners' community.
2. Distribution. Learners are organized into groups ($g_1,\ldots,g_n$). Each group receives a subset of the information and references to missing pieces of information. These missing pieces of information should be acquired by talking to members of other groups.
3. Intra-communication. Each learner group compares, discusses and agrees over the shared units of information, and plans how to find the missing ones.
4. Inter-communication. Learners interact with members of other groups either to ask or to provide information.
5. Final agreement. Each group of learners agrees upon the whole information.

The amount of units of information determines the minimum number of groups needed to deploy the pattern. Depending on the desired amount of discussion, the teacher could increase the number of groups. Problems inherent to any communication process such as the lack of ability to communicate information or misunderstandings should be neutralized through redundancy of information [18].

To illustrate how to handle the information redundancy among a group of students, let us analyze the example presented in Figure 1. The diagram shows three groups of students denoted by g_1, g_2, g_3, and four units of information denoted by u_1, u_2, u_3 and u_4. With this schema of distributing information, each group acts as guarantor of the quality of information it owns. Each student group receives from the system three units of information and must seek another piece of information which is known by the other groups. For instance, each member of g_2 receives the units of information identified as u_1, u_3 and u_4, and must enquire the missing information (u_2) among members of the groups g_1 and g_3. In this example, each piece of information is known by at least two groups of students, thus in order to seek the missing information, it is enough to talk to people from other groups. Furthermore, u_4 corresponds to basic information that must be received by all groups.

The pattern is inspired by the linear error-correcting Hamming code [10] which is able to protect a set of information bits (u_1, u_2, u_3, u_4) from a single error on the channel by adding redundant bits to the signal (g_1, g_2, g_3). Hamming code can also correct any single error that occurs in the bits. Each redundant bit is the result of a parity check computation performed on a subset of the information bits. Thus, in our schema, groups represent redundancy bits of Hamming code and are the guardians of information accuracy. Instead of parity check calculations, the schema promotes the dialog among group members to recover and validate the units of information. The Hamming code can be applied to any number of units of information and groups.

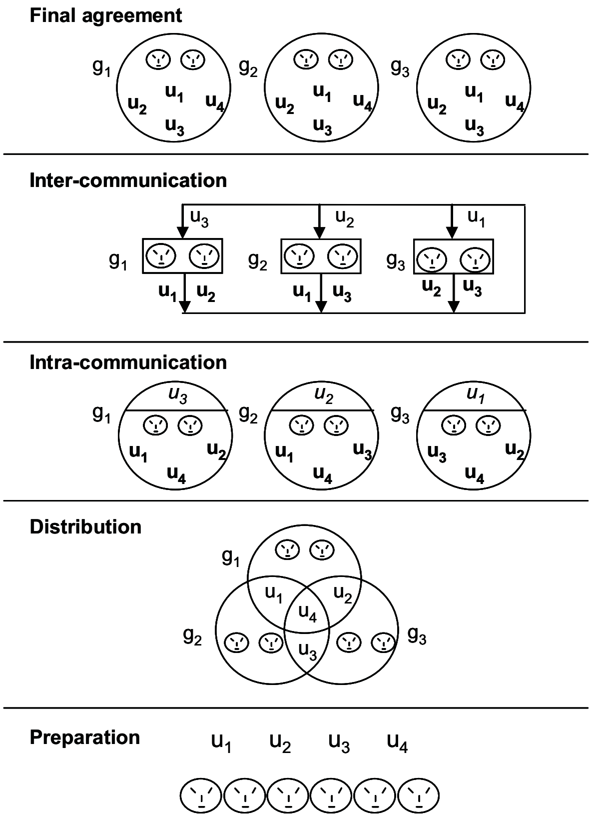

Figure 1. Interdependency pattern for acquisition and distribution of information using redundancy

2. Deploying the interdependency pattern in MUVEs

The interdependency pattern presented in Section 1 requires administrative and workflow management capabilities in order to be successfully deployed in a MUVE. Administrative management capabilities are needed to organize learners in groups, to populate the world with information and to restrict visualization of information to groups. MUVEs can provide information not only through the multimedia channels found in flat web namely text, audio and video; but also through the 3D setting, interactive 3D objects and synthetic characters. Workflow management capabilities are required to guide students through the different learning tasks.

2.1. Administrative management capabilities

Regarding information, MUVEs offer the possibility to transmit information using primarily visual and auditory channels in a three-dimensional interface. The 3D scenery can be considered as a medium to transmit visual information which is frequently enhanced by 3D audio. Both are primarily responsible of evoking the feeling of immersion among users. The MUVE's scenery can be populated with multimodal information represented either by text, pictures or video associated to smart objects. In order to deploy the interdependency pattern presented, the units of information must be associated to smart objects. Units of information must be provided to students with permission to access them. Thus, MUVE toolkit must provide scripting and visibility (or security) capabilities. On the other hand, synthetic characters offer singular possibilities both to provide information and to guide the workflow of learning activities. They are potentially very valuable for transmitting information through dialogues, and can cohabit with instructors or team mates in the virtual world [17]. To this end, synthetic characters could hold the units of information chosen by instructors during the preparation phase. Then, at the distribution phase synthetic characters will be grouped according to their units of information forming conversational groups. These conversational groups will be programmed to perform a theatrical representation to learners belonging to their group. In summary, scripting capabilities of smart objects and synthetic characters along with group creation and visibility capabilities of 3D virtual world software toolkits, allow to support the first and second phases of the interactive pattern presented in Section 1.

2.2. Workflow management capabilities

When dealing with the coordination of collaborative learning activities, it is worth distinguishing between the support for guiding learning flows and the coordination of interactions that lead to collaboration [6]. Research on technology-enhanced learning have mainly been devoted to the former through modeling languages such as IMS LD [12] which allow the specification of actors that will use a subset of learning resources, when this should occur and under what conditions. In the collaborative arena, authoring tools such as COLLAGE [11] use these specification languages to formalize collaboration scripts that mediate the interaction of group discussions in learning environments.

Attempts have been made to integrate learning management systems to 3D virtual worlds to support the flow of activities. For instance, Sloodle [15] integrates the Second Life immersive virtual world with the Moodle Learning Management System while <e-Adventure> [3], a platform for the creation of eGames, is connected to a Learning Management System to report the results achieved at the end of the game activity.

None of the approaches found take advantage of the graphical capabilities of 3D virtual worlds to support automatic orchestration. In the education arena, synthetic characters are potentially very valuable. They can be used to support a narrative story that guides learners' interactions in the learning environment. Indeed, synthetic characters can be in charge of the enactment of orchestration scripts that help on individual accountability throughout the different learning tasks learners have to accomplish.

For the particular case of the interdependency pattern presented, three kind of options seems feasible:

1. Instructors guide students within the 3d virtual world.
2. Synthetic characters guide students through the different pattern's phases.
3. Integrate a learning management system to the MUVE and program the transitions from the distribution to the final agreement phase.

In relation to the effort required to deploy the chosen solution, the first option is the most appealing whereas the last option is the hardest to deploy. The second option is a trade-off solution that allows to use the narrative possibilities of MUVEs.

3. The interdependency pattern applied to a case study

The interdependency pattern was originally developed by the authors of this paper as a fostering mechanism of communication among learners of Spanish as second language within a 3D virtual world. The situated learning experience took place in a 3D multi-user virtual world that imitates the Madrid landmark, "Gran Vía" boulevard, an emblematic area because of its architecture, commercial activity, and cultural atmosphere. Students were the main protagonists of a story that began at "Plaza Cibeles", continued along the "Gran Via" boulevard and ended at "Plaza España". Every student, by means of his/her avatar, walked up and down the Boulevard compiling information on the shows available in the different theatres with the final goal to purchase a ticket for the show he/she preferred. However, none of students was allowed to compile all the required information directly, the interdependency pattern forced them to exchange information with their peers in order to take their final decision. Synthetic characters guided and provided relevant information to students during the learning activity. The didactic goal pursued was to improve students' communicative language skills that include language comprehension, expression and interaction with peers.

The learning activity was designed applying the Robert Gagne's nine events of instruction [8] applied to edutainment [9] and take advantage of interdependency pattern to force students to build knowledge in community by practicing communication skills in a ludic way, being protagonist of a plot (see Table 1).

Table 1. The interdependency pattern applied to a learning activity devoted to foster communication skills among learners of Spanish as second language

Gagne's nine events	*Case study's activity*
Gain attention	The activity was situated in a mirror word where learners could be faced to a similar situation. The MUVE provided advantage of immerse participants in a controlled environment without external stimuli.
Inform of objectives	A synthetic character was responsible for informing participants about the mission they had to accomplish so as well as how to begin the next activity. This was the first activity and was situated at "Plaza Cibeles".
Stimulate recall	Not applied

Lesson	The lesson was composed of all except the preparation phase of the interdependence pattern. At the distribution phase, initial information was provided through dialogues enacted by groups of synthetic characters placed between "Plaza Cibeles" and "Plaza San Luis". The dialogues provided information about the shows on at the time, but different (and complementary) information was given to different students. Inter and intra communication phases where carried out in different places at "Gran Via". The intra-communication phase was held between "Plaza San Luis" and "Plaza Callao", and the inter-communication phase was held between "Plaza Callao" and "Plaza España". Whereas the distribution phase promoted listening skills, inter and intra-communication phases promoted speaking skills.
Provide learner guidance	A synthetic character informed participants about what they had to do in each activity.
Provide feedback	Not applied
Assess performance	Once each group of participants finished the final agreement phase, they wrote their conclusions in a 2D note included in the virtual world and sent it for final grading to the instructor. Then, the MUVE provided them with a ticket for the show chosen.
Retention and transfer	Not applied

The learning experience was deployed in Open Wonderland v0.5 (OWL) [16], a client-server toolkit for building 3D virtual worlds. Besides its immersive and communication capabilities that enable the deployment of collaborative social spaces, it offers particular features useful in supporting this learning activity:

- The environment can be customized by designers' artwork and multimodal information can be included.
- OWL scripting mechanism allows the interaction customization of 3D objects and synthetic characters for learning purposes.
- OWL has capabilities to assign users to groups along with a security mechanism that restricts interactions with assets according to group membership.

4. Preliminary results

The case study was deployed in Open Wonderland and a pilot study was carried out to determine whether the interdependency pattern would foster collaboration among learners and engage them into a situated learning experience. To this end, twelve participants were recruited to work through the task scenario. Participants ranged in age from 20 to 40. None of them had experience in the use of virtual worlds. Six sessions were carried out, each with the participation of two participants located in different rooms. Each participant was guided and observed by an evaluator. The sessions were video-recorded. During this process participants were asked to use the "think out loud" protocol and evaluators observed their behavior when using the application. Finally, each participant was interviewed by his/her evaluator.

Preliminary results of the evaluation showed positive effects on participants' collaboration during the activity, communication was established in a natural way and complementary information was exchanged following the steps of the interdependency pattern. Participants became part of the designed plot within the "Gran Vía". They were guided by synthetic characters and received the required information through the dialogues enacted by groups of synthetic characters.

5. Conclusions

Educators have confirmed the usefulness of MUVEs to fulfill educational goals using modern pedagogical approaches and to reach desirable learning outcomes due to their immersive and interactive capabilities. However, most attempts to use MUVEs for educational purposes deploy learning activities with scarce or no orchestration. As a result, successful collaboration does not always emerge. Our work intended to provide an example of MUVE's capabilities to deploy learning activities where orchestration is guided by synthetic characters through a narrative process.

We presented an interdependency pattern designed to foster communication through distribution of incomplete information to participants. Participants are forced to communicate the information received with their fellows in order to gain the knowledge necessary to accomplish a final goal. The pattern is based on the Hamming code, linear error-correcting codes. Thus, it can be easily adapted to deal with a different number of groups, and different amount of information. Consequently, an instructor should focus her work on defining the narrative goal and group the pieces of information that are necessary for students in order to build their knowledge.

The interdependency pattern was deployed into a MUVE designed to practice communication skills for learners of Spanish as second language. Synthetic characters were used both to provide the information to participants and to guide them along the learning activities. Learners were immersed in a mirror setting of "Gran Via" boulevard in Madrid and were invited to participate in a story with a final mission. They were confronted to the difficulties of not having the necessary resources to achieve their goal and were forced to practice communication skills in order to succeed in their mission. This learning activity can be easily deployed in another context by changing the 3D setting, the synthetic characters and adapting the interdependency pattern as we indicated before.

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Techland, a virtual world for maths and science

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Abstract. This paper describes Techland, a virtual world based on OpenSimulator [1] developed for didactic purposes. Techland is structured as a group of thematic islands dedicated to maths, chemistry, biology and earth sciences. It was built by the author in 2010 and it is used in everyday lessons. This paper explores how virtual worlds with its different learning settings and degrees of interactivity is useful in teaching sciences to 11-14-years-old students. Two case studies are described, the first about maths, the second concerning sciences. The interactivity capabilities range from viewing the contents of the world on an interactive whiteboard, as a support for the teacher's lesson, to logging on the student's avatars into the world for collaborative works. Finally the paper focuses on the importance of integrating different learning setting in order to increase the quality of teaching, and to motivate students.

Keywords. OpenSimulator, Techland, Virtual worlds, Maths, Science, Machinima

Introduction

One of the major challenges facing today's teachers is to bridge the gap between their own language and that of the digital natives [2]. Virtual worlds are one of the ways that can help teachers to improve students' learning using the same digital technologies they love and making subjects such as maths and science attractive and appealing, without sacrificing scientific accuracy.

Since 2010, the author (aka Michelle Techland) started to build and experiment Techland, a virtual world for students from 11-14 years old, combining the passion for informatics and virtual reality with her teaching job.

Techland was initially created to simplify the learning of mathematical concepts, and it has gradually evolved and expanded, including the various branches of science (in Italy maths and science are generally taught by the same person for that age range of students).

Techland was planned and designed to go beyond the concept of 'classroom' as the only learning environment. To emphasize this aspect, there's nothing there that resemble a college: no classrooms and no desks, avoiding the re-creation of the preexisting models of education. It is a mix of natural and urban environments where stimulate the creativity and imagination of students and show them how to study in an interactive and collaborative way, making learning fun.

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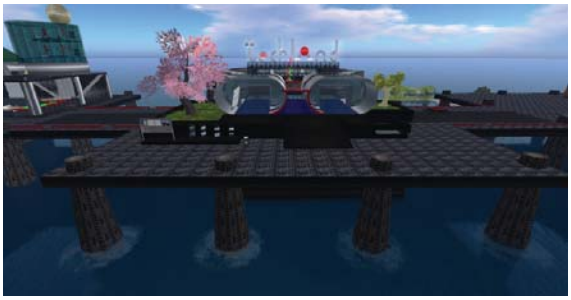

Figure 1. Techland, the Welcome Area.

1. Techland

Techland (Figure 1) is a group of a dozen thematic islands dedicated to maths, chemistry, biology and earth science [3], [4]. It is based on OpenSimulator (OpenSim for short), an open source 3D application server software to create virtual worlds and it resides on a Linux server (2 TB local disk space, 16 GB real memory) managed by the author. All data are stored in a MySQL database. Techland is configured to be accessed from the internet only by authorized teachers and students and runs in a Standalone mode, as a private world, for security reasons [5] for the protection of underage students. If necessary, the world could be configured in a Hypergrid mode [6] to travel among different worlds in different Opensimulator installations. Generally students log into the world using Singularity or Imprudence as a graphical interface user (viewer) [7], [8]. Every island covers a specific subject or facility (Figure 2):

- Techland is the Welcome Area, where the initial information is found and where students can reach the other islands by the teleport system. Here the ongoing projects are displayed.
- Mathland is the city of math (Case study 1, section 3.).
- Waterland, focuses on water (Case study 2, section 4.).
- Powerland is dedicated to renewable energies, particularly hydro, solar and wind energy and it is the result of a collaborative project [9] developed in 2012, the International Year of Sustainable Energy for all, focused on the renewable energies and the relationship between humans and the environment
- Chemland concerns to the structure of matter and chemical reactions.
  Through the animation of atoms and molecules students better understand the various atomic models, the properties of elements and their bonds, and they can follow in real time a chemical reaction taking place.
- Bioland is dedicated to environmental and cellular biology. Like other sims, it spreads over several levels: on the ground it is configured as a set of natural environments (the coast and the sea, the marshes, the Mediterranean flora). Starting from about 1000 meters high there resides a giant cell and other biological simulations.
- Earthland is the place where students learn earth science. At the sea level the water cycle is shown, using special scripts called particles [10] to simulate rain, fog, clouds, rivers and rainfalls. In the air the layers of the Earth and of the atmosphere are represented.

Figure 2. From above and left: Bioland, Powerland, Mathland, Earthland, Chemland and Waterland.

- Techstore and Tech Sandbox are service sims that support all activities. The first is a big Store where textures, small objects, avatar apparel accessories and scripts are found; the second is a building area where students are free to enjoy with *primitives*, the basic geometric building shapes, and learn how to build.

2. Learning settings

Generally two main approaches to the world are described: Teachers allow students to develop all their creativity in building and animating objects or teachers build a specific subject eventually to be re-used by different cohorts of students [11].

We have been experimenting Techland in several non-mutually exclusive ways, with different degrees of interactivity.

- Displaying the contents of the world on an interactive whiteboard to support the 'classic' lesson in the classroom. In this case the teacher's avatar acts as a sort of teaching assistant, interacting with the objects and giving information.
- Using screen capture software, such as CamStudio [12], to film the in-world activity or single objects (reactions, geometric transformations, physical phenomena) and then to include videos in multimedia products (web sites or e-books) or to display them on the IWB. In literature reviews it is reported how video and hypervideo tools handle mathematical concepts in a way that help the learning process [13].
- Let students log into the world by an avatar (with or without the teacher, from classroom or home) to explore the world, to follow virtual lessons, to interact with 3D learning objects and to customize their knowledge pathways.
- As a virtual community, developing together specific projects in the classroom or at a distance.

It follows that pedagogical concepts are based on "learning by doing" in a collaborative way.

In daily teaching Techland is mainly enjoyed by showing its contents on the IWB and creating multimedia products (see section 3.). Experiences of virtual communities have been made in the context of specific projects in a given period of time (see section 4.). In any case, students are free to access the virtual world from home to customize their learning, or to enrich the content of an island importing their own multimedia presentations or building objects.

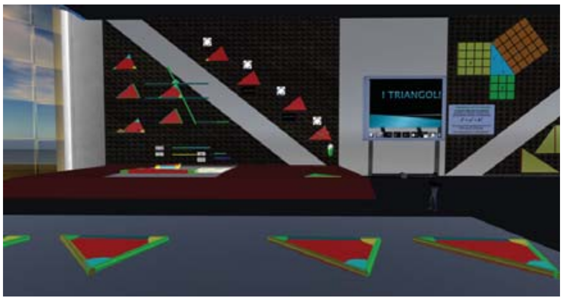

Figure 3. Animated objects and a slider in the 'Plane Geometry Area', Mathland.

The following are two different learning settings, with different degrees of immersion and interactivity, the first about mathematics, the second concerning science.

3. Case study 1: Mathland

Mathland is the city of math. It is built on a big platform in the sea of Techland and it looks futuristic and technological, and its architecture has strong geometric connotations as well.

It has been created with the main objective of simplifying complex abstract concepts in geometry and letting the students' approach to math be fun [14], [15]. The idea has been to provide a flexible learning environment to support the daily work of the math teacher in the classroom and, at the same time, to promoting personalized learning of the students in the free exploration of the city from home. Geometry topics are developed as a sort of 'urban path', both care-free and guided, in different sections of the city, where animated objects show different geometrical properties and interact with the avatar, giving information in real time.

Starting with the conviction that a 3D vision simplifies the understanding of complex and abstract concepts and gives a correct perception of space and geometric transformations [16], the city has been structured where most of the animated objects are 3D paragraphs of a virtual immersive and interactive book, displaying dynamic geometric properties in real time. Objects shifting, rotation, colour and size changes are obtained by inserting scripts inside them. Scripts are written in LSL language (Linden Scripting Language) and they are directly created in-world with a special text editor [17], [18].

The more laborious part has been to design animations, making them effective, easy to understand, attractive and more explanatory than any pictures, providing, at the same time, enough information. Thus by simply clicking students interact with the object, start the animation, make multiple choices through the menu, or chat with the object to issue commands. During the animation they get information from items by instant chat and also label. Moreover, using special Info Point students can also link to notecards for further investigation or click through external web links or Geogebra files [19], to expand or integrate the world resources, downloading or consulting materials. In a special area students create and transform *primitives* to obtain simple or more complex geometric shapes, or they use special photo sliders to place the common multimedia presentations, previously converted into images (Figure 3). Videos can be displayed in-world on special screens.

Students go around the city, passing or flying through lines and angles or cubes, or even run between two parallel planes or sit astride a line. They become familiar with the spatial relationships between different parts of a geometric figure and 'feel' the same objects' properties that can be realistically manipulated and experienced. The teacher can evaluate the students' work by screening their slider and objects, by in-world test competition between students, or by common written tests.

Therefore Mathland can be considered a 3D immersive and interactive book, in which different media are well integrated, enjoyed both on IWB in the classroom and from home. A copy of Mathland is open to visitors in the Craft grid [20] and Osgrid [21].

4. Case study 2: Waterland

Waterland is a typical example of how it is possible to enjoy the world in a collaborative way with the integration of different media. Waterland was just a verdant expanse of land as long as the students took possession of the empty island with their avatars, planting their class flag, and creating a 3D project about water.

The island has been considered by the students as a sort of repository in which collect and store all their work (research data, multimedia presentations, graphs, videos, simulations). All activities had been planned and discussed in the classroom, sharing ideas and dividing jobs, then they were developed both in the computer laboratory and at home. Waterland was divided by students into thematic sections:

- A building area to build 3D objects, which are then moved in the relative sections of the island .
- The Water Palace, a huge water molecule, dedicated to the chemical structure of water and its properties. Several physical and chemical phenomena such as changes in states of matter, capillarity and solubility of ionic compounds in water was displayed.
- The Info Point, a building on the sea to organize all the videos and multimedia presentations made by students.
- The Statistical Area, with the 3D graphs of data emerging from the research
- A house to display all data about domestic water use.
- A 3D representation of all the other activities that consume water and that are a source of pollution (agriculture, industry).
- The wastewater treatment plant and phytoremediation.

Students worked together, exchanging information, sharing inventory objects and tools and communicating on a horizontal level. Therefore students were encouraged to take more control of their learning process. During their activity, students recorded videos in-world (*Machinima* technique) to illustrate the water properties, to explain the world situation of water resources and consumption, to sensitize people to a conscious use of it. Using *Machinima* movies they showed their point of view in a creative way [22]. All videos and multimedia presentations also became part of a website [23].

As a result of this project they obtained a second place in a national competition and wished that other cohorts of students could take advantage from their work.

5. Conclusion

In this article two different but strongly integrated approaches to the virtual world, have been discussed. Real and virtual teaching both contribute together to the involvement and motivation of the students. While the explanation in the classroom, mediated by the virtual world or the video lessons, manages to capture the attention and simplifies the learning of abstract concepts, the home reworking of the student classwork, on the other hand, is a key moment of the learning process, both personal and collective (in the free exploration of the islands, the building activity or the organization in-world of the multimedia sliders). It is clear also that the students consider the islands a kind of repository continually evolving, adding information and objects, and this gives them the awareness that knowledge must be built and shared.

The beauty of this world is that it is continuously evolving. Topics are expanded and modified according to the needs of the classes, working side by side with traditional methods.

Until now the project has been focused on 'learning while building' the world. In further researches more attention will be paid to investigate in depth the impact on students of this teaching method and to create a stable virtual community of teachers who use the world together with their students.

For further information visit http://www.virtualscience.it

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Flexible Automated Assessment in 3D Learning Environments: Technical Improvements and Expert Feedback

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Abstract. Immersive 3D learning environments have a great potential to improve learning. This holds especially true for the usage of computer simulations in science education. Nevertheless, the importance of formative assessment, guidance and feedback requires the implementation of automated and flexible assessment solutions within these environments. Our workgroup has recently introduced a flexible assessment framework with focus on behavioral assessment and immediate feedback provision. The aim of this paper is to report about the latest technical challenges and improvements of our Open Wonderland prototypes, as well as a first expert evaluation that yields promising results. From the technical perspective, issues with synchronization and the amount of data being transferred have been identified and a first solution has been implemented. The expert evaluation confirms the assessment concept and reveals interest among (emerging) practitioners; however, several ideas to improve the feedback provision and usage of simulations have been stated as well.

Keywords. Immersive environments, STEM education, assessment, science, physics, feedback, guidance, learning, framework, open wonderland, expert evaluation

Introduction

The increasing support of new technologies has enabled the average user to benefit from Internet technologies and rich computer graphics. Certain pedagogical benefits, such as collaborative and contextual learning is ascribed to *3D learning environments*. These include games, simulations and virtual worlds. [1] The latter combine the constructivistic affordances of social interaction and immersive graphics [2].

Given the challenges STEM education is facing [3, 4], these technologies are considered a powerful learning environment [5]. Literature reveals significant evidence that computer simulations improve conceptual understanding and enable *scientific discovery learning (SDL)*. That means students can simulate an entire research cycle, i.e. finding research questions and hypothesis as well as conducting experiment, evaluation and interpretation. Nevertheless, it is also confirmed that guidance is important as an entirely unstructured simulation does hardly foster learning. Besides that, supportive and procedural information is required by students in order to

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successfully complete the tasks. But it was found that collaboration also significantly contributes to the learning outcomes. [6] In addition, particularly formative assessment and feedback are important for the success of learning [7].

Literature reveals first approaches for automated assessment in virtual worlds. But there are still several issues. Connections to existing e-learning systems, such as Moodle can at this time only deliver traditional e-learning content and question items, such as multiple-choice questions or predefined conversation patterns [8-10]. There are more advanced and interactive solutions, enabled through in-world scripting. But teachers might not have the skills (and probably time) to script custom assessment solutions. Despite that, such solutions are usually not flexible as they are written for a specific platform. [10] Little has been reported about approaches that would consider complex player behavior for assessment measurements (*cf*. [10]); although, Ibáñez et al. [11] promote the potential as player actions could be easily intercepted. Nevertheless, first examples exist in the context of game-based learning (*see* [12-15]).

Based on similar issues we have recently reported about a conceptual solution architecture for a flexible assessment framework that externalizes the assessment process, and thus supports a variety of platforms and environments. It is based on a semantic-enabled approach and is supposed to target different 3D learning environments. For this approach, a software component, called *assessment module* is a necessary pre-condition that must be implemented once for a certain platform. Thus, our first steps included the development of prototypes for the virtual world platform Open Wonderland (OWL). These prototypes include an assessment module as well as a simulation of a physics experiment that conforms to the approach. [16]

In this paper we briefly report about additional technical challenges and improvements of the prototypes. Based on that, an enhanced showcase is presented. Furthermore, the entire set of implemented showcases including the recently implemented one, was demonstrated to a group of experts, including young teacher trainees (students) but also an instructional expert (school teacher and university lectureship), research expert and two university lecturers. The most important results of this evaluation will be presented and discussed as well.

1. Improvement of the Prototypes

1.1. System Overview

The flexible assessment framework consists of three tiers, including the *immersive software platform*; and arbitrary *assessment system* that contains the actual assessment logic and acts as middleware; as well as possible connections to *external systems* to access learner specific settings and data. The immersive environment and the assessment system communicate via a web service API. The central component is an *assessment module* that is attached to a specific immersive environment and is responsible to compile and forward events to the external assessment system. These events consist of intercepted user interactions and environmental conditions, rather represented on a semantic level instead of raw information. The module is further supposed to process and display incoming feedback messages appropriately on the clients of the participating learners.

In order to adopt the approach for other platforms, the assessment module is supposed to implement the following three dimensions of event construction:

1. *Common events*: Simple user actions which belong to virtual worlds in general – such as moving the avatar or using gestures – should be intercepted in a generic fashion and compiled into "semantic events".
2. *Tagging and metadata components*: The position of the users' avatars should be monitored through the introduction of annotated spatial sections that could also be nested. Appropriate events are generated when an avatar enters or leaves such sections. Besides, all virtual objects should be enhanced with general metadata that identifies the object on a semantic level, e.g. attributes for object classification. Additionally, this also includes the definition of proximity ranges that declare discrete distances to the avatar. This should at least include the general perception of virtual objects as well as an appropriate operational distance.
3. *Programmatically invoked events*: To support more concrete interactions with objects, the most important part is the enhancement of individual object types. This means that a virtual object is generally supposed to report about changes of state as well as object-related interactions of users.

In addition, feedback mechanisms for each type of generalized feedback should be implemented. A web service connection is consequently supposed to deliver the events to an external assessment system and receive feedback commands to be realized through different feedback plugins. The latter could also be implemented as part of the assessment module, for instance, a simple text-based display feature. A more detailed explanation can be found elsewhere [16].

We believe this approach will be flexible in general because semantically self-descriptive objects could be reused in similar settings; and 3D environments have potential to become semantically self-descriptive in the near future. But it appears at this time a commonly accepted standard for such semantics is still outstanding. [17] Furthermore, also Schmeil et al. [18] discuss the relevance of semantic considerations for collaboration in virtual worlds from a conceptual perspective.

1.2. Technical Challenges and Solution Approaches

Two major issues emerged during the development of the prototypes, especially regarding the enhanced showcase that will be introduced in the next subsection. The following paragraphs will briefly explain these issues and sketch their solution.

First, the amount of data being transferred to the external assessment system was a problem. While autonomous state changes of any virtual object should only appear from time to time, real-time simulations consist of rapidly changing properties that can become required for the assessment process. Hence, it was decided to introduce three different levels of data that cumulatively contain each other and define the state of an object or entity:

- *Dynamic* state refers to continuously changing properties. This type of data is only reported together with a user interaction. But the assessment module takes care that each object that is currently in the range of the learner's perception will report its state, independent of which object was involved in the user interaction;
- *Changeable* data includes dynamic data but is extended by information that does not change too often. This level of information is only reported for objects that have directly changed through a user interaction;

- *Full* data updates, which contain also the identification (metadata) of an object, are only included if a learner enters into the range of an object.

Second, due to the potential collaboration between users it is also important to synchronize the simulation model of all clients and servers in the range of a few milliseconds. Because simulations should be rendered as fluently as possible each node is responsible on its own to propagate the simulation. Therefore, it was necessary to negotiate exact time codes between clients and server. This enables also transport delays to be incorporated when the simulation model is updated from time to time in order to prevent an accumulating divergence. However, further findings indicate also that times between user interactions and compilation of event data on the server-side is crucial for an exact representation of the simulation data in the context of the external assessment system. This has raised our interest in a possible support framework that allows for synchronization of arbitrary simulations in OWL based on exact time codes.

1.3. Enhanced Showcase

Based on the improvements that have been discussed in the previous subsection an enhanced showcase could be developed, representing an actual experimental task. Besides the simulation of a *simple pendulum* that has been used for the first show cases [16], an additional object has been added to the context. This *'assignment object'* – depicted as a rotating box with question marks – opens a control panel that contains a *stop watch* as well as an *input field*. The learner is supposed to use the stop watch to measure the periodic time and calculate the current frequency of the pendulum. It is important to note that these two objects – pendulum simulation and stop watch – are technically decoupled objects. That means pressing a button on the stop watch will not consider the state of the pendulum explicitly. However, all other assessment-compliant 3D objects in range – and this includes the pendulum – will be triggered to report their *dynamic state* at the same time.

The external assessment logic separates between two cases. If the input of the frequency was wrong, but the previous measurement appeared to be accurate it suggests that the learner should check his or her calculation. Otherwise, the system recommends repeating the measurement (see Figure 1). This is achieved by comparing the deflection angels of the pendulum at the time user interactions – *starting* and *stopping* the stop watch – are sent to the system. The result of the last measurement is remembered in the context of the assessment system and used when the learner *submits* the calculated frequency.

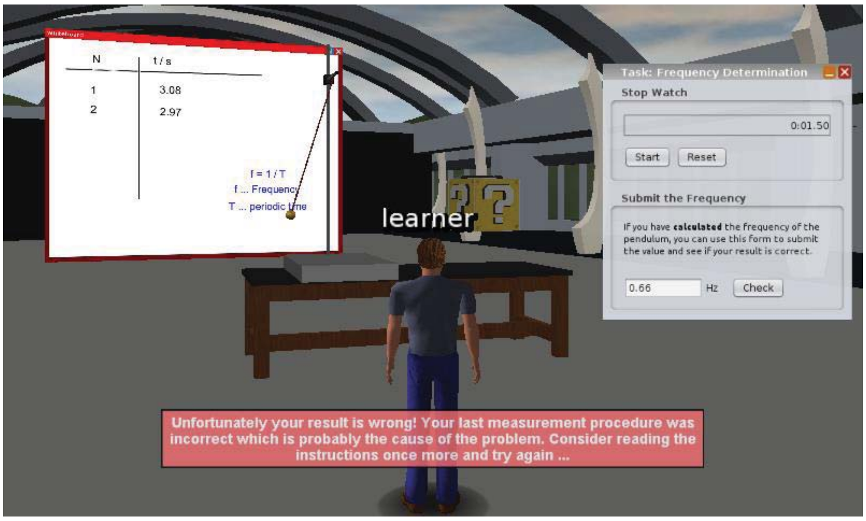

Figure 1. Learner has entered a wrong frequency and the assessment system leads this back to an imprecise or conceptually flawed measurement.

2. Expert Evaluation

The prototypes and test scenarios are not yet completed enough to be used in a real student context. But it seemed necessary at this stage to obtain initial feedback from people who might actually use these systems for teaching. The purpose was to avoid a fundamentally wrong direction, collect suggestions for improvements and to explore which options might be relevant for teachers in order to obtain information about students.

2.1. Methodology

The expert evaluation was conducted as informal, semi structured interviews based on a predefined questionnaire, whereas specific sets of fixed-response questions have been ask prior to the demonstration. The intention was to align the attitudes regarding formative assessment, feedback and the potential of 3D learning environments – but also the individual foreknowledge about e-learning and immersive education – with the results of the actual prototype evaluation.

The demonstration itself included three showcases which have been presented to the experts; whereas the first and second have already been reported in [16] and the third in the previous section:

1. The learner approaches the experiment workplace. Immediate feedback is triggered based on the location which directs the learner towards an in-world PDF reader, providing written instructions;
2. If the learner deflects the pendulum too much, a warning appears, as this would leave the idealized measurement range;

3. The learner is supposed to measure the periodic time of the pendulum, subsequently calculate the frequency, and finally, confirm the result through a submission form. The external assessment system observes the entire process and can provide different feedback. In addition, assessment models have been switched manually in order to demonstrate the difference between more and less intensive feedback provision. That means intermediate feedback is either provided before the final submission or not.

Most of the subsequent questions were also based on a fixed range of answers (e.g. strongly agree to strongly disagree) referring to a Likert scale as well as similar rating scales. The participants were, however, also invited to contribute additional comments and keywords in written form. Besides, particularly important statements and attitudes, if not covered through the questionnaire, have been recorded during the entire session in form of written keywords from the perspective of the interviewer.

2.2. Results

In total nine subjects participated in the study: five teacher trainees in physics (students; age group 20-29, except one 30-39; one female only); a high school teacher in physics who is also university lecturer in subject didactics (male; 50-59); a university lecturer/assistant in experimental physics (male, 30-39), a university lecturer/assistant in chemistry who is also teacher trainee in school physics (female, 20-29); as well as a computer science expert with a research background in immersive education (male, 40-49).

Because all participants of this evaluation are German native speakers, some statements have not been provided in English. All quotations used in this paper are either close translations or might have experienced marginal linguistic improvements.

The *initial* questions[2] revealed that the average do not feel themselves particularly experienced with e-learning (M = 3.11, SD = 0.99; between *almost unfamiliar* and *very experienced*). But almost all participants highly agreed on the importance of formative assessment (M = 4.11, SD = 0.74; between *irrelevant* and *very important*), timely (immediate) feedback (M = 4.56, SD = 0.50), as well as on adapted feedback for individual students or groups (M = 4.44, SD = 0.50). However, besides multiple-choice questions (selected 8 times), novel e-assessment practices appear rather unknown to the participants, as hardly anyone has used e-assessment tests (or could name anything) that goes beyond fixed response questions, numeric or free text answers (approx. selected 4-5 times each). The question if multiple-choice questions are sufficient to evaluate the learning outcomes of science education rather diverges (M = 2.89, SD = 0.87). Some commended that it depends whether it is about factual knowledge or skills and competencies. Nevertheless, experiences with computer games (M = 2.22, SD = 0.63; personally playing, between *never tried out* and *very often*), as well as computer simulations (M = 2.78, SD = 0.79) and 3D virtual worlds (M = 1.89 of 4.00, SD = 0.99; between *never heard* and *professionally used*) for learning activities are practically not existent (the research expert certainly used it professionally). Although the greater part was convinced that 3D learning environments can motivate but also improve learning (M = 3.78, SD = 0.63).

[2] The range of all answers is between (1) and (5), further between *strongly disagree* and *strongly agree*, if not otherwise indicated.

The major *results of the actual prototype evaluation* are listed in Table 1. Results reflect the quite good perception of the prototype and its showcases by the experiment group.

Table 1. Results of the actual prototype evaluation

Question or Statement	Mean (SD)
What is your overall impression[3] of the demonstrated assessment and feedback aspects?	4.11 (0.74)
I think the example is authentic.	4.33 (0.47)
I think the textual feedback provided at the bottom of the window was helpful.	4.44 (0.68)
I think the feedback provided would improve the outcomes/results of students.	4.33 (0.47)
I think the feedback provided would improve the understanding of students.	4.00 (0.67)
I think the kind of player actions evaluated – measurement activity and calculation – can be used in accordance with competency-based learning models – i.e. the approach is valid to reflect on skills and competency levels of the learners.	3.94 (0.68)
I think the different intensity of feedback messages is appropriate to catch up with the different competency levels of students.	4.22 (0.63)

Positive comments included *"well done"*, praised the immediate and individual feedback, as well as the *"challenging tasks as motivation for students"*, and referred to the approach as *conceptually* very good and *interesting*. It was further stated that it was a *"practical experiment"* which is *"easy to handle"*, also including the idea of a PDF containing written instructions. One participant stated that the *"different colors for positive, negative feedback are fine for 'visual types'"*.

Nevertheless, regarding the *negative comments*, one participant contrarily stated that the *"feedback is very generic"* and it is *"difficult to provide feedback individually"*. Other participants suggested *"to force students to read the instructions (e.g. by implementing a control task)"* and that the *assignment box* would not really feel authentic. It should also be mentioned that the quality of the overall surrounding environment was criticized, although that is not directly related to the evaluation of the assessment concept. Particularly one participant, who was generally less fond of computer-based and 3D virtual world approaches stated: *"3D graphics is in my view not necessary required (with the pendulum)"*. In addition, also the feedback was considered too small and positive feedback could still be displayed brighter. Especially two participants who were less convinced on the benefits of 3D learning environments had a hard time to focus on the assessment concept and concentrated a lot on general imperfections that arose from the used platform, materials and exemplary approach.

Several (easier to implement) *improvements* can directly be extracted from this feedback but there have further been more explicit recommendations, concerns that implicitly validate the requirement for this approach, as well as further ideas for future developments:

- Sound should be added, and maybe also *"laboratory music"*;

[3] Question is rated between insufficient (1) and very good (5); all other statements between strongly disagree (1) and strongly agree (5).

- An important recommendation was that the computer should read the feedback aloud*;*
- One participant stated that *“more comments and hints regarding the expected actions would be fine”*, he or she guesses that *“students who are not that talented could be disappointed since they might have problems with starting their own exploration of the virtual world”*;
- Movements should be combined with numerical representations;
- A pocket calculator should be added in-world;
- Minor aspects as the position of feedback could be improved;
- To facilitate a game-based approach, for instance, the explanation of a formula could be released as a reward for achievements in the practical exercise;
- The considerations of external influences, in the context of a pendulum simulation for instance an eddy current brake.

In addition, several questions were dedicated to *decisions for future developments* and an integrated stack of systems, including feedback for teachers. The greater part has expressed interest for information at a glance, including overview of students’ problem domains (selected 9 times), as well as an overview on the entire classroom or groups (7 times). One participant added an additional item and expressed interest on the collaboration activities of students.

Besides that, the participants were asked if a challenging aspect, e.g. progress information among fellow students or groups, might improve the motivation for learning (*cf*. [19]). Most experts agreed with that (M = 4.44, SD = 0.68). When it comes to the incorporation of assessment information from such virtual activities into the grading schema, the answers are less clear and have a larger divergence again (M = 3.78, SD = 0.92). At least one of the participants seemed to be concerned about legal issues. Nevertheless, almost all participants agreed positively on the idea to offer a graphical editor system to design assessment rules on their own (M = 4.00, SD = 0.67); although, some did not feel themselves particularly capable of basic programming during the pre-questionnaire. In addition, it is also worth mentioning that during the informal interview process it became clear, that some participants were concerned on the available time for both, review on student information as well as the design of assessment rules.

Finally, the motivation to use immersive 3D virtual worlds in different application contexts was acquired (see Table 2). Most experts clearly considered it a supportive measurement for additional exercises when conventional material is used without practical experiments. Other usage options included the comparison between model and reality, homework exercises, as well as additional exercises following practical experiments. In addition, further value on the application of 3D virtual worlds was seen regarding communicative aspects, game-based environments, training, concept explanation, the reduced necessity to read, as well as experiments which are complicated or not possible to be implemented in real world settings.

Table 2. Types of application of immersive 3D virtual worlds in physics education (predefined categories)

Usage option	Count
Preparation for real practical lessons	4
As support for courses/activities which do not feature practical (laboratory) lessons	9

If embedded in a greater context, as replacement for real practical activities	3
Not at all (please provide comment)	0
Other usage	5

3. Discussion and Outlook

The aim of this paper was to report about the latest findings of a flexible assessment framework that is able to support different application domains and immersive learning platforms based on a semantic-enabled approach. The first prototype of an assessment module has been implemented in Open Wonderland in the context of STEM education; whereas a simulation of a simple pendulum was supported through external feedback messages to guide the learner (*see* [16]).

The first section was concerned with technical challenges and solution approaches that occurred during the ongoing development. Especially two critical aspects have been examined. *First*, it was necessary to introduce different levels of semantic-enabled data to prevent an overstress of the communication layer and external assessment service. Continuously fluctuating values of simulations will only be reported based on context and related user interaction. *Second*, in order to provide fluent simulations among different clients, and to provide accurate information for server-side and external assessment systems, it was necessary to reliably synchronize clients and server based on exact time codes. This will need further research and improvement in the future. Additionally, an enhanced showcase was introduced that depends on this synchronization and allows learners to determine the periodic time and frequency of the swinging pendulum.

The second section reported about the methodology and results of a first expert evaluation. Three showcases were demonstrated to a group of nine experts, consisting of teacher trainees in physics, practicing teachers and related research experts. To subsume, the greater part of the participants was quite interested, although not particularly aware of e-learning approaches (electronic assessment) and especially immersive 3D environments. Nevertheless, most experts would welcome such integrated tools as part of an available e-learning solution, thus confirming the overall concept. Besides that, the need for guidance and individual feedback is significantly confirmed (*cf*. [6], [7]), which would also justify the need for such a flexible approach in general. Negative attitudes towards computer-supported education, more precisely 3D learning environments, also matched with a less euphoric evaluation of the prototype which is less surprising. Beyond that, several recommendations have been given for further improvements. Some of them can be realized rather easily, others require more afford, such as spoken feedback; but the latter not less interesting, considering the basic idea of an immersive computer environment.

Based on these findings, we consider it promising to further investigate this approach on different dimensions. The next steps should include a proper implementation of an enclosed learning setting and let students experiment with the scenario. Furthermore, the coupling of the assessment module with non-player characters (*cf*. [11], [16]) offers potential for an additional feedback mechanism in the near future, which might even uses a speech synthesizer to provide also an auditive source of feedback. Regarding the provision of real individual feedback, it is still open to connect the external assessment system with learning management systems to access preferences and learner profiles to provide custom feedback. Another aspect refers to the usage of different assessment logic, which – in contrast to a simple rule-based assessment engine – might rather be based on more advanced solutions in artificial intelligence. These issues should determine the next series of research projects.

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Towards Immersive User-Friendly Future Learning Spaces in Education

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Abstract. This paper discusses the changes required in the future physical and virtual learning environments. The paper briefly introduces the preliminary findings of the case study of changing physical spaces towards more immersive and user-friendly learning environments. This paper provides information for facilitating a development of teacher training, and how to change traditional physical learning environments towards future learning spaces taking into account immersive environments. It is important to develop learning environments for the 21st century learners by taking into account pedagogy, architecture and technology approaches and being able to change school working culture including changes in teaching, leadership, technologies and physical school infrastructure.

Keywords. immersive, collaboration, physical learning environment, virtual learning environment, virtual worlds, vocational education

Introduction

Future physical and virtual learning environments are under a large investigation in the field of education. Learning environments can strongly influence students' learning experiences, for example, according to [5], there is an explicit relationship between the physical learning environments and educational outcomes. Weak conditions of learning environment can make teaching and learning more challenging. Also, 'play in education' has been seen as an important factor in learning. Different outdoor technology enhanced playful learning environments have been designed and implemented in Finnish schoolyards [19]. Learning should be regarded as a life-long process, which occurs in different learning contexts, for example, in formal schools and classrooms, but also in other innovative and informal places and spaces [22]. Different creative and participative learning activities, including games, with new technologies have regarded as an important aspect of learning in innovative learning environments [13][20][22]. This paper introduces the evolution of vocational education and learning environments. Then, three dimensional (3D) virtual learning and training environments are described from education point of view. Finally, the paper presents the case study

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of the changes in vocational school's physical learning spaces and the preliminary findings. The aim is to introduce ideas and needs for the development of an immersive physical learning environment. This information will help to develop teacher training and physical learning environments from a traditional physical school environment towards future learning spaces taking into account immersive environments and utilizing digital learning materials and ubiquitous computing solutions.

1. The evolution of vocational education and learning environments

Multidisciplinary professional training requires different learning environments. Finnish education providers can be seen as pioneers in introducing new learning environments and developing those within the institutions. Various learning environments have been piloted with advanced technology such as Augmented Reality (AR) and virtual worlds. These new environments combine the personalized learning environment into collaborative new space of engaging learning and gaming as far as offering challenging learning experiences such as edupreneurship in virtual worlds.

Vocational education and training in Europe is evolving and converging. The aim of the European Credit system for Vocational Education and Training (ECVET) is to enhance a cooperation in vocational education training, international mobility and ensure recognition of learning outcomes based on credit transfer. Learning outcomes are not dependent on the learning process or the learning context in which they have been achieved. Thus, it is possible to use them to identify what the student has achieved in one learning setting or context compared to what the student could have been expected to achieve in another setting or context. ECVET outlines people’s greater control over their individual learning experiences and offers flexible ways and learning paths to move between different countries and different learning environments. [29]

ECVET and European cooperation will challenge vocational education and training providers in various ways to explore new pedagogical models and learning solutions. Teaching of labor-intensive sectors is often demanding with expensive equipment and special expertise. New learning environments, such as 3D environments or simulations, allow for instance practice dangerous situations in authentic learning environments or similar circumstances. Teaching and learning safety at work is an important learning point when designing new learning environments for education providers. Education expenses can be cut by strengthening the cooperation between organizations and through exploitation of new technologies.

1.1. Challenges to change vocational education and training

The aim of development programmes in vocational education is generally to improve students' performance and enhance completion of studies. The purpose is to provide opportunities to achieve the knowledge and skills to meet working life competences needed today, and especially in the future. Technology, of itself, cannot drive the educational change. Instead, in vocational education and training, pressure for change is particularly directed at the role of teachers, leadership and educational support services as well as updating training and learning environment solutions. Technology often encourages teachers to foster student-centred teaching methods. New advanced technologies enable personal learning environments to improve learning outcomes and student motivation by enhancing collaboration and just-in-time guidance.

Vocational teacher's role is essential in the renewal of vocational education. The demands of working and daily life skills are constantly changing. These changes are apparent in teaching and learning. Technology is advancing rapidly, and an individual vocational teacher often finds it demanding to keep up to date on both pedagogical methods and new learning environments not to mention their personal substance knowledge. Collaboration and networking among teachers enhance sharing best practices, pedagogical models, innovative learning environments and creative approaches when utilizing immersive technologies in education. However, there is still a great demand for simple action models for implementation. These action models should include both pedagogical and technological descriptions and instructions.

Learning in virtual worlds often supports constructivist learning. Connectivism is an alternative theory of a digital age for behaviourism, cognitivism, and constructivism. The learning theory by Siemens [33] states that learning is primarily a network-forming process and learning happens as a part of diverse, social network, which is augmented by the modern digital technology. The entity of personalized learning path is always a combination of a variety of different learning environments and pedagogical approaches. The blended solutions bring the pedagogical paradigm to connectivism and connective knowledge. Learning a profession is contextual by nature, and an important skill for a future's talent is to know how to combine different sources of information, estimate validity of information and apply all the information available. Pedagogical approach based on connectivism supports collaboration and makes exploring such learning environments challenging and rewarding. Pedagogical models combined with the added value from new solutions of virtuality are expected to promote students activity to acquire more knowledge and skills. This is believed to encourage shared experiences and expertise among both teachers and students. One of the objectives for development is often related to personal learning environment with the idea of lifelong learning combined to digital portfolio as a personal knowledge database of an individual to serve for a life.

1.2. InnoMill and LIPPO projects

It is often thought that virtual environments are created to complement the physical space. The design process may also be reversed. The change of physical environment in the InnoMill project described in Section 4, began to form in an augmented reality project. LIPPO – augmented reality and open social networks in learning [27], is a national project piloting augmented reality and mobile solutions in vocational education and training. This project aims at large-scale development of the physical and virtual learning environments in vocational institutions. The main purpose of the project was to create the multidisciplinary pedagogical development model as well as to share and spread the experiences of augmented reality in labor-intensive training.

The pilot project aims to improve student performance and improved learning outcomes by enhancing student-centered learning methods and creating enriched learning environments. Augmented reality and mobile solutions bring added value in teaching and learning in order to provide opportunities to learn the knowledge and skills that meet the current and future demands of working life. The model promotes working life-cooperation and learning outside the classroom.

The project was preceded by the pedagogical development team report of different suitable virtual and mobile learning solutions for the institution. The main target was to define labor-intensive learning environments and teaching and learning methods as a whole in order to provide directions towards the future of vocational education in different areas and different organizations with applicable solutions. The future of vocational education in Finland was launched and designed during the project with the results and ideas for a new kind of physical learning environment and learning spaces where different kinds of media solutions blend seamlessly into the various areas of teaching and learning, as well as teachers 'and students' everyday lives.

Vocational education focuses often on teaching different type of skills. Social media services and new technologies provide a platform of visualization on what students have learned, as well as it reflects on a variety of ways to work. The most important step in the learning process appears to be the ability to enhance the personal growth and professional identity. Students learn to combine theoretical knowledge and experience of the generated data into knowledge needed in working process. Professionals of the future find their identity consisting of growth towards goal-orientation, commitment, attitude and ethics of the profession. This process is based on a connective knowledge and shared expertise with both learning networks and professionals in the district.

ECVET enables lifelong learning for all, with transfer, recognition and accumulation of individuals learning outcomes achieved in formal, non-formal and informal contexts. In the future, it will be significant to identify how the employee includes oneself in relation to employment and occupation. The teacher's role is to encourage and guide the student to become aware of their professional identity and skills. Visualizing the puzzle of expertise into concrete skills helps students to understand their full professional potential, their own suitability of the industry and their own desires and interests. Visible work processes during the training will set a view to the nature of the work and to sustain progress towards professionalism. In working life the employee is required to identify personal skills, professional knowledge and to market their own skills and strengths. All these demands encourage students to develop a digital portfolio with blended media solutions. The LIPPO - project also tested extensively augmented reality brought into the teaching and learning methods :

- Augmented reality business cards
- Virtual guiding in premises of the institution
- Virtual information and communication technology education presentation
- Operating manuals for machinery implemented with augmented reality.

2. 3D Virtual learning and training environments

In today's world, learning is no longer restricted to sitting quietly in the classroom, reading books and memorizing things [35]. Students can easily access information by themselves from the Internet and other sources. As the world and work life have changed drastically, the educational methods used in schools have still stayed similar for a long time. At the same time more and more students are stating that they do not enjoy school or feel that the information that is taught there is too theoretical and far from their daily life. This is one reason, why there is certainly a need to review the educational methods used in schools and introduce new types of learning to school. Educators must react to the obvious changes in the society and be prepared to review the learning methods being used in their teaching. It is also important to try out new educational methods open-mindedly and see the potential in developing them. 3D virtual learning environments have great potential in bringing new, immersive learning to schools. Virtual learning environments can enhance online communication to a completely new scale. The first impressions of having students sit individually in front of their computers might seem unsocial, but in fact studying in virtual learning environments can be extremely social and interactive. Using avatars, it is possible to bring people from all over the world to the same virtual space to communicate and collaborate. Being in the same space can make interaction feel more real than if it is done using online chatting. In addition to that, the meeting spaces can be created culture-neutral if so wished, which is never entirely possible in real life [15].

2.1. From 2D towards 3D virtual learning environments

The use of new information and communication technologies (ICTs) including 3D virtual learning environments has provided additional value to previous e-learning environments and learning processes. Tools for collaborative and phenomenon based learning are under development. Also, social interactions are important in virtual learning situations. For example, discussions and argumentations with others can lead into better learning results. Therefore, learning environments are needed to be developed for supporting learners to be more self-guided and -directed [21]. There is a need to move from traditional classroom type of learning environment towards game-like learning environments and simulations. Future virtual learning environments should be developed in a way that they can facilitate the learner in thinking and learning processes. [34]

Virtual learning environments (VLEs) have a long history and there has been various range of different kinds of virtual learning environments [31][30][7]. VLEs have turned the traditional 2D Internet based environments towards 3D learning spaces [14][30][10][11][16]. The interaction with the 3D environments can enhance a learning experience when compared to the real life learning situation, and thus, learning can be more motivating [4][36][37]. Even though, 3D virtual environments have been extensively investigated [16][12][23], there are still lacks in usability and user experience issues in new 3D virtual environments. Often new environments have been development from a technology point of view - not enough from a user point of view. Therefore, more studies are needed in order to improve the interaction with 3D virtual spaces and objects. Likewise, there is a need to develop physical learning environments towards more innovative, immersive and use-friendly spaces in order to meet future challenges in terms of collaborative, mobile and immersive learning. A challenge is to bring physical and virtual environments close to each other in order to provide smooth interaction for users to live and learn in both, physical and virtual environments utilizing the available material for learning.

2.2. Examples of 3D virtual learning environments and their use in education

There are two types of virtual environment platforms: open source platforms and proprietary platforms. Open source platforms are developed by communities of experts, allow users to possess rights to the content they have created themselves and move it to other environments if they so wish, and are usually free of charge. Proprietary platforms (e.g. Second Life), however, are conducted by companies that own all the rights to the content that is created by the users. Both types of platforms are commonly used and have their own strengths.

TOY (Tulevaisuuden OppimisYmpäristö) [24] is a virtual learning environment developed for comprehensive schools by realXtend [28] in cooperation with the School of the Future programme at Center for Internet Excellence and subcontractors. It has been built to enable users to produce content and functions. In the TOY environment there are three kinds of spaces: a communal lobby, a cooperative learning space and a private sandbox space. The environment has been studied with pupils and students from primary and secondary schools [3]. The realXtend platform has been used also in Vocational Education School at HAMK University of Applied Science, where the Virtual-Mustiala 3D learning environment was developed and studied [25]. Based on these previous experiences, in the SILC (School Innovation and Learning Center) project, 3D virtual learning and education environments will be developed for the upper secondary and vocational education, and then evaluated with authentic users, both teachers and students.

EON reality (www.eonreality.com/education) is one example of a proprietary platform using advanced 3D technology. In education, EON reality has specialized in developing an interactive virtual 3D library, where there are various different 3D models dealing with different phenomena and school subjects. Educators can put different 3D models together to create their own 3D scenes with interactions. All the contents, for example a magnification of human's heart or a planet in space, can be seen in 3D with the according equipment. This kind of learning could be one example of how exciting visualizing and interacting can help to facilitate learning in all levels of education.

AvayaLive Engage is a virtual platform that can be used both in business and in education. Users can choose own environment from different already existing templates and then tailor them. [1][26] Many universities in USA have virtual campuses via Avaya. For example, Massachusetts Institute of Technology has used AvayaLive Engage to be able to bring together virtual and real life lectures so that some students have been attending the lecture physically and others virtually from around the world with AvayaLive Engage. [17]. *Open Wonderland* is an open source virtual toolkit for creating collaborative 3D virtual worlds (http://openwonderland.org/). Wonderbuilders Inc. builds special-purpose virtual learning environments for customers. VMed Learning Spaces is one example of their products; its purpose is to enhance communication and teamwork skills training for doctors, nurses and other health professionals (http://www.wonderbuilders.com/portfolio/vmed). Students can practice social skills and different procedures in a virtual hospital setting alone, with other students and instructors. *ShanghAI Lectures* is a global cooperation network that functions mostly as a lecture series via videoconferences. In 2009, 18 universities from all over the world participated in these lectures. [15][8] *iSocial* is a virtual learning environment developed "for teaching social competence to youth who have been diagnosed with Autism Spectrum Disorders (ASD)" (http://isocial-temp.missouri.edu/iSocial/). Its students can practice social interaction with each other and teachers.

Second Life is the largest and most used user-created virtual world with millions of users around the world. Joining Second Life is free, but if a user wants to build something there, he/she has to pay for it. Users create different spaces and can for example get to know people, shop or visit tourist attractions in there. Second Life can be used to learning; many schools have their own islands in Second Life and there are also for example areas where it is possible to learn languages with native speakers. Examples of using Second Life in education:

- *East Carolina University* is one of the many universities worldwide that have created their own campus with different kinds of features in Second Life and used it in their courses in various ways. [18].
- *Korea National University of Education* has organized teaching practices in Second Life for pre-service teachers. The teacher students were first given demonstrative lectures by the course teachers and then placed in virtual traditional classrooms to practice teaching each other. [9]
- In *Konnevesi high school* there has been a project called Learning games and virtual environments supporting the renewal of teaching and learning (LEVI, OVI in Finnish) in which different possibilities of using virtual worlds in secondary education have been examined. (http://www.peda.net/veraja/konnevesi/lukio/ophhanke2010/engl)
- *EduFinland* is an archipelago in Second Life, where "Finnish educators can easily and safely experiment with the possibilities of Second Life in education". Both, the educators and the students, can use the area to collaborate and share ideas. (http://edufinland.fi/in-english/)

3. Challenge to change physical learning environments and working culture

The world has changed, learning has changed and even learners have changed, while the school as an institution and the classroom has stayed almost the same for the past hundred years. The narrowness of the definition of the learning environment, classroom- and book-orientated teaching, the central role of the teacher as well as a limited variety of teaching methods have hindered the school's progress, making it unable to keep up with the development of society at large. A comprehensive change in the school's operational culture is required. The role of teachers, management and support systems and learning environments need to be developed simultaneously so that they can meet today's and tomorrow's requirements.

The school can no longer claim the sole right to learning, the teacher no longer owns the knowledge and the book is no longer the only source of learning. In addition to formal circumstances, learning happens in informal situations, anytime and anywhere. Students utilize technologies and media mostly in order to create learning networks and to find information for them. Although digital natives adopt new technologies from an early age, their understanding of information in context is still to be guided to learn. Critical evaluation and judgment of information and its sources becomes a new skill to be developed by students.

Learning environments in the school of the future cover a new variety of different pedagogical opportunities without excluding traditional learning and teaching methods. They offer a wide range of flexible areas that can be used by the entire local population from morning until evening. Teachers' opinions must be taken into account, but equally students, parents, local companies and the entire community must have a say. The premises must be suitable for all user groups and all occasions, from everyday operations to school celebrations. In the school of the future the central areas will be in efficient and versatile use during evenings, weekends and school holidays.

4. Case study of the changes in physical learning environment

This paper presents the changes in physical learning spaces towards innovative and user-friendly learning environments in InnoMill project. Our study approach is based on the Sawyer's [32] theoretical framework, where one key idea is to understand learners' active role in their own learning process. In this approach, learning is no longer seen as a knowledge transfer between a teacher and a student, but the teacher’s role has turn from a transferor to an instructor. One of the teachers’ tasks is to design learning environments in a way that they can facilitate students to learn deeper conceptual understanding. Learning environment is a place, a space, a community or a practice that supports learning. In this case, we see learning environments not just as spaces but as unities that include many dimensions: virtual, physical, social, pedagogical and psychological.

The aim of the study was to find out how physical space and furnishing influence learning activities in the learning area from the collaborative point of view. We studied a physical learning environment in a vocational education institute in Finland. One big learning area, old sport hall, (Figure 1A) was developed towards future learning environments by changing furniture and ways to use space. Our approach was to make changes in order to facilitate the use of space and technology. In start situation, the use of the old sport hall was very minimal. In this study, the environment was totally redesigned taking into account social communication and collaboration aspects. Finally, six spaces were designed into new learning environment (Figure 1-3):

1. **Space A: Living room** for 20-40 participants, acted also as a presentation area.
2. **Space B: Cradle of creativity** (a tent) for 10-20 participants, acted as an innovative collaborative space.
3. **Space C: Business Forum** (wooden barn) for 5-10 participants, acted as a teamwork place e.g. entrepreneurship studies.
4. **Space D: Warehouse** (an army tent) for small group 3-5 participants, acted as a regulation and personal practice spot.
5. **Space E: Camp fire** (fireplace space) was designed for (further) collaboration and brainstorming area.
6. **Space F: Virtual space**, a context of virtual space can be adjusted according to use and learning situation. Virtual space is projected on the wall and it will act as a bridge between physical and virtual spaces.

A: The start situation: The space was an old sport hall which was not in active daily use.

B: A plan of the future situation: three different sized tents, one barn and a virtual wall.

Figure 1. A) The start situation in the sport hall and B) the design pattern.

Space A: Living room
For 20-40 participants.
Acted also as a presentation area.

Space B: Cradle of creativity
For 10-20 participants.
Acted as an innovative collaborative space.

Space C: Business forum
For 5-10 participants.
Acted as a teamwork place e.g. entrepreneurship studies.

Space D: Warehouse
For small groups 3-5 participants.
Acted as a regulation and personal practice spot.

E: Camp fire
For 3-5 participants.
Acted as a more relaxed collaboration and brainstorming area. (benches around the fireplace)

Space F: Virtual space
For present and remote participants.
Acted also as a bridge between virtual and physical spaces.

Figure 2. New learning spaces A-F developed into the old sport hall.

5. Findings: From 'Three times a year' to 'Three times a day'

In this paper, we present our preliminary findings on how users, both teachers and students, experienced the new environments. These findings are gathered by observation and small scale interview discussions. In general, all users experienced new learning areas (Spaces A-E) positively. They experienced that the new learning areas can support collaborative working methods and it is easier to work in groups. In addition to regular users, many visitors have tested this new learning space and found it motivating and interesting. This kind of space is one of the first trials in vocational and higher education, where there is a need to develop future learning environment and solutions for 21st century learning and training.

One main benefit of changing this learning environment (old sport hall) was the utilization rate of the environment. Before the change, the old learning environment was used three times a year. This space was not used for sport at all, because the vocational institution has new sport hall for that purpose. After the development of these new learning spaces, the environment is used three times a day. This is a remarkable change. In this project, an empty and almost unused space was transformed to a versatile and innovative learning spaces. Learning environments consisted of various kind of tents supporting different learning activities. The atmosphere was created by using solid paintings and a virtual stage like constantly changing speaker's corner.

The other new space, we designed for the environment, was a virtual space (Space F). At this design stage, we merged physical environment with virtual environment possibilities. This virtual space enables the further development of the learning space used with virtual learning environments.

Figure 3. Example view of the new learning and collaboration environment. Spaces E and F are located on the stage on the right side, after space A (Stage is snow in Figure 1A and Figure 2F).

6. Conclusion and future work

In this paper, we have discussed the needs for changes in future learning environments, both physical and virtual. One aim of this paper is to raise discussion about the state of traditional learning environments and their inability or weaknesses to meet future challenges of the 21st century learning and the use of physical and virtual spaces in education. We also examined how both physical and virtual vocational education spaces could be designed to reflect the changes in architecture, technology and pedagogy. In this paper, we presented how the changes in furniture and in the use of space can produce an innovative, immersive and user-friendly learning environment.

The preliminary findings of the users' experiences of new learning environment are also presented. In the future, we will conduct more extensive studies of how users (e.g. teachers, students, visitors) experience the learning spaces and what possible needs and wishes they have for the both physical and virtual teaching and learning spaces. Also, in the future, it is important to design spaces for one or two people in order to enable individual and more private work.

In addition, we have planned to use the already existing environment and develop it further in vocational education. The development work will include additional changes in physical infrastructure like acoustics and lighting. Moreover, we will concentrate on developing the use of virtual worlds in the learning environment. In vocational education this means development of virtual 3D training environments (e.g. hotel, bank, insurance company or virtual shop etc.) where different professional learning situations can be trained. Virtual environments will become a part of the physical space and enhance immersive experiences in both worlds.

In the future, it is important to develop innovative learning environments for the 21st century learners by taking into account pedagogy, architecture and technology approaches. The key issue is to change the school working culture, which includes changes in teaching, strategic leadership, in-service training, technologies and physical school infrastructure. At best, the change in working culture and the change of the physical environment go hand in hand and reflect the change in the use of virtual worlds. This comprehensive information is needed in all levels of education - from basic education to vocational and higher education.

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The Midrivers Project: an Initial Experiment to Stimulate Non-discriminatory Creative Problem-Solving via a Virtual World.

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Abstract

This article is a review of the Midrivers Project, originally designed to be a type of crowd-sourcing scheme to combat negative discrimination in recruitment and in the workplace, and doubling as an informal science and technology outreach or educational island. The first forays into virtual worlds revealed that discrimination persisted, but in this case it was based entirely on initial visual perceptions of the avatar, regardless of the reality of the typist behind it. Set against the negative was a new society of friendly enthusiasts from all over the world, of both genders, varied avatar gender or sexual persuasion, many of whom were gifted individuals both artistically and technically. Described here are some of the issues encountered as a naïve user and then as novice estate manager on a Second Life island called Space Destiny. The Midrivers Project itself had the strap line of 'Thinking outside the planet for the planet', an objective which was achieved in part only, but the learning process and the social interaction encouraged positive outcomes for several participants in their real lives. It did not set out to be a full academic study, but this review is intended to highlight some of the experiences which could inform the design of a more rigorous investigation.

Keywords Second Life, creative problem-solving, discrimination, perceptions, informal education

Introduction

After experiencing gender and ageist negative discrimination in the job market, the author conceived a scheme whereby ideas for practical solutions to real world problems could be generated and either sold or used as a means to employment without the buyer/employer knowing anything prejudicial about the producer.

Originally envisaged as being merely website based, the idea progressed with the advice of a colleague at Heriot Watt University (North 2009) [1] to virtual worlds, beginning with Second Life. The fictional setting for the project was a space colony, designed ultimately to be independent from Earth. It needed not only realistic designs for the everyday physical problems encountered by astronauts and cosmonauts today, but also designs to maintain sustainability. It was in effect a thought-experiment version of the Biosphere 2 projects in Arizona (Diesendorf, 2000) [2], with the benefits of being low cost and having virtual realisation in the form of 3D models which avatars could walk around or inhabit.

2. Background: History and development of the island

Space Destiny island was originally formed by a non-profit group who wished to make space exploration available to all. In the event, the group had disbanded but the island continued to exist. The author was eventually invited to take over management of the island simulation by the private funder.

The island also hosted other groups, notably the Star Trek build from 2000 virtual metres upwards. The leader of this and her friends proved to be keen allies of the project and provided many items in return for their build continuing to exist. Individuals who made significant contributions often had had their own builds elsewhere, often having lost the island where they had been. Relevant parts were then used for the Midrivers build, notably a large ecological study by 'Wesley Farspire; from Australia. Buildings were supplied by members of the Trekkies group and also 'Nadege Kyong' from France. (Real life nationalities used by permission). Other individuals contributed to the science and technology: 'Haplo Eberhard' (USA), 'Icarusfactor Scientist' (USA) and 'Wesley' all had exhibitions of their ideas. 'Archivist Llewllyn', a NASA volunteer who built the prize-winning Neil Armstrong Library on the then NASA Co-Lab island, also contributed photographs and furniture.

An 'aerial' picture of the island generated in 2011 is shown in Figure 1. The inset is taken from the appropriate page in http://maps.secondlife.com/ and is of Space Destiny as at June 2013. A composite of a sample of the work by the volunteers is depicted in Figure 2 at the end of the paper.

Figure 1 *Space Destiny Island showing Solar Hazard study (top right) and the main hall in 2011. The inset is the map as at 2013*

3. Description of Space Destiny Island and the Midrivers Project themes

3.1 *Geography*

The topography of the island was generated using a process called terraforming, and textures added to give interest and realism - this attracted comments such as ‘it reminds me of Corsica’ and ‘looks a little like somewhere in Scotland’. The design was formulated after visits to many other islands in the region (the *SciLands Archipelago* and others) and an informal assessment of what worked and what didn’t. A flat square of grass, as normally supplied, was considered to be tedious, and moreover, the themes benefited from a topography which focused attention on each,

3.2 *Project themes*

A variety of themes were explored. These are illustrated in Figure 2. and included:

- countering the lack of gravity
- transport
- food production and nutritional sustainability
- health and wellbeing
- social order
- effects on the psyche
- energy
- hazards - notably from solar flares.

4. Evaluation and outcomes

4.1 *Collective problem-solving*

The project was intended to assist in solving the problems of individuals through combined ideas for the solution of real world problems. The overall theme may have been fictional, but it addressed real issues, most recently the threat of solar flares, by way of example. On the one hand, visitors could participate in wider studies on this matter via information and links on the island. On the other, they could provide concepts, models and further information on more mundane but vital matters. For instance, a discussion on food production linked with social order produced the suggestion that study could be made of the kibbutz projects in Israel.

4.2 *Participant benefits - selected individuals*

- An academic contributor was encouraged to participate in group activity rather than searching directly for a soulmate. He appeared much happier before he left Second Life to become more immersed in his work.
- Autistic contributors were encouraged to pursue what they were good at, and one returned to college to catch up with is education. The author still receives enthusiastic reports to the time of writing.
- A workplace prejudice victim (female) was encouraged to seize the opportunity to attend a prestigious overseas university. She succeeded in gaining a fellowship, had a fantastic time, and was invited to several speaking engagements at Universities in the land she visited.

- One unemployed computer engineer was encouraged to explore the science and technology ideas which fascinated him, debating their practicality with the author who was able to advise on his proposed experiments, occasionally with regard to his personal safety. He actively volunteered in real life and recently became employed.
- The earlier registered island owner regained his health after a year of constant migraines, returned to college and is continuing his education towards a new career.

There are others for whom participation in the island's activities, if not the Midrivers Project directly, has led to friendship and a sense of achievement, one of whom continues to contribute at the time of writing. The Midrivers Project was intended to assist those who, for whatever reason, felt sidelined or undervalued. Given the above accounts, the project might be deemed a success in this regard alone.

Figure 2; *Midrivers Project themes: Top row, left to right - countering the lack of gravity, transport, habitats and food production sustainability. Middle row - health and wellbeing, social order, effects on the psyche, hazards - notably from solar flares. Bottom - combined studies including autonomous energy, sea-steading (parallel study) and sustainability; a view of the main forecourt of the Liyana Hall, the flags demonstrating international contributions, inside the Hall during an exhibition week on Mars exploration (using NASA and other resources), and lastly a monument on top of the central mount commemorating those who perished in pursuit of space exploration.*

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Acknowledgements and an important note

The project was funded in part by a private benefactor who sponsored the Linden Lab fees for Space Destiny island for the duration of the experiment.

It is important to note that personal accounts referred to in section 4.2 are necessarily from material disclosed to the author and are taken at face value. It has been possible to verify many of them through later real life friendships and volunteered information. Not only would it be inappropriate to identify any of the individuals, the Linden Lab terms of agreement (Wiki, 8 February 2012) [3] state that private real life information should not be disclosed inside or outside of Second Life, disclosure within the simulation risking a ban. Care has been taken so that as far as possible they cannot be identified in this paper unless express permission has been given, but inevitably there may be readers who, from shared experience in Second Life, may consider that they know the residents concerned. Should this be the case, it is requested that their privacy be maintained.

Getting Started in Immersive Education: the case for in-world training

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Abstract. User manuals and other guide documents are popular instruments for training new users of a software system. Quite often these documents have many screenshots of the application user interface which are used to steer a new user through sequential orders of actions. However, for complex scenarios of user interactions, such as those found in virtual worlds, these types of document can become unhelpfully lengthy and less intuitive. This paper describes a systematic comparative analysis of traditional document-based user support with an in-world approach. The results suggest that for learning the skills essential for effective use of OpenSim-based educational environments, an in-world approach is likely to be significantly more effective than traditional user manuals.

Keywords: Open Virtual Worlds, Learning Environments, Immersive Education

1. Introduction

Although virtual world based learning environments have been found to be engaging and effective in various domains ranging from cultural heritage [1, 2] to computer networking [3] there remains a difficulty when *getting started*. OpenSim [4] and Second Life [5] based learning environments in particular have rich user interfaces with a multitude of controls and options that can distract new users from their educational purposes and even cause them to fail to achieve intended learning outcomes. So, getting started is a crucial step in ensuring such environments engage new users in the intended way. Second Life (SL) has a user guide document [6] which covers basic avatar actions with the point-and-click UI and special key combinations which perform the same actions. This is now augmented by a community-based wiki and short video clips. The other method SL uses is to direct new avatars into a uniquely designed region known as Help Island. Help Island in SL is intended to be the first place an avatar interacts with the SL environment if they register through the standard process; an exception is, an institution can have its own SL registration interface through RegAPI in which new users can be directly located into SL regions thereby bypassing Help Island. Help Island provides training for basic functions and free content such as inventory items, body shapes and clothes for avatar customisation and opportunities to receive rewards in Linden$; these are used to motivate new users to actively engage in the Linden Labs economic model through the SL Marketplace.

There does not appear to be any specific research data on evaluating Help Island compared with the user guide document for training new users. One of the major

[1] Corresponding Author.

drawbacks when using Help Island for education is that its design explicitly prioritises commercial activity and entertainment use cases in SL. This can tempt some students to engage in game-like behaviour, which they may not have even imagined to be possible had they not been exposed to Help Island. Furthermore, there is no guarantee that an academically motivated group of users will be on hand in Help Island when a new student enters SL; this can negatively affect a student, shaping their behaviour towards non-educational practices in the virtual world. Because of these reasons, universities often bypass Help Island and locate students directly on their educational islands and provide them with a user guide document for basic tasks.

In general SL is now seen as relatively unsuitable for educational purposes when compared with OpenSim [7], scoring poorly on issues such as commercial cost, programmability, content management, scalability and manageability. However, the lack of suitable training materials for helping students learn how to competently interact with OpenSim is an area where OpenSim currently trails SL. For locally managed OpenSim based educational environments there is no Help Island for new users. Because of the similar functionality between SL and OpenSim and their shared client applications, OpenSim users can use the SL user guide document. However, further information such as the OpenSim grid location URL and avatar user credentials have to be added to the document. The Open Virtual Worlds group at the University of St Andrews have been using a modified user guide, derived from the SL user guide for learning support activities across a range of OpenSim-based projects. Although that approach has helped for login and access problems, students still show an initial difficulty when interacting with the environment. It is evident that the document, although it includes the necessary information for completely new users in a detailed manner, is not effective for learning essential OpenSim interactions. Often, the first half of a laboratory session is used by students getting familiar with these OpenSim functions; this can take up the entire session for some students who may find it more challenging to map the training information from the guide onto the skills they practice in-world. Moreover, a greater number of support academics (lecturers, tutors, demonstrators) are usually required to help the students in building their confidence in using the learning environment during the lab session.

In SL with Help Island content, individual users train themselves without additional support mastering the various basic functions available at the client side. Also, the SL user guide and wiki have been popular places that SL users look at to clarify their doubts about the environment and how to achieve their preferred behaviours. Moreover, Second Life discontinued its in-world mentor program claiming that Help Island is sufficient for the training needs of new users. Due to these observations and challenges in training students and academics in OpenSim, it was decided to develop in-world user support for OpenSim environments (compatible with SL). In order to set a baseline for evaluating the usefulness of the development a pre-test was conducted to compare these two approaches: a region similar to Help Island and user guide documents.

2. Document vs In-World: a Comparative Framework

A prototype OpenSim region with basic information about avatar interactions was developed. The objective was to examine user performance on completing a given set of tasks in-world after visiting the training island. To compare the performance, a controlled study was carried out using the SL user guide. For accuracy the same training content from the user guide was selected and put on display-boards in-world. This way the participants of the two samples, i.e. experiment sample and control sample, see the same training content but in two different mediums, one in OpenSim and the other in a document. Because of this a performance variance between the two groups is more likely to be due to the different training approaches and less due to the contents or tasks. Fig. 1 shows an aerial view of the prototype island with scattered training content displays and a close up view of the first display the avatars see when they enter the island; it helps avatars to explore the environment. Lines of trees were used to separate different categories adding a more immersive flavour into the training experience instead of forcing them to follow a sequential path as happens in the printed document.

Figure 1: Pre-test Prototype Island and a training guide at the arrival point

10 voluntary participants[2] with no prior experience were identified for this pre study. 5 participants were selected randomly for two groups: a group to access the training island and the other group to refer to the user guide. The two groups were named Group-Doc (the group that used the user guide document) and Group-Island (the one that used the island for training). Participants were encoded according to their groups: i.e., Group-Doc {User1-GDOC, User2-GDOC, User3-GDOC, User4-GDOC, User5-GDOC} and Group-Island {User1-GIsland, User2-GIsland, User3-GIsland, User4-GIsland, User5-GIsland}.

The experimental set-up allocated each participant a 30 minute session – 15 minutes to get familiar with the environment using the training material provided (either user guide or training island) and the rest of the time (15 minutes) to follow a set of tasks on a separate island. Individual user sessions were essential since we examined user performance; this arrangement provided a uniform test environment with equal load on the server minimising errors due to variations of server and client performance.

[2] As this was designed as an indicative pre-study rather than a rigorous statistical test the number of participants was deliberately kept low.

To compare user performance between the two groups five of the most basic tasks that any avatar should be able to perform confidently for successful engagement with the environment were selected. Walking and flying were selected as the two important tasks that enable avatars to explore the environment. Object creation and being able to perform basic editing on the created object were also selected as essential skills. Finally, a task with basic communication inside OpenSim - IM and chat - was selected. The task scenario in brief was as follows:

When you arrive at Test Island you will be located at a starting place. Please complete the following tasks as soon as possible.

1. *Your first task is to walk along the road until the end of the road. Please make sure you walk on the middle of the path marked by white dashes on the black tarmac.*
2. *At the end of this road you will see a signpost asking you to fly over the sea to the island. Please do so and land on the exact location marked with a signpost on the island.*
3. *Now create an object (cube) on the ground and follow the instructions given on the relevant signpost to edit your cube.*
4. *Start walking on the second road until you reach its end.*
5. *Perform the tasks on IM and chat as instructed by the signpost at the end of the road.*

It is important that you try to complete these tasks as accurately as possible and as soon as possible for the evaluation requirements.

For task 3, object edit was required to reshape the cube with given dimensions (x, y, z with 2 decimal place accuracy), reposition it on a given location (x, y, z coordinates, with 2 decimal place accuracy) and re-colour only a selected face (the top face) of the object in red. Task 5 included sending an IM with the given text to a previously added friend in the avatar friend list – Test User, and publish the text Task completed using the chat channel in-world. At the beginning of each task these specifications were displayed to the participants using signposts at the relevant locations.

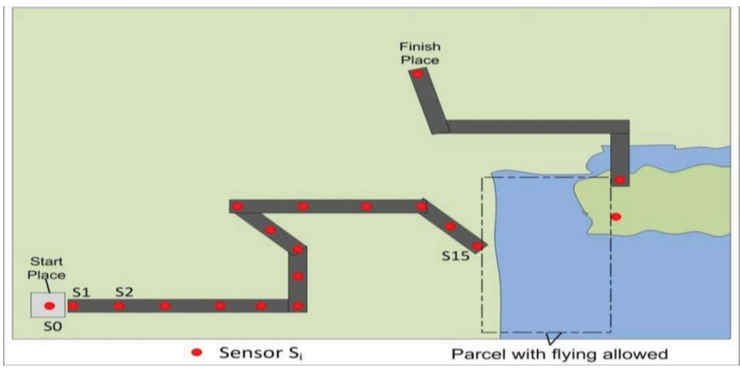

Figure 2: Design map of Test Island for the pre-test evaluation

Another advantage of this arrangement is that the way users perform these tasks can be an indirect indicator of user self-regulation level, i.e., by trying to follow a specifically given set of instructions and tasks with constraints.
The task environment (Test Island) was designed using the task list to place performance monitors. Fig. 2 shows the map of the island. The red colour circles represent the sensor locations to capture the avatar movement times during the experiment.

To make sure the participants do not fly when they are meant to be walking, the region was divided into two parcels: the one shown on the map has been set up to allow avatar flying, and the rest of the land (the other parcel) has restricted settings for flying. A set of sensor objects were deployed as shown in Fig. 2.

The LSL [8] sensor function llSensorRepeat()was used to implement the sensor functionality with parameters of 1.0m range from the sensor and time interval of 0.1 seconds to repeat the scanning. When an avatar is detected by the sensor it triggers the required functionality as defined in the event call. The LSL llGetTimestamp() function was used to obtain the timestamp of the avatar detection, which is within 1ms accuracy.

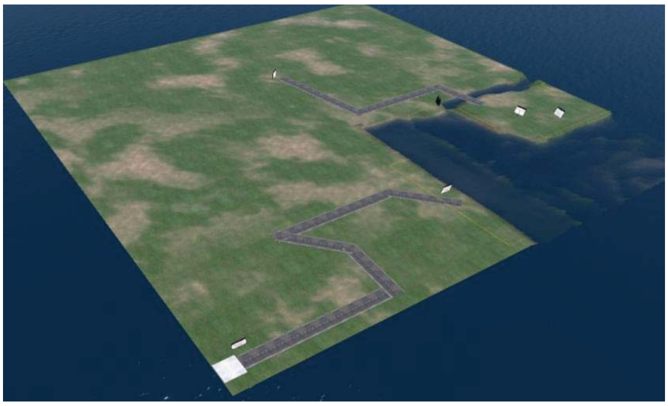

Figure 3: Completed Test Island with parcel settings and sensors

Angular bends on the path are used to evaluate avatar movement performance. Fig. 3 shows the actual implementation of the island with the designed layout. Sensor scripts were embedded in cubic prims of 0.5m of size. To conceal the sensor locations, these cubic prims were made transparent and were half-buried in the middle of the path at planned locations making all the sensors deployed at the same height (z-axis) along the path. The sensors were not distributed in equal distances from each other but according to the path segment and the bends. Timestamps of object creation, object edit and communication (IM and chat) were traced through the object profile and island chat history.

3. Results and Analysis

The first analysis was performed on the times that each user spent in reaching the first set of sensors on the walking path. The distributions of the user times at each sensor are shown in box plot graphs in Fig. 4 (for Group-Island) and Fig. 5 (for Group-Doc). The distributions generally indicate a higher amount of time for Group-Doc than Group-Island. Also the variance of times per sensor is considerably higher for users from Group-Doc compared to Group-Island.

The distribution of average times for each sensor for the two groups is shown in Fig. 6. A clear difference in the mean times can be seen during the early stage of walking. Until the 5th sensor the participants from Group-Doc showed much longer times to reach sensors while walking on the middle of the path. From the 5th sensor to the 14th sensor the time distributions are somewhat similar in their trends but with a reasonable time difference. This may have been due to the fact that the Group-Doc users gained an opportunity to train further during their walk within the first few sensors; yet, the time taken is higher compared to the other group, although the difference is in the range of a few seconds.

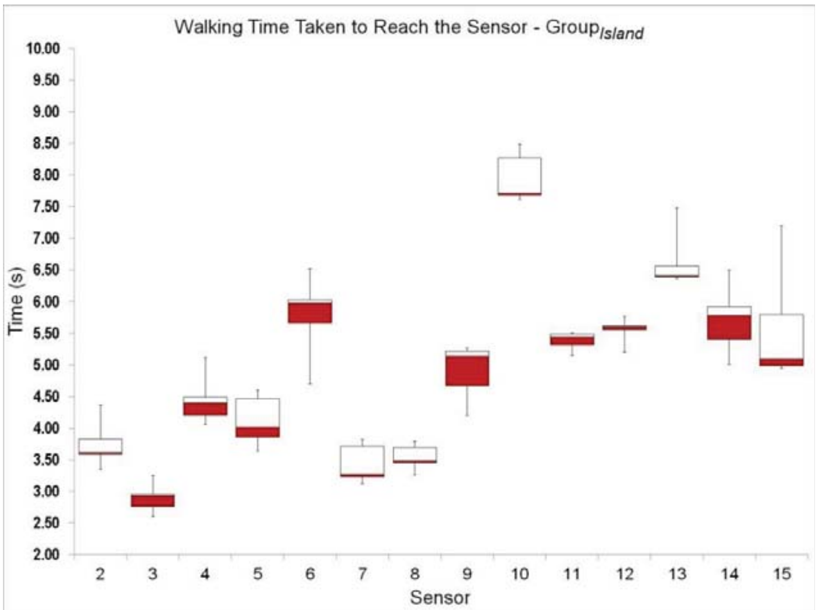

Figure 4: Boxplots of walking times to each sensor for the island users

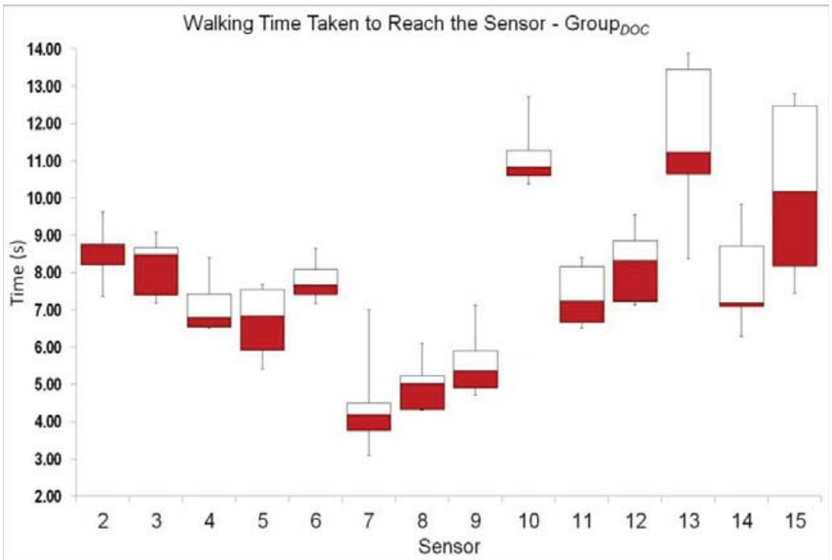

Figure 5: Boxplots of walking times to each sensor for the document users

For the 15th sensor, a further difference is noted in between the two sample trends with a deviation. One of the important observations during the experiment helped to explain the reason for this. The users from Group-Doc often slowed down at the end of the walk trying to figure out how to fly for the next phase of the task. In contrast the users from Group-Island confidently finished walking and started their flying without hesitation. Both groups showed increased times for passing sensors 6, 10 and 13. These sensors are located at the bends of the path that require extra avatar control effort to maintain their trajectory.

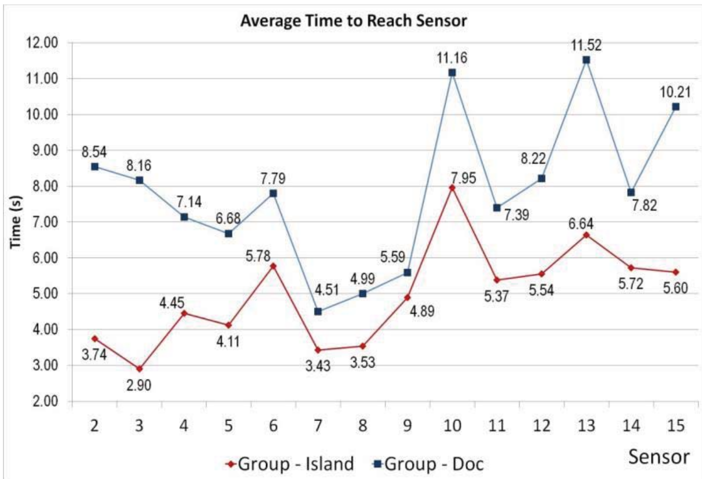

Figure 6: Average times taken by each group to reach sensors

A time comparison of avatar flying between the two groups is shown in Fig. 6.7. Group-Island users showed lower times compared Group-Doc; we use pairwise comparison based on the user codes assigned (i.e., User1-GDOC with User1-GIsland; User2-GDOC with User2-GIsland; and so on) only for presentation purposes (figures 7 - 10); we do not infer on pairwise comparison. Moreover, the users of Group-Island show a lower variance in time against the other group; in fact, it was the expected result as the flying path was a straight line, these users showed more confidence in doing their task quickly and on a straight path while the users who trained from the guide document showed some tremble in all directions during their flying.

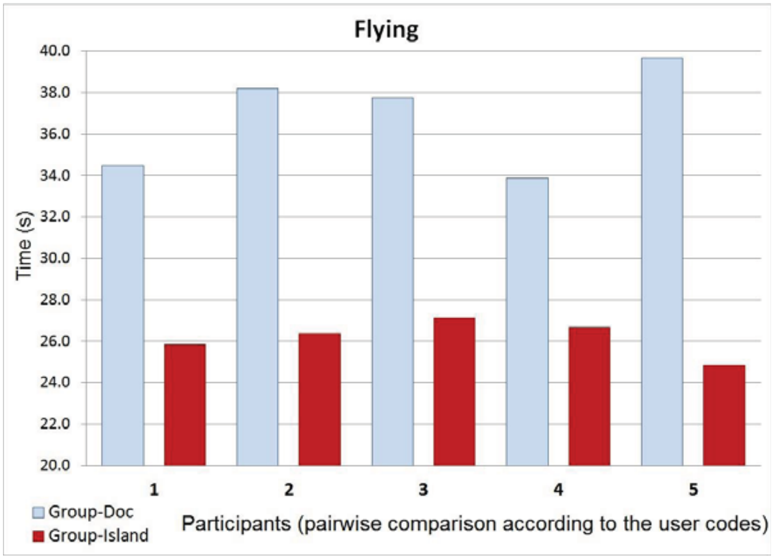

Figure 7: Average time taken by the two groups – Task Flying

Figures 8 and 9 show the times spent by each user for object creation and the required editing tasks, respectively. For both tasks, all users from Group-Island showed much less time than the other group of users. For object creation the time difference was slightly lower since it comprised a single task. However, for object editing, which included a few tasks, the time difference between the two groups is high. Also the variance of times is lower with users from Group-Island. For example, most Group-Island users carried out the object resize and re-position task in a single try through typing the exact figures, while the other group (Group-Doc) tried to drag and resize using the mouse showing a poorer understanding of the system which resulted in a trial and error approach.

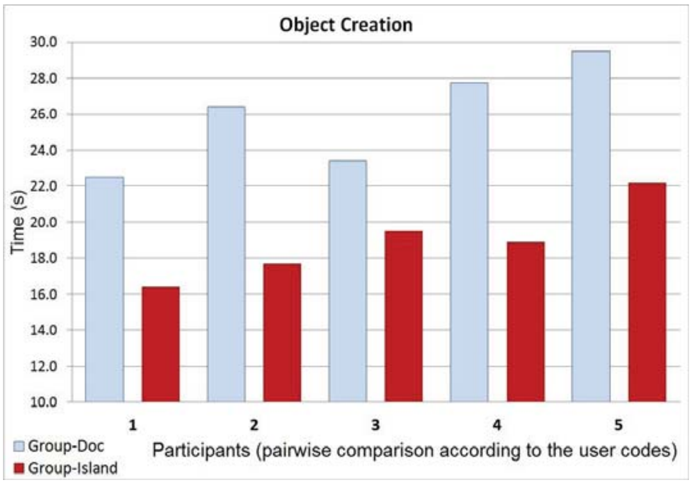

Figure 8: Average time taken by the two groups – Task object creation

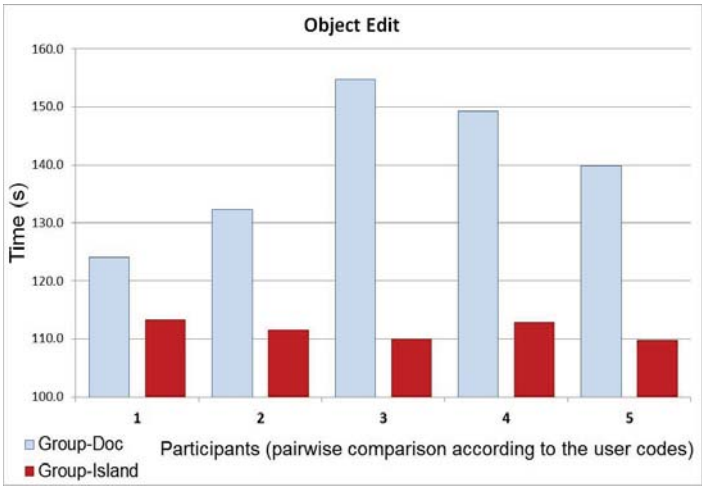

Figure 9: Average time taken by the two groups – Task object editing

At the end of the object-editing task users were asked to move along the exit path and carry out IM and chat to finish the task session. Fig. 10 shows the times used by each participant in the two groups. User3-G_{Doc} and User4-G_{Doc} show a lesser time than User5-$G_{Island,}$ which is an interesting observation. However, when closely examined it was identified that these two users from the Doc group did not complete the IM messaging and abandoned it. Further details about task completion will be discussed later.

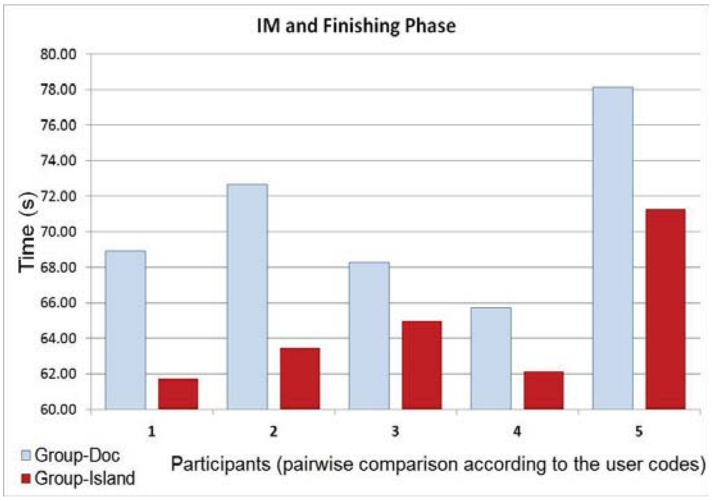

Figure 10: Average time taken by the two groups – Task IM and finishing

Table 1: Average time comparison for the four task phases

Group	Flying (s)	Object Creation (s)	Object Edit (s)	IM and Finish (s)
G-$_{\text{Island}}$	26.16	18.91	111.49	64.70
G-$_{\text{Doc}}$	36.78	25.90	140.04	70.75

Table 2: Descriptive statistics of the entire task for the two groups

Group	Mean Total Time (s)	Std. Deviation	Std. Error of Mean
G-$_{\text{Island}}$	291.07	5.76	2.58
G-$_{\text{Doc}}$	383.44	11.07	4.95

There was a noticeable difference in the completion of tasks between the groups. Table 3 summarises the key observations about the task completion. Only one participant from the Group-Doc could complete all the tasks as expected. In particular, the complex tasks such as object manipulation seem to be the most challenging. In contrast, only one participant from the Group-Island use failed to complete all the tasks. However, all the participants successfully engaged in the activities of walking, flying and chat messaging.

Table 3: Key observations of each user on the task engagement

Participant	Key observations about the completion of the tasks
User1-G_{DOC}	No object surface colour change, object positioning is not accurate
User2-G_{DOC}	No object surface colour change
User3-G_{DOC}	No object surface colour change, object size & object position are not accurate, No IM message
User4-G_{DOC}	No IM message, the whole object is red, object position is not accurate
User5-G_{DOC}	All tasks were done
User1-G_{Island}	All tasks were done
User2-G_{Island}	All tasks were done
User3-G_{Island}	No object surface colour change
User4-G_{Island}	All tasks were done
User5-G_{Island}	All tasks were done

4. Participant Feedback

A brief questionnaire was used at the end to examine the participant opinions. The first question asks about the support they received from the user guidance approach and the second question asks their opinion about the alternative approach (either document or island) instead of what they had. This alternative arrangement of questions helps the participants to compare their experience and respond highlighting their preferred method of receiving OpenSim training. The questions were designed with Likert scale answers at 5 levels: Strongly Disagree (1), Disagree (2), Neither Agree nor Disagree (3), Agree (4) and Strongly Agree (5).

The following two questions were asked from the Group–Doc participants; their responses are shown in Fig. 6.11

Q1 – The guidance document helped me to complete the tasks inside the MUVE comfortably

Q2 – A training island would have been a better and more usable method for me to train myself for the tasks

All of the participants from Group-Doc are of the view that it would have been a better approach to use a MUVE for their training needs. Interestingly, they have indicated that there is a certain level of challenge for them to map the information they have learnt from the document into the OpenSim context. Acknowledging the fact that they have learnt some information from the user guidance document, these participants showed their doubts about a document for training complex OpenSim tasks.

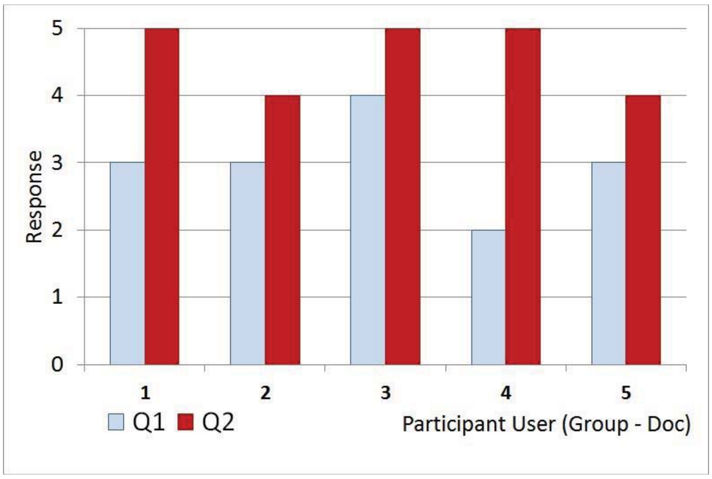

Figure 1: Group-Doc user feedback for the questionnaire

The following two questions were asked from the Group–Island participants and their responses are shown in Fig.12.

Q1 The training island helped me to complete the tasks inside the MUVE comfortably

Q2 A user guidance document would have been a better and more usable method for me to train myself for the tasks

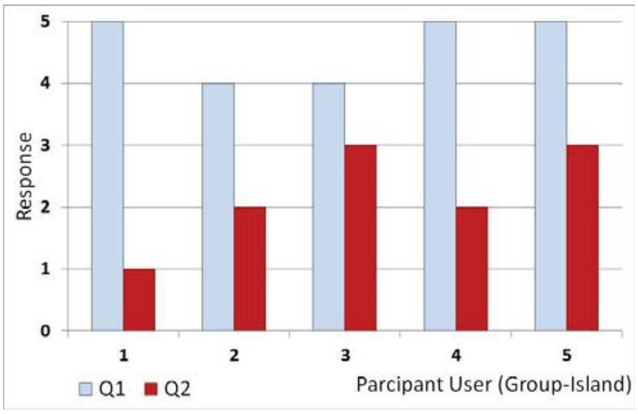

Figure 12: Group-Island user feedback for the questionnaire

5. Conclusion and Next Steps

In order to establish a baseline for developing an effective training environment for new users of educationally oriented virtual worlds a comparison was carried out between document-based and in-world approaches.

The participants that tried the document-based approach showed some difficulty in completing the relatively complex tasks. It was further observed that participants who had experienced the in-world training island showed more confidence in completing the given tasks in comparison to the other sample. From the user feedback all participants indicated that using a training island is likely to be a better option.

Also, the study findings suggest that a higher level of user self-regulation was present in the group that used the island compared to the document users with respect to their task completion; the island users showed a better ability to perform the tasks as they were required.

Considering all these findings this pre-study will be used as the basis for developing an environment that can be used as a common platform for user training needs in any OpenSim based learning environment. The new training environment will act as the first place for new users to visit allowing them to learn how to interact competently with the immersive virtual environment before starting their educational activities. An iterative approach based on evaluations, revisions and enhancements will be used to ensure that the resulting island will fulfil the identified need.

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Collaborative Peer Assessment in a Blended Learning Environment

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Abstract. In this work, the concept of (online) collaborative peer evaluation is introduced, and a pilot study is done to gain insights about the effectiveness of this approach in terms of consistency with an expert evaluation and learning enhancement. The outcomes of the study indicate that online collaborative peer evaluation can be used for both purposes where groups of assessors evaluate assignments by online discussion. They are expected to reach a conclusion about the result and the feedback to be supplied without external moderation. Both the discussions in the evaluation process and the feedback supplied are effective for learning enhancement.

Keywords. Peer evaluation, blended learning, assessment, collaboration, learning enhancement

Introduction

Advances in computing and communication technologies have enabled effective use of blended learning replacing classical face to face instruction carried out in the classroom only. Blended, or hybrid, learning can very basically be defined as the combined use of e-learning techniques together with classical classroom instruction. The major benefit of blended learning can be identified as the utilization of the best features of both techniques. In the ideal case, students are given the opportunity to advance in their own pace using e-learning techniques where the content can be delivered electronically (mostly online). In the classroom, on the other hand, activities are carried out that cannot be achieved in the online and/or digital environment. The literature contains numerous works about blended learning, its advantages and shortcomings [1-9]. Essentially, the independence in space and time is considered to be the major advantage of blended learning that favors active learning for the student. On the other hand, the lack of an instructor may be a degrading factor for some groups of students' performance. Furthermore, online collaboration is still inadequate in some tools deployed for e-learning, and the immediate feedback of an experienced instructor cannot be replaced by any tool. As of today, there is still no clear agreement in the learning community how the instruction should be structured, or partitioned in a blended learning environment for maximum effectiveness and efficiency [6, 8].

A commonly used component of blended learning is learning, or course management systems that are online environments enabling the e-learning component

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and supporting the classroom instruction. As the new generation of students has emerged in educational institutions in the last fifteen years, it has been observed that those "digital natives" exhibit different characteristics about use of online environments [10-11]. Especially the extensive usage of social networks has allowed the learning community to easily integrate virtual platforms into the e-learning environment. The students are used to such platforms in their private social life, and this experience can be utilized to structure blended learning in a way that further functional components of instruction can be shifted to the online environment. An interesting feature of this kind is peer evaluation. Peer evaluation, or assessment, is a well established method that has several benefits: increasing the student's interaction with other students and the instructor; enabling the student to understand other students' learning process, and enabling the student to understand the evaluation process [12-15].

As learning management systems have been used, peer evaluation has also been integrated into those blended learning environments. The literature contains many references about the deployment of peer evaluation in online environments [16-22]. Moreover, recent literature surveys revealed use of online peer evaluation in many more diverse areas and settings where the primary focus of those surveys was academic education carried out in a blended environment [23-25]. However, the findings of the research are aligned in diverse directions on different issues such as effectiveness, consistency, and learning enhancement. The majority of research agrees that peer evaluation enhances "student engagement" [16-18, 20, 21, 23-25] and promotes "critical thinking and knowledge sharing" [16]. Regarding the reliability of peer evaluation, the majority of research work finds out that peer evaluation is consistent with teacher evaluation, so that it can be used effectively [17, 18, 20, 21, 25]. However there are also counter examples where there is no consistency between the peer and expert evaluations [22, 25]. Regarding the performance enhancement in learning, the community is more severely divided. Many have found out that peer evaluation (and the formative feedback supplied) enhances student learning [16-18, 25, 26] whereas many others argue that peer evaluation has no significant effect on learning outcomes [19, 20, 22]. An important observation in [20] is that peer evaluation enhances "conceptions of learning" but not learning outcomes. The conclusions of recent research can be summarized as follows: It is difficult to identify characteristics of effective peer evaluation methods as they are heavily context and content dependent. Hence, more research has to be carried out to figure out dependencies among the variables of peer evaluation where quantitative measures for enhancements in learning outcomes and for validity have to be developed [23-25].

As can be seen above, there is a large base of research on (online) peer evaluation. However, to the best of the author's knowledge, there is no research about collaborative peer evaluation. Collaborative peer evaluation can be defined as the evaluation of one's work by a group of peers where there will be only one "decision" or "grade assigned" by the group. The details of this approach will be explained in the next section. This is not a mere aggregation of the individual decisions of group members as is the case for the instances in the literature. Collaborative peer evaluation is based on a "critical review" of the work where in this research the assessor peers (group members) have also submitted the same assignments, and they are also assessed by other groups of peers. The main objective of such a collaborative evaluation by peers is to enhance learning of *all* peers as they will be contributing to the discussions carried out in the review process. In this sense, collaborative peer evaluation aims to act as a collaborative learning activity that has also been mentioned by others [20, 26, 27].

It should be mentioned that collaborative peer evaluation would be most useful in assignments that require critical argumentation and reasoning skills where the individual assessors would be able to freely discuss their own opinions. It would not be suitable for cases where the instructor would supply a set of “fixed solutions” to be taken as the guide for evaluation. The evaluation process has to act as (display the characteristics of) a “problem solving” process so that it can be used as a learning activity effectively.

A serious motivation for the design and implementation of such a collaborative peer evaluation scheme is the new type of behavior observed in the student community at the university level. Among other characteristics, the students belonging to the y-generation live in the connected world, can efficiently do multitasking, want to express their opinions anonymously and get appraisal in the virtual world [7, 10, 11]. Grading (like and dislike) and commenting on posts (any kind of text, memo, phrase, picture etc.) of others (and replying to such comments) in social media, has become a daily routine for many of the students. Even though they are rarely eager to contribute to discussions in the classroom, they actively participate in online forum discussions. They prefer to read books on the screen instead of holding a printed copy in their hands. Hence, the student body seemed to fit perfectly into an online collaborative peer assessment process.

Last but not least, such an online peer assessment activity would also be beneficial for achieving the learning outcomes of the “Engineering Guide and Ethics” course that freshman engineering students (approximately 150 students each year) are required to take in their first semester at our institution. This three credit course exhibits the general characteristics of the engineering profession with its relationships to the society and the environment. Engineering ethics forms a major component of the course. The learning outcomes and the course objectives related are given in Table 1.

Table 1. Objectives and learning outcomes for the “Engineering Guide and Ethics” course.

	Course Objectives:
1.	To be a guide for students in their undergraduate study.
2.	To give the student an understanding of the engineering profession and the main engineering problems with their social context.
3.	*To collaborate in small groups to analyze a case and identify the problem, to synthesize a solution, to formulate arguments for a debate and to develop communication skills.*
4.	Developing skills in moral reasoning, having an understanding of ethical implications of the engineering profession. Consciousness in academic ethics.
	Course Learning Outcomes:
1.	To understand the academic system.
2.	To understand knowledge management and its importance.
3.	Ability to use office applications software for word processing, spreadsheets, and presentation.
4.	*Ability to communicate in written and verbal form, and ability to make presentation.*
5.	*Ability to collaborate with classmates for discussion, problem solving, and project work.*
6.	Ability to define engineering, its characteristics, and main concepts associated with engineering: systems approach, modeling, optimization etc.
7.	To understand the impact of engineering in society, culture, and environment.
8.	Ability to define tasks of engineers and their work areas.
9.	Ability to define ethics and the relationship of engineering and ethics.
10.	Ability to analyze an ethical case, and to develop a solution/comment about the case.
11.	Understand codes of ethics and academic ethics.
12.	Understand the need for lifelong learning.

The course is carried out in a blended fashion where a professional learning management system is deployed. Assignments (Home works, quizzes, and project) except the midterm and the final exam are carried out online using the learning management system. All presentations enriched with sound recordings and related documents for reading are available in the learning management system. The class meets one hour per week for activities like group work, discussion, exercises, and practical applications. As can be seen, the course also aims to develop "soft skills" of the students, such as communication, argumentation, and group work that the professional world expects from the university graduates (objective #3, and outcomes #4-5). Henceforth, it would be a nice experiment where students would evaluate their peers' assignments in a collaborative group work that would serve two aims: learning enhancement by critically reviewing other's work; and improvements in soft skills mentioned above. The methodology and the process of the experiment are described in the next section. Section 2 will display the findings, and finally Section 3 will conclude the paper with comments and suggestions for future research.

1. Methods

In the blended structure of the course, the students are assigned five home works that have to be performed individually. The students submit the home works via the learning management system. Furthermore, the students take 10 online quizzes, and perform three class exercises in groups. Out of those 18 grades, the best 10 grades will be taken into consideration for the student activity component of the final grade. Therefore, some home work assignments are submitted by a relatively low number of students. The fourth home work has been selected as the assignment to be used for collaborative peer evaluation as this assignment has no "correct" answer, but rather, the student is expected to carry out a critical analysis. The description of the assignment is given in Table 2. The assignment is adopted from the textbook of the course [28]. Essentially, the students have to analyze the Challenger space shuttle accident with respect to the four ethical theories; and they have to express their own opinion whether the space shuttle should have been launched or not.

In the fall semester of the academic year 2012-2013, a total of 32 students have submitted a response for the assignment, will be labeled as *paper* from now on. An introductory tutorial has been given to those students in an extra session where the methodology is explained, and the process steps have been highlighted. The papers are text documents that do not include any information about the student so that the assessed students remain anonymous. The students also did not know beforehand that such a peer evaluation process will be carried out for this assignment. The assessors (32 students that have submitted the home work) are divided into 8 groups of 4 students in a random fashion. The assessors have been instructed to communicate online only without disclosing their identity. Each paper is assigned randomly to 3 groups for evaluation where the submitter is not among the assessors in those groups. Hence, each group (made up of 4 assessors) has evaluated a total of 12 papers.

Table 2. Description of the assignment used for collaborative peer evaluation.

GE103 Assignment-4: Challenger accident and ethics (adopted from the textbook)

The aims of this assignment are:
- Getting to know about the ethical theories, their similarities and differences.
- Getting to know about the Challenger accident, and to gain insight about critical analysis of a case with respect to ethics.
- Getting experience in ethical reasoning and judgment.

Instructions
1. Review Chapters 1-3 (pages 1-44) in the textbook “Engineering Ethics” with special attention to
    - Challenger case (pp. 6-11)
    - Ethical theories (pp. 35-41)
2. Analyze the Challenger case using the four ethical theories:
    - utilitarianism (consider issues such as benefits of space shuttle program to USA, Morton Thiokol, and mankind),
    - duty ethics,
    - rights ethics, and
    - virtue ethics.
3. Prepare a one page report in Word that includes your analysis of the case with respect to the four theories. At the end of the report, provide a conclusion with the answer of the following question: What is your opinion whether the Challenger should have been launched? Give your reasons! (see the template below)
4. Upload the *.doc file as the Safe Assignment response.

Template for Report:
Analysis of Challenger Accident:
Utilitarianism ....
Duty Ethics ....
Rights Ethics ....
Virtue Ethics ....
Conclusion: Should Challenger have been launched? Why/Why not? ....

The procedural flow of collaborative peer evaluation process is as follows:

Step 1: Setup. The students are randomly divided into 8 groups. For each group, a random student is selected to be the moderator who has the privilege to supply the final group grade, and the feedback to be supplied to the assessed student.

Step 2: Individual Browsing. Each assessor is expected to read the papers assigned to his/her group before the collaborative evaluation sessions starts by logging to the online environment. The assessor notes strengths and weaknesses of the paper in terms of accuracy and consistency of the reasoning carried out.

Step 3: Collaborative Evaluation. Each group meets online in the forum environment for collaborative evaluation. The forum displays (and stores) all written communication as a sequence of comments. The moderator selects a paper, and starts the discussion. There is no time limit for a single paper; each assessor is expected to comment about the strengths and weaknesses of the paper. Then, each assessor is expected to reply to the comments of others. There is a “microphone” button to take the privilege of posting a comment. Once an assessor takes the order, others have to wait until the post is finished. Each assessor offers a grade for the paper. The allowed values for the grade are 0, 20, 40, 60, 80, and 100.

Step 4: Evaluation Submission. The group is expected to reach a conclusion about the grade and about the feedback for the paper. The feedback must contain the strong and weak points of the paper. Once the group decides about them, the moderator enters the grade, and the feedback. Then, Steps 3-4 are repeated for other papers. The group may decide to give a break and meet at another time.

Step 5: Self Evaluation. Once all evaluations are finished, each student is asked for assigning a grade for his/her own paper.

Step 6: Feedback Evaluation. Then, the student may access the results. Grades supplied by three groups (and the average of them), and the feedback supplied by the groups can be seen by the student. The student has to evaluate the feedback supplied by each of the assessor groups. For this purpose the Likert scale is used (5: Strongly agree, 4: Agree, 3: Neither agree nor disagree, 2: Disagree, 1: Strongly disagree) to determine the opinion of the student whether the feedback supplied is appropriate.

Step 7: Instructor Evaluation. The instructor evaluates the papers in parallel with the previous steps. Results of Steps 1-6 are not visible to the instructor yet.

Step 8: Process Evaluation. After all feedback evaluations are carried out, and the instructor evaluations are finished, the students are asked to fill a questionnaire. The questions of this short online questionnaire are given in Table 3. Again, the Likert scale is used for evaluation. Last but not least, the students are asked to comment on the whole process in free format.

Table 3. Questionnaire used for process evaluation.

	Do you agree on the statement below? (5: Strongly agree, 4: Agree, 3: Neither agree nor disagree, 2: Disagree, 1: Strongly disagree)
1.	Reading peer's papers has enhanced my level of understanding.
2.	Collaborative peer evaluation has enhanced my level of understanding.
3.	Peer feedback has enhanced my level of understanding.
4.	I liked to perform collaborative peer evaluation.
5.	I would like to have my assignments be evaluated by peers.

2. Results

The students got quite excited and they were enthusiastic at the beginning as they had not performed such an activity before. However, the evaluation process could not be followed within the planned time frame because the students could not finish Step 2 (Individual Browsing) in time (1 week). Next, the students could not easily agree on the appointment schedule for Step 3 (Collaborative Evaluation) so that some students asked for the help of the instructor to arrange an online meeting schedule. Even if some of them did it lately, all 32 students have participated in the evaluation process. There was only one student who has not completed Step 8 (Process Evaluation).

The summary of the peer evaluation activity can be seen in Table 4: Individual evaluations of papers (A1-A32) by groups and their average (Step 4, columns G1-G8, and PEER), self evaluations by students (Step 5, column SELF), evaluations by the instructor (Step 7, column INST), and the average value for feedback evaluations by students (Step 6, column FEEDBACK). Average grades by group, self, and instructor evaluations are also given in the last row of Table 4. The correlation coefficients between the parameters of group averages (PEER), self evaluations (SELF), instructor evaluations (INST), and the feedback evaluations (FEEDBACK) are given in Table 5 to display the dependency among those evaluation parameters. Finally, the outcome of the process evaluation survey is displayed in Table 6. The counts of student responses on Likert scale for the questionnaire are displayed with the average and standard deviation values for each question.

Table 4. Evaluation results for the papers A1-A32: Paper evaluations by groups and their average (Step 4, columns G1-G8, and PEER), self evaluations (Step 5, column SELF), evaluations by the instructor (Step 7, column INST), and the average value for feedback evaluations (Step 6, column FEEDBACK).

GROUP		G1	G2	G3	G4	G5	G6	G7	G8	PEER	SELF	INST	FEED-BACK
G1	A1	-	60			60	40			53	80	80	4.0
	A2	-	60	60				80		67	80	80	3.7
	A3	-		60	60				60	60	80	60	4.3
	A4	-			40	60	80			60	60	60	5.0
G2	A5		-	80		80			80	80	100	80	2.7
	A6		-		80		60		60	70	60	60	2.7
	A7	80	-	80			80			80	80	100	4.3
	A8		-		60	60			60	60	60	60	3.0
G3	A9	80		-	40		80			67	80	60	2.7
	A10			-	80	80		80		80	100	100	4.0
	A11			-	80		80		60	80	100	60	3.3
	A12	60	80	-			80			73	80	80	3.0
G4	A13				-	80		40	60	60	80	60	4.0
	A14	60	80	80	-					73	80	80	2.7
	A15	100	100		-		100			100	100	100	5.0
	A16		100	100	-			100		100	80	100	4.7
G5	A17				60	-	80	80		73	80	80	3.3
	A18	80		60		-		80		73	80	80	3.3
	A19		60		40	-		40		47	80	40	1.7
	A20		60	80		-	60			67	80	60	3.7
G6	A21	80					-	60	60	70	80	60	4.0
	A22		80	80			-		80	80	100	80	3.0
	A23				80	60	-		80	70	100	80	3.3
	A24	60		80			-	80		73	80	80	2.7
G7	A25	40			60			-	60	50	60	60	1.7
	A26	60		80		80		-		73	80	80	3.3
	A27		100		40			-	100	70	100	80	3.3
	A28	60				60		-	60	60	80	80	3.7
G8	A29		100				100	100	-	100	100	100	5.0
	A30	80				100	80		-	87	100	100	3.7
	A31		80			60		60	-	67	80	80	2.7
	A32			80		80		100	-	87	60	80	4.0
									AVERAGE	72	83	76	3.5

Table 5. The correlation coefficients for the evaluation parameters of Table 4.

Parameter	SELF	INST	FEEDBACK
PEER	0.48	0.76	0.51
SELF		0.49	0.18
INST			0.48

For Table 5, the values of correlations are statistically significant ($p<0.01$) for all pairs except the pair SELF and FEEDBACK. The first observation that can be made is that the group evaluations' average grade (72) is quite close to the instructor's evaluations average (76). The positive correlation (0.76) between them indicates that there is an acceptable level of consistency between peer and instructor evaluations. However, students' self evaluation grades are on the average 10 points higher than the peer evaluations, and the correlation between self evaluations and peer/instructor evaluations are (0.48/0.49) only. This can be explained by the high expectations of the students. It should be kept in mind that this assignment has not been submitted by all students. So, it can be assumed that the students have really got involved in this assignment, and they have a certain level of confidence in their competency, and they expect higher grades. The positive correlations between students' evaluations of feedback and peer/instructor evaluations (0.51/0.48) along with the correlation between students' evaluations of feedback and self evaluations (0.18) indicate that students of papers with higher grades are more likely to agree with the feedback supplied. In summary, collaborative peer evaluation appears to be consistent with expert evaluation and this can be utilized for its own benefit.

Table 6. Evaluation results for the process: Counts of student responses on Likert scale for the questionnaire, their average and standard deviation (total number of respondents is 31).

Statement / Opinion in Likert Scale	1	2	3	4	5	Average	Standard Deviation
Reading peer's papers has enhanced my level of understanding.	0	5	8	12	6	3.6	0.95
Collaborative peer evaluation has enhanced my level of understanding.	0	3	7	12	9	3.9	0.89
Peer feedback has enhanced my level of understanding.	0	2	6	18	5	3.8	0.59
I liked to perform collaborative peer evaluation.	0	2	7	7	15	4.1	0.95
I would like to have my assignments be evaluated by peers.	3	7	14	5	2	2.9	1.02

Reviewing the data in Table 6 (survey about the process itself) two conclusions can be achieved. Firstly, the students *agree* that their level of understanding in the subject has been enhanced by this activity. This statement is based on the average values of 3.6, 3.9, and 3.8 obtained for the first three questions. Seemingly, the collaborative evaluation part with online discussions has been most useful for learning enhancement. Secondly, the students are still skeptical about being evaluated by peers (an average value of 2.9) even though they have liked that activity (an average value of 4.1). Almost one third of the students disagrees or strongly disagrees with this idea.

Finally, the "free text" comments of the students have been analyzed, and it has been found that more than half of the students are complaining about the difficulty of reading 12 papers within one week of school time. Even though each paper was not longer than one page, the students were not used to it. 90% of respondents indicate that they have liked to do peer evaluation. Almost 30% of students argue that the process would be more effective if the online discussion would be replaced by face to face meeting where they would be able to speak directly instead of writing comments. A minority of 5 students have found the process to be very difficult and long, especially the determination of the group grade and the feedback.

3. Conclusion and Future Work

In this work, a pilot study about online collaborative peer evaluation is carried out. The work had a well defined methodology, and the process has been conducted according to the principles defined in the methodology. The outcomes of the study have been analyzed quantitatively and qualitatively. The major conclusions of this work are:

- Collaborative peer evaluation can be used effectively for evaluation purposes.
- Collaborative peer evaluation enhances understanding of assessors.
- Students are not willing to be evaluated by peers.

As this study is limited to a single offering of a course, those conclusions cannot be generalized extensively. Further research is necessary for reaching general conclusions. However, the consistent outcomes of the study look promising even though there is a seemingly conflicting outcome that students are unwilling to be evaluated by peers whereas they liked the process. It has to be investigated further why students are skeptical even though the peer evaluations are close to the evaluations of the instructor. A possible explanation may be that this process is new for students, and that trust to peers is not developed so easily. Cultural prejudices may also be effective. The benefits of this process in learning enhancement constitute the actual potential for collaborative peer evaluation. Moreover, the following items can be investigated in future research to gain insight in this subject:

- Inclusion of students in the evaluation process that did not submit the assignment, and measurement of the learning level specific to the assignment. In this way, both the effectiveness of peer evaluation and the amount of learning enhancement can be identified quantitatively.
- Review of individual assessor comments made during the collaborative discussion phase. This would clarify the group process involved and the dynamics of reaching a conclusion after negotiation can be understood more clearly.

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Learning about Collaborative Virtual Environments by Creating Collaborative Virtual Environments

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Abstract. We present a case-study based on a range of work from student projects working to a brief to create 3D and web-based projects to promote collaboration and public participation in local cultural heritage and urban regeneration. Aside from being an opportunity to allow students to *use* virtual worlds for collaboration, the project brief was set to ask them to consider how end-users might make use of their projects for collaboration and discussion. A review of the issues faced by students and of the final projects themselves is conducted to provide a means to compare five different virtual worlds and to gain some appreciation of how the choice of virtual world or 3D platform impacts on student work.

Keywords. Virtual Worlds; MUVE; Virtual Heritage;

Introduction

We review the results of using a cultural heritage and urban regeneration project brief with a number of groups of final year University students working in a range of 3D multi-user virtual environments (MUVE). The deliverables and results of each group reveal not only differences in the abilities and motivations of the groups, but also some of the strengths, weaknesses and idiosyncrasies of the different platforms used. While a number of previous works have explored the affordances of different virtual worlds, the comparison in this case study highlights some differences between platforms which when considered independently might otherwise appear quite similar in terms of features and capabilities. We also reflect on the use of virtual cultural heritage and urban regeneration based projects in virtual worlds, and how these can benefit from the collaborative features of modern MUVE.

1. Collaboration and Learning in Virtual Worlds

3D virtual worlds generally offer rich sets of tools and features that can be used to support discussion, cooperation and collaboration. Over the years, a number of papers have explored the technical and pedagogical affordances, capabilities and potential of a range of MUVE platforms, such as Active Worlds [1] or Second Life [2]. These can vary from detailed explorations of a single environment that tightly focus on technical features and the basic interactions available between users (e.g. text or voice based chat, private messaging, ability to modify the 3D environment itself, etc.) [1] to more general explorations of the types of educational interactions and activities that might be carried out using the platform (e.g. self-paced tutorials, role-play, simulation, constructionist learning activities, etc.) [2].

Dalgarno and Lee [3] try to characterize the learning affordances of 3D virtual learning environments (VLEs) in general, and identify five distinct affordances of 3D virtual environments:

- "3-D VLEs can be used to facilitate learning tasks that lead to the development of enhanced spatial knowledge representation of the explored domain." ([3], page 18)
- "3-D VLEs can be used to facilitate experiential learning tasks that would be impractical or impossible to undertake in the real world." ([3], page 19)
- "3-D VLEs can be used to facilitate learning tasks that lead to increased intrinsic motivation and engagement." ([3], page 20)
- "3-D VLEs can be used to facilitate learning tasks that lead to improved transfer of knowledge and skills to real situations through contextualisation of learning." ([3], page 21)
- "3-D VLEs can be used to facilitate tasks that lead to richer and/or more effective collaborative learning than is possible with 2-D alternatives." ([3], page 23)

Overall, these range from the obvious (that 3D virtual environments can be used to support tasks that require developing knowledge of a 3D space), to the highly arguable (do we have a good enough understanding of what is *possible* in 2D learning environments to be able to say authoritatively that 3D VLEs allow more effective collaboration than is possible using 2D tools). This last also overlooks the ways that 2D learning environments – VLEs such as Moodle, discussion forums, video conferencing, social networking and video sharing via YouTube or similar are often used to enrich and supplement 3D VLE learning activities (see, for example, the many thousands of instructional videos for Minecraft that are available on YouTube). If this final statement were true, it would neither be necessary nor common to support learning in 3D virtual environments with a rich range of 2D alternatives. So perhaps the two should be seen more as complementary rather than one being necessarily better than the other.

The potential for complementary use of 2D and 3D learning environments spurred the development of SLOODLE, a tool to integrate teaching and learning across the two types of environment [4], and considering MUVE and other digital media as complementary allows more explicit consideration of how they might be used together in the classroom to foster and support effective collaboration. As the Computer Supported Collaborative Work (CSCW) research community have learned, however, effective collaboration is not something that can be created simply by adopting a particular set of technologies. Collaboration is a human process [5], one that requires people to invest in, in order to achieve the intended or hoped for goals.

Nunamaker, [6], identifies nine principles for effective virtual teamwork. Most of these principles are centered around making communication as effective and explicit as possible, and finding ways to provide motivation and incentives for successful team work. Activities that get the virtual teammates to get to know one another, and changes to reward structures are as important (if not more so) as embedding the collaboration technology into everyday work. One example of an effective learning design along similar principles is documented in [7], where web-based discussion forums, audio forums and video sharing are all used as tasks to introduce team mates for a collaborative project *before* the students start to work together in Second Life.

One type of learning activity that virtual worlds are often used for is a collaborative project where students have to work together to create some kind of artifact. The artifact might be a (re-)construction of some scene in the virtual world [2, 8], or the creation of a video made by recording some action within the 3D world.

While many of these projects do not explicitly refer to the pedagogy of constructionism [9], the idea from constructionism of learning through creating for others is a common thread in a wide range of virtual world education research projects and published examples of best practice. It should be noted that this is a long established pedagogical approach for learning and teaching with virtual worlds, with examples dating back to the 1990s, in both graphical [10] and text based [11] virtual worlds.

2. Learning CVE by Creating CVE

Constructionist ideas strongly influenced the development of a final coursework for a final year class at the University of the West of Scotland on *Collaborative Virtual Environments* (CVE). The class teaches students about a wide range of collaborative tools, providing a broad base of knowledge in Computer Supported Collaborative Work (CSCW) and related fields. Students also have to work in both small (2-3 students) and mid-sized (4-6 students) collaborative groups within the class, working on an essay and a practical project respectively.

For the essay assignment, students were matched with partners from the other campus where possible, and groups were to collaboratively write a research essay on a topic selected from a list. Collaboration was to be online using any available tools: Google Docs was highly recommended, but not obligatory. A wide range of additional online tools such as Skype for online video-conferencing and online mind-mapping applications were also recommended for use. In this exercise, while working on an essay on a relevant topic, students were thus learning about common web-based CVE by using them in order to produce their essays.

For the practical assignment, the goal was somewhat more ambitious. Students would have to work together to create a CVE for another set of end users.

2.1. The Brief: Paisley 2020

The project brief was to create a blended web and 3D CVE to support public participation in urban regeneration and planning for the Scottish town of Paisley. A brief was developed in participation with Andy Campbell of Plan for Paisley (www.paisley2020.org) – a local group seeking to "generate, maintain and share civic pride" in the town, and support greater public participation in plans for redevelopment of the town.

The project brief developed with Plan for Paisley is shown in Table 1. While elements of the brief are quite specific, individual groups had significant leeway in choosing exactly what to implement. Options included making use of Augmented Reality to add a virtual layer or information, discussion and interaction to physical locations in the town, or to focus on creating 3D representations of selected areas of the town where users could see areas of the town as they are or as they might be, and participate in collaborative discussions or other activities to support town planning and public participation in the planning process.

An integrated web-site was a set requirement, as was the development of a short video to show-case the CVE created by the group.

Table 1. Project brief, developed in Plan for Paisley

Supporting Urban Regeneration and Public Participation in Planning
Plan for Paisley (PfP), http://www.paisley2020.org, is a group of individuals from various backgrounds interested in the regeneration of Paisley to transform the town into a desirable location for businesses, housing and entertainment venues.
PfP are interested in the use of digital collaborative technologies to support urban regeneration and public participation in planning.
To help with their long term (25+ years), the group would like to create a full 3D interactive model of Paisley town centre and nearby surrounding areas. The 3D model will be at the heart of current review and future planning activity. It is to act as the showcase platform for the visionary options for the future of the town. Animations and flythrough will be generated to help clearly communicate plans. Furthermore, the 3D model could extend beyond as a marketing tool or as an interactive front end for tourism or marketing.

2.2. The Participants

In academic year 2012-13 the class was taken by 31 honours (final) year students, 23 of whom were based at the University's Paisley campus. The remaining eight students were based at the Hamilton campus. The students were drawn from a range of computing related courses (BSc Computing, 6 students, BSc IT, 7 students, and BSc Computer Games Development, 18 students), and were overwhelmingly male (4 female, 27 male).

Students were formed into six groups, each of between four and six members. Four of the groups each had two members from the university's Hamilton campus, with the rest of the group made up of students from the larger Paisley cohort. The remaining two groups consisted of Paisley students only. While online collaboration was an important part of the module experience, it was felt that a lone remote student in a group might be unfairly isolated – which led to the pairing up of students from the smaller campus. Group composition was set by the lead tutor.

All groups were given a private discussion forum and wiki for group discussion and planning on the class Moodle pages, on the institutional VLE (Virtual Learning Environment). Students were encouraged to use this along with any other collaborative technologies for planning and carrying out the work – including, of course, the selected CVE base platform itself. And all cross-campus groups participated in at least one on-campus video-conferencing session during early stages of discussion and planning.

Game development students, in particular, all had experience working with a range of 3D development tools and technologies – though no-one in the class had prior experience with the virtual worlds technologies used in the class – with the exception of Minecraft (see below).

3. Platforms and Preparation

Groups were given a list of suggested or recommended platforms for creating their CV, including a range of 3D virtual world platforms, Google Earth and a range of Augmented Reality apps and toolkits. None of the groups chose to work with Augmented Reality, and choices were constrained by the availability of resources: There was an Open Wonderland server available to the class, and for budget reasons it was easier to support multiple projects in OpenSim than in Second Life – with the commercial cost of hosting for an 'island' in OpenSim for one year roughly similar to that of hosting for one month in Second Life.

The platforms used by the six projects were:

- Google Earth
- Second Life, Figure 1.
- OpenSim (used by two groups), Figure 2.
- Open Wonderland, Figure 3.
- Minecraft, Figure 4.

With very little participation from two of its members, the Google Earth based project had relatively limited progress, and is not discussed here. From reviewing the individual evaluations of the two members who did work on this project there is no clear reason why the other two members did not actively participate. It is also apparent that the active members were not particularly experienced with the web-technologies that they were using, perhaps explaining their limited progress. It had naively been assumed that students choosing this option would have had greater web-development experience.

3.1. Project Preparation and Schedule

During the early part of the class, three taught two-hour lab sessions were dedicated to basic navigation, communication and building skills in Second Life/OpenSim, and one lab on using Open Wonderland. No lab time was given to Minecraft, but two of the members of the group working with Minecraft had had considerable prior experience in using the platform for entertainment purposes.

The CVE class ran for over 13 weeks in total (plus an additional vacation week mid-course). The essay assignment was due on week 6 of the course, and although groups for the practical project were established before this, it was anticipated that the final 7 weeks of the module would be the principal development period for the group projects.

4. The Projects

While each student group selected a different area of Paisley, and there were differences in how each group tried to fill the brief of creating a collaborative virtual environment for public discussion and participation in the planning process, a brief review of the other five projects illustrates some of the key strengths and weaknesses of the platforms.

4.1. Second Life

Figure 1. Paisley High Street modeled in Second Life.

The students built a model of part of the Paisley High Street (Figure 1) and a nearby park. Throughout the area a number of signs were places that, when clicked on, would give a notecard with some text giving background information to the user. One feature of Second Life that was very heavily used was the ability to embed a web-page in a 3D setting – with numerous displays and screens that linked to external web-pages including a discussion forum.

The 3D models present were all built from 3D primitive components, and gave a reasonable sense of the High Street, albeit at a low fidelity.

4.2. OpenSimulator

The two OpenSim groups shared a server, with the area split between the two groups. One group focussed their attention on the Town Hall, Abbey and surrounds (Figure 2, left), while the other modelled a small section of the town centre (Firgure 2, right). Both groups included a range of discussion and meeting areas in their builds, to allow for group discussions as well as presentations to larger audiences, and both placed a range of signs that would pass notecards or messages to users when clicked on.

Figure 2. Paisley Town Hall and Paisley Abbey (left), and a section of Paisley Town Centre and War Memorial (right) modeled in OpenSim.

The town centre model was successful in applying a few methods to support the rapid development of a 3D urban model: a number of buildings were created as simple cubes, then textured with images obtained from Google's Streetview or from photographs. This group also placed a number of voting booths around the model, allowing visitors to vote on priorities for re-development, and a number of interactive displays for collaborative writing. The availability of in-world scripting within Second Life/OpenSim is a powerful feature for developing and customising CVE, but one that was little used by the students.

4.3. Open Wonderland

Figure 3. Part of Paisley High Street modeled in Open Wonderland.

A detailed 3D representation of Paisley High Street and some of the surrounds was easily built, making use of models of buildings in Paisley that were freely available from 3D Warehouse, a site containing (http://sketchup.google.com/3dwarehouse/). Models on this site are generally available in the Collada format, and can be simply dragged and dropped into an OpenWonderland scene. In principle, Collada models can also be imported into Second Life, but the group using Second Life were unable to manage that successfully.

While visually detailed (Figure 3), there was very little interactive content other than some basic information displays. While not as easily extended as Second Life/OpenSim, there are a range of collaborative tools that are included in a standard installation of Open Wonderland, but only the most basic display tools were used.

4.4. Minecraft

The final group used Minecraft, where three separate areas were developed: an area of housing with redevelopment needs, a model of a recently built student residence for students (Figure 4), and a concept building for a new town library.

Figure 4. University of the West of Scotland new student residences modeled in Minecraft.

All of these were built out of ‘blocks’, which are available in a wide range of colours and with a range of textures, including semi-transparent ‘glass’ blocks. Minecraft’s ‘creative’ mode was used for this. The 3D models that resulted were impressive, but with much less fidelity than the other environments used.

Other than text chat, the only facility for visitors to dicuss or interact with the buildings was using ‘books’. Books in Minecraft are items that users can use to record text messages. To use the books, users would have to collect them from dispensers available in a few locations, open and edit the text and then leave the book in a chest where an administrator could return at a later date to check for updates.

It is possible to develop plug-ins and extensions for Minecraft, and a large number have been created by the Minecraft community online – but this is not as simple as using the in-world scripting available in Second Life or OpenSim, and requires changes to the program itself.

5. Comparing the CVE

While accepting that the projects are all the product of relative novices, with only a few months to work on them, we believe that a comparison of the CVE developed in each platform and of the issues encountered along the way can highlight some of the advantages and disadvantages of each as a platform.

5.1. Technical Issues

All platforms had their share of technical issues and platforms. As the University had used Second Life in the past, there were relatively little problems with this. Graphics driver software required updating in labs, but the firewall had previously been configured to allow access to Second Life.

Running OpenSim locally in labs worked, once graphics drivers had been updated, but would not allow access from outside the university. An externally hosted OpenSim server was used for the projects, and required a similar network configuration to

Second Life. Once set up, this allowed access from on and off campus. While there is a high degree of compatibility, the official Second Life client was used for that, and Firestorm used as the preferred OpenSim client.

The University hosted an Open Wonderland server for the student project which, due to firewall issues, this was only available to students on-campus. Students were unable to access Open Wonderland from home, and while a request to enable student access via a VPN was sought as a work-around, this was not provided in time to be used. Additionally, support for voice communication within the environment was not supported by the server provided.

Minecraft was initially hosted by some of the students themselves on his own laptop set up as a server. However, this turned out to be even more problematic. Whenever the student hosting the server required his laptop for other purposes it was offline and unavailable to other students. Minecraft was not accessible from the University network, the rules for which require IP addresses of external hosts to be included in paperwork asking for network ports to be opened, but was not a fixed IP address. Eventually the students arranged a third party host, but this was close to the end of semester with too little time to enable access from the University.

5.2. Web Integration & Support for Collaboration

The platforms themselves all feature a range of collaborative tools, whether built in or available as plug-ins or developed using a scripting language. However, of the different platforms, Minecraft clearly had the most limited set of tools for collaboration.

Using a separate application for voice chat, and the available text-chat tools, the student team were able to work together to develop a range of buildings and environments. Some of the prototyping was quite rapid with one of the areas being developed in its entirety in just a few hours. Minecraft was therefore very capable at supporting the collaborative efforts in developing a model Paisley, but the model that was developed is very static and limited in how it might support collaboration in the planning process. There are no decision support tools, no easy to use means to record discussions, and no web-integration. The permissions system needs to prevent visitors from modifying the world as it is otherwise very easy to destroy the models, even accidentally, but this prevents visitors from adding their own contributions to the model. A more fine-grained permission system that restricted the ability to modify some areas while providing public building sandboxes would be useful to prevent vandalism as has been experienced in other projects (c.f. [12]).

The Open Wonderland environment that was created was not significantly more interactive than the Minecraft one, beyond text chat. A small number of text displays were included that, when clicked on, would open web-pages related to the Paisley urban regeneration projects and local businesses. Modules that provided a range of other collaborative tools and which were available for use, such as collaborative text-editing, were not used.

The scripting language of Second Life makes it incredibly extensible, and allows the development of custom collaboration tools [4]. However, the Second Life project did not make significant use of custom tools for collaboration. The one feature that was used was the embedded web-browser that allows users to view web-sites together. Several browsers were included in the build, one of which was set to a discussion forum to allow users to leave comments.

The two OpenSim projects stood out from the others in providing dedicated discussion and presentation areas both within and beside the CVE. Both provided areas for small group discussions and for presentations to larger audiences. One of the most basic forms of collaboration within a CVE, this was still overlooked by the other groups. Both also provided a range of information displays, but only one made use of additional interactive objects (voting booths, collaborative editing text displays, web-based presentation board) to support collaboration.

6. Student Evaluation of Online Collaboration

All students were asked to submit individual evaluations with the final project reports, and evaluations were submitted by 25 of the 31 students. Disappointingly, given that the topic of the class was specifically about collaboration, many students reported poor communication as being an issue within their group. This was the most frequent complaint in individual evaluations, reported by 14 students. The second most reported issue was lack of contribution from a team member (in some cases students noted their own limited contribution to a group project), being reported by 12 students.

Technical issues, including some relatively minor issues and issues that were resolved after a few weeks, were reported by 8 students. The most common of these was the inability to access Open Wonderland from off campus, due to firewall issues (reported by 4 students).

Only 5 students identified no significant issues with collaboration or teamwork in their reports – these including four of the five students who worked on the first OpenSim project.

Outside of technical issues, a positive experience with the collaborative technology itself was widely reported – in a few cases alongside clear dissatisfaction with the individuals that some students had within their groups.

7. Discussion

It is clearly unrealistic to expect students to break new ground, or develop novel and innovative ways of using technologies when presented with a CVE platform for the first time. However, a review of the CVE environments developed by the students reveals common omissions. While all groups have collaborated in the development of a CVE, there has been limited consideration of how end users might make collaborative use of the platforms that they developed. Several of the CVE are in effect little more than static models for visitors to walk round and view, with collaboration happening somewhere else.

The Minecraft CVE is the most striking example of this. Minecraft appears to be a very effective platform for allowing a small group to prototype a low-resolution 3D model. Minecraft has been incredibly successful commercially, having sold many millions of copies, and fans have posted vast numbers of videos to YouTube of their adventures and creations [13]. But for all of Minecraft's success as a platform for creative expression and play, it appears to be lacking in features for use as a collaborative virtual environment for other purposes.

In their article [5], Denning and Yaholkovsky are careful to emphasize that it is not computers that collaborate, but people. That successful collaboration is rooted in processes and practice, not in tools. And yet it is clear that for online communities that effective support in the form of easy to use tools is necessary to make even basic collaboration possible. All of the other platforms used in the student projects provide a range of tools that can support collaboration, and yet groups seem to have put relatively little thought into how end users might use their CVE. Some consideration has been given to the tools, but very little to the collaborative processes and practice.

Although the human factors are most important in ensuring effective virtual teamwork, problems with technology not working can certainly hamper chances of success [9] – and a wide range of technical issues were encountered on these projects. With Second Life entering its second decade, it might be hoped that collaborative work in a 3D CVE would no longer present such technical challenges but problems with firewall configuration, access from outside the institution, access from inside the institution and the capabilities of lab computers to be able to support the 3D CVE were all encountered.

In terms of practical recommendations to take from this, specific recommendations for working with different technologies are difficult to produce – it being the authors' experience that quite varied and different technical issues are experienced at different institutions. Perhaps the simplest advice would be that for most purposes and institutions it would be prudent to focus efforts on one virtual world platform, perhaps ascertaining which platforms are easiest to work with and gain access to on and off campus.

But even these technical challenges were second to the issues of student collaboration itself. As noted by Nunamaker [6], it is communication that is key to successful collaboration. Where student projects lack good communication, good collaboration is extremely challenging to achieve – and this goes beyond the abilities of software tools to correct if students are not engaging with their project work and with each other.

For all the problems, some aspects of success do need to be recognized. In a short space of time – approximately seven weeks, part-time – five groups of students each developed a distinct and individual CVE. In most cases, the students had to first learn how to use the chosen platform. When commercial 3D environments can cost millions of dollars and take many years to develop, the chosen platforms all have clear strengths for the rapid development and prototyping of 3D CVE.

We hope to build on this work, and strengthen our partnership with Plan for Paisley in the coming year. Based on these prototypes, the rapid development of a CVE which can be used by the broader public to promote participation in the urban planning process is certainly a viable goal.

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Ureka Potential

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Abstract. This fictional prototype appraises recent advances in the fields of intelligent glasses and brain computer interface technology to address possible impact on a more immersive style of teaching and learning. The former advance can be used to measure eye gaze and hence to assess whether a student is at least looking in the correct place and possibly attending to lecturer or computer screen; the latter can measure and quantify changes in brain activity. Could changes in brain activity be used to signal cognition and acquisition of knowledge or understanding? This is a much more ambitious goal and the prototype extends current achievements in electrophysiology to unearth an 'understanding' component, termed here the 'Eureka Potential'. Two exhibitions which ran concurrently over the summer in London at the Victoria and Albert museum, "David Bowie Is" and "The Memory Palace" provide the inspiration for the piece. The motivation for this work is that assistive technology could encourage our students to become more 'active' learners.

Keywords. Brain computer interface, intelligent glasses, teaching, learning, "David Bowie Is", "The Memory Palace".

1. Introduction

The backdrop to this work is the serendipitous colocation of two exhibitions at the V&A during June 2013. The first "David Bowie Is" was a retrospective testimony to musical and artistic genius. This is a subjective experience, in the eye of the beholder. The second, "The Memory Palace" warns of the danger to future digital society of loss of technology. In the Orwellian society that emerged, at an individual level a citizen's memory was controlled. Memory of course underpins all cognition, understanding and creative thinking, even genius.

The paper uses a water metaphor, which flows through the different sections, in search of a potential, until the author declares, "I have found (it)".

Of course the focus of the work is immersive education, and technology that supports it. Intelligent glasses can provide an objective measure of engagement. But how do we as teachers know that a student has understood a topic?

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2. Discussion

The paper addresses education and the problem of assessment. For example, in an examination, if a student replays a 'stock' answer to a question, have they really understood the topic? This is manifest to the author in the discipline of Computing and Mathematics. In this subject problems that have been previously seen can normally be solved by students, but performance falls off for questions which require 'problem solving' skills. In programming for example we try to teach core problem solving skills from the bottom up in year one of an undergraduate degree, but sometimes a weaker student simply searches the Internet for solutions to problems, often tweaking variables without really understanding the consequence, sometimes even by trial and error.

To engage the students many departments have used exciting interactive technologies such as Mindstorm's Lego robots, Robosapien and novel input mechanisms such as Nintendo Wii motion plus and Microsoft Connect. Indeed working in multimedia design or in game design is often the expectation of the student and motivation for the course in the first place. Novel use of technology can have beneficial engagement effects over the standard integrated development environment (IDE) for learning programming skills, particularly in a team environment. Yet most of our employers still seek students who can 'program', often for the financial sector, with commensurate rewards. This really means students who can problem solve.

However technology continues to improve and throw up unanticipated consequences for its application. This prototype addresses such technology for application in immersive education.

3. Fictional Story

3.1 Lecture Theatre May 2014

As I finished my final lecture of the semester to the normal hub-hub of relief for all concerned and looked up to my audience, now paying customers, a door at the back of the theatre opened purposefully, a burly customer entered the lecture theatre and descended towards me. His eyes were transfixed on mine, as he made his way down the stairs, seemingly oblivious to the tide of final year students leaving. I knew why he was here. He was a first year student from my computer networks class, indeed by all accounts a particularly good student[2].

3.2 Two faces of life: 22 June 2013

I had just left the "David Bowie Is" exhibition at the Victoria & Albert (V&A) Museum. Most V&A exhibits portrayed long deceased characters taken from a dour fourth form history, art or music lesson – Archimedes, Van Gough, Mozart and many more of our forebears touched by genius; Bowie was

[2] The scenario was inspired by colleagues at an evening meeting in Colchester, Sept 2013

an exception to this, as befitted his esoteric music career, the "Is" was crucially important, he is still alive[3]. The trivia and memorabilia were encased in glass and the vivid stage costumes on display conjured up Bowie's stage and screen personae, a series of iconic instantiations from the David Jones[4] template, each with a distinctive look, like a Japanese kabuki [1] character's mask. The popularity of the exhibition[5] cascaded the visitor along a current of people, old and young, flowing from entrance to exit, accompanied by a whirlpool of sound and vision, an immersive 'mash-up' of his 70's and 80's songs. Bowie's songs acted like a switch and instantly ignited my memories of the fourth form disco, shoulder length hair and blue jeans, riots on the streets of Belfast, and the imminent arrival of aliens from space; definitely no school lesson in this museum. The 'David Bowie Is' experience kindled my optimism.

"I'm not a prophet or a stone age man, just a mortal with potential of a superman" [2]

These lyrics resonated around and around in my head, swirling in a continuous loop. I had long since believed that Bowie was indeed a latter day prophet, and it goes without saying, a superman. He was a creative genius, often blazing a path where his peers, some mere mortals, others definitely from the Neanderthal side of the spectrum, meekly followed, often releasing pale imitations of the master's work, like fake Van Gough's paintings. Where did this creativity come from? The exhibition portrayed his upbringing in Brixton, an unremarkable youth, no Mozart child genius, somewhat overwhelmed by the intelligentsia and artisan 'in-crowds' of Soho's swinging 60's. Then it all changed as he grew to a twenty-something, like a switch. What if we all had this potential for creative thought, I pondered? It may just be a matter of flicking the switch.

My research had centered on 'potentials', electrical ones from the brain, so I tried to decipher the deeper meaning in the lyric. I was sure the 'prophet' has a message for me.

As I was about to leave the V&A to meet up with a group of similarly minded Bowie followers, I noticed a disturbing image in my peripheral vision. It was a display banner advertising a "Memory Palace" [3]. It provided a "dramatic vision of the future through an immersive exhibition experience". I assumed it was co-located by chance. The title intrigued me – I decided to go in to experience the author, Hari Kunzru's future vision [4]. The first poster in the exhibition confirmed my curiosity.

> *"Hari Kunzru's story is set in a future London, hundreds of years after the world's information infrastructure was wiped out by an immense magnetic storm. Technology and knowledge have been lost, and a dark age prevails. Nature has taken over the ruins of*

[3] David Bowie's latest album "The Next Day" has been nominated for the 2013 Mercury Music Prize

[4] David Robert Jones was born in Brixton (8 January 1947), he is better known by his stage name David Bowie

[5] 'David Bowie Is' was the most popular V&A exhibition ever, with reserved tickets completely sold out, night-time slots and long morning queues for the remaining day tickets

> *the old city and power has been seized by a group who enforce a life of extreme simplicity on all citizens. Recording, writing, collecting and art are outlawed."* [3]

By contrast there was no tide of people in this room, a still silent V&A backwater, where the few visitors meandered from station to station. This Palace was not a happy place. The narrator of the story, a dissident in the Palace, was trying to hold onto his memory. It presented a dystopian view of the future, where society dictated that citizens were 'programmed' to conform, a subject coincidentally envisioned by Bowie in his 'Future Legend', a version of 'Metropolis' [5].

"If you could keep only one memory, what would it be?"

This was a tag line for the exhibition. My thoughts lingered on our recent Alzheimer's assistive technology research work, a depressing proposition indeed, if all our citizens suffered these symptoms of memory loss [6], destined to repeat some small set of meaningless phrases, before they too faded. Some dissidents in this future world did what they could to retain their free thoughts and save their memories; but the narrator of the Palace ended up in prison.

> "*..accused of being a member of a banned sect, who has revived the ancient 'art of memory'. The narrator uses his prison cell as his 'memory palace', the location for the things he has remembered: corrupted fragments and misunderstood details of things we may recognise from our time. He clings to his belief that without memory, civilisation is doomed."* [3]

The Palace provided an antidote to my Bowie induced 'high', no creativity, society in a downward spiral, a Tower of Babel [7] in the digital age, yet to come.

I pondered on the education process, and reflected that nowadays students were being similarly programmed, fed information which they would duly regurgitate to show they had 'understood', but I doubted it. New tasks would often initiate a quick surrender; problem solving and creativity were being stifled. Information was now disposable, to be consumed, filed away in the cloud, then seemingly forgotten. Were we in danger of taking a step closer to this future legend? Of course I blamed the 'system', which absolved me. This tempered my optimism, a little, until I left to meet my colleagues in a nearby pub and my memory dwindled, aided by a relay of 'Metropolis'[6] real ale.

But I was left with a question. How could teachers inspire students to be more creative, like Bowie's lyrics had inspired me? At least students could still write down to help them remember (or download, ….hmmm!) but how could

[6] Metropolis, "A superb golden session beer, with enormous balance and depth of flavour and a long floral, spicy finish."

we know that they understood the subject? How could they put the fragments together? I was in danger of becoming a Palace dissident.

3.3 A perfect storm: May 2014

My London trip was filed in my own Memory Palace (for later regurgitation, of course), I was back in my day job end of semester; sometimes a teacher, sometimes a researcher, a confused academic struggling with the paperwork in my paperless office. I filled in my Higher Education Statistics Agency transparency return form which detailed my effort: 50% time on teaching, 50% time on research, not too hard, although increasingly it seemed that much of my time was spent on filling in forms.

However, my research had gathered new impetus this year. As a post-doc researcher I had been involved in the investigation of brain electrical signals, the electroencephalogram known as the EEG. The EEG had been first recorded by Hans Berger [8] in the 1924, a scientist, prone to bouts of depression, but undeniably touched by creativity[7]. By using various sound and vision stimuli a class of diagnostic brain electrical signals known as event-related potentials could be generated for subsequent analysis. These potentials were powerful indices of the function of the brain; some could be used to objectively assess sensory function such as hearing and sight, others were diagnostic for degenerative neural conditions such as multiple sclerosis, epilepsy, even brain death. My own research focus had been into the cognitive potentials. Some excellent work had been done by to identify the various important cognitive 'waves': the P300[8], the N400, the mismatch negativity (MMN), the contingent negative variation (CNV); all useful to psycho-physiologists in the study of memory, attention, and even the understanding of language.

In the 'noughties', the fusion of Human Computer Interaction with recorded EEG spawned the area of brain computer interface (BCI); I duly got involved in this research stream, as befitted my teaching role in Computer Science. BCI was set to be the next 'big thing' for accessing computers by thought alone, but the research had stalled for some years, leaving those involved to devise ever more complex signal processing algorithms to show modest increases in classification accuracy for one or other classification model, using well-worn datasets.

But in Sept 2013 came a disruptive change, a new headset designed by Tan Le and funded by a Kickstarter crowd source project changed everything [9] – the 'Insight' would provide a paradigm shift. EEG caps were now designated as brainwear!

> *"A sleek, multi-channel, wireless headset that monitors your brain activity and translates EEG into meaningful data you can understand."*

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[7] Berger eventually succumbed to suicide like many touched by genius

[8] The labelling implies a positive peak 300 msec after a stimulus to the subject; P300 is important in memory update

The headset was technically limited by neurophysiological laboratory standards; it had only 5 EEG channels; but multimodal add-ons included a 6 axis inertial sensor (gyroscope and accelerometer) and 3-axis magnetometer. As it cost only a couple of hundred dollars; it could be treated as a computer peripheral, a bit like a 'souped up' mouse. The headset could be applied in seconds. Indeed I had dreamed of such a device [10].

Better still my research group had found a way to solve the tricky problem of electrode reuse. With the advent of 'dry'[9] electrodes, it was possible to make disposable electrodes from plastic, of all things. The electrodes had to replicate the intricate shape to fit the headset. But of course this could now be done cheaply with a 3D printer, giving a potentially unlimited supply, for extensive reuse. The 3D printer provided a new way to make things that could be drawn on a computer cheaply.

These technology advances had come hot on the heels of 'intelligent glasses' [11] These glasses could be programmed to measure eye gaze, meaning that when a student looked at a computer screen, it was possible to track the areas that he/she was attending to.

For my research area, this was a perfect technological storm.

BCI could be enhanced by this technology. This was really exciting. By combining eye gaze and BCI our lab had already built a 'hybrid BCI' that outperformed our previous BCI systems, and in addition, the hybrid technology was robust, reliable and easier to use [12]. With the addition of the Insight headset it could be aesthetically pleasing, even cool. The eye gaze was measured unobtrusively by the glasses and linked with the BCI allowing menu selections on a computer interface to be made using BCI, eye gaze or both in collaboration.

3.4 Another Brick in the Wall

How can we be sure that the students attend to our lectures? How can we be sure that the student has understood a topic? These two questions were the holy grail of pedagogic research.

The first question had become easy to answer.

If student wore the intelligent glasses then it was straightforward to work out if the student attended to the lecturer (in the seminar) and the computer screen (in the lab). At the end of a class the lecturer could view summary data pinpointing any students that tended to stray 'too much'. Feedback to the student[10] could be instant, initially causing a fair degree of alarm – 'big brother' [13] had arrived in the classroom. I had used the system throughout the semester and I was surprised how quickly the students accepted it, but of course students of computing are early adopters of 'cool' technology. I felt that the technology was having a positive effect and this spurred me on.

[9] Previous electrodes required gel

[10] A student was now of course a paying customer demanding value for money

The second question was a little more complex.

For the last 20 years in cognitive research, neurophysiological researchers had been looking for the ‘next’ event related potential wave; something that demonstrated cognition. There were many such candidate waves distributed all over the scalp, but their patterns were illusive, not reproducible. We had got lost in the laboratories; too many electrodes, algorithms that indeed were too sophisticated, a feature set that had exploded. We were a victim of BIG data, drowning in the deluge. We had been looking for the ‘needle in a hay stack’. There were just too many needles.

But over the last couple of weeks in the BCI we had been recording with our PhD students, a clever bunch. We devised a set of problem solving questions and monitored the brain activity, using our newly acquired Insight headset.

The years of toil were about to pay-off. Little did we know that the answer to our understanding process was there all the time, but occurring much later in time than researchers had been observing. It was very easy to miss. When a test subject solved a particular problem, an event was embedded with the raw EEG data, and an off-line algorithm mined the EEG channels for discernible features. The peaks and troughs in the EEG came and went. We needed a way to visualise the activity, so we hooked up the analysis software to large display screen and pondered, numbers were translated to colours, and we waited for patterns to emerge in space and time. This was ‘CSI - Jordanstown’[11]. We could see some classic waves ebb and flow. We stopped the analysis after about 2 seconds and the EEG had returned to background levels.

Coincidentally we had just taken on a sixth form student, to give him some experience as part of a STEM[12] placement. On first impression the student, Archie, was the typical ‘geek’ programmer, good with computers – less so with people, really a young version of ‘Brains’ from Thunderbirds [14]. One afternoon we demonstrated the hybrid BCI system, to give him a project to present for his presentation day, a requirement of the placement. He was very enthusiastic and could program, but he didn’t have our expertise and experience of course. He duly underwent the recording procedure and I left him to analyse his own data using a simple MATLAB routine. Later I returned to the lab to help him. It was a bit of a mess, not unexpected of course, ‘rookie’ mistakes. “The magnetometer and inertial data are completely different from the EEG, why did you subtract the vectors?”, I queried using my authoritative, academic kabuki mask. “The evoked potentials finish after 2 seconds post-stimulus, I continued, there’s no need to continue...” He wasn’t attending to my comments, but excitedly showed me the pictures of his brain wave on the screen. Initially I wasn’t attending to his comments. It would probably suffice for his project, I reassured myself. Then I noticed an interesting pattern in my peripheral vision.

Of course the EEG waveform, contaminated with magnetometer and inertial sensors data was all ‘noise’, pretty but completely corrupt, ebbing and

[11] Akin to Crime Scene Investigation_NewYork, http://www.cbs.com/shows/csi_ny/

[12] STEM: science technology, engineering and mathematics

flowing with random swirls for a couple of seconds. But then it happened; arriving like a giant tsunami wave that washed over the brain emerged a ‘slow’ wave, only observable subtly in the time waveforms as a small dc shift. We could only see it begin to emerge after about 1900msec and it lasted for at least a second; spatially it moved around the brain sites, detected first by one electrode, then another; as realisation of the ‘answer’ to a question in the subject’s brain emerged at the frontal cortex, built up and then moved clockwise to the right temporal lobe, then occipital, then the left, and then the front again. It appeared that as an event occurred, as a question was answered, ‘cognition’ was being achieved and the answer filed to memory, then checked as part of intra-brain communication and a form or brain democracy. And then, a second identical pattern, like Usain Bolt[13] on a celebration lap as it became apparent to the source (i.e. the human mind) that they ‘knew’ that they knew it! But the shift was only there in the ‘hybrid’ system and best observed in a simpler system, like the Insight.

But why were we seeing it now? It was pure serendipity. The EEG by itself was too noisy. In labs there were too many channels. By subtracting the magnetic field and compensating for movement, using crude subtraction, the dc shift pattern could be sustained, after the EEG potentials had normally ebb away. I thought, “Brains, no Archie, he’s a genius!”

A few weeks work with our PhD students followed. The pattern was reproducible in our lab. Well, with this potential we could now objectively test if a person really ‘knew’ an answer to a question. Think of its effect on teaching and learning; this could for the first time become a shared collaborative and measurable paradigm. This was a game changer; no longer would a student be able to claim that they understood a topic, a memory dump was no longer a substitute for ‘active learning’.

3.5 Testing Times

Twenty first year students filed into a computer lab to take their final part of their year 1 Computer Networks assessment. At the instructor’s desk I could check on an individual’s progress or choose to view a ‘dashboard’ summary of attention as measured by each student’s glasses. Each student donned the intelligent glasses. I told my students,

“Think about it, I know where you are looking”. “For this final test I would like you all to wear a BCI headset”, I said. “The test is only worth 5%, but I want to check your understanding of our subject, I said”.

Puzzled looks from the class, but the glasses had been such a hit so no revolt. The test began. I checked my eye gaze metrics. The students were looking at the test, a few distractions but totally acceptable. Task 1 accomplished, they were engaged, but would they demonstrate cognition – acquisition of knowledge?

The test was designed to be pretty easy as first, to encourage the student, and then become a bit more tricky as time progressed. The data was streamed to the computer for analysis in the lab. Twenty questions to provide my

[13] Usain Bolt is the Olympic & World 100m & 200m champion and officially the ‘fastest’ man on earth

objective test of understanding, five straightforward recall, ten which required some logical deduction and five which required significant problem solving.

The off-line process was automated and quite fast, being visualized a few minutes after acquisition. The 20 student hybrid EEG patterns were displayed on a 5 x 4 grid. As the test questions kicked in, and following the data processing delay I could begin to visualise the brain waves of the students, and then the tell-tale circuits of EEG (and subsequent victory laps) began to emerge. As the test became more difficult, the performance fell off, just as I had anticipated. The marking was anonymous and automated; 1 mark for each question which elicited the double-lap cognition pattern, with marks returned directly to an-online student system.

3.6 Lecture Theatre May 2014

The first year student was clearly perplexed. "I paid the money and this is all I got in your test. I got good marks in my other modules, I just don't UNDERSTAND". "I know", I said, "UREKA".

This was my confirmation; the potential could be collected in the classroom. Using this potential the students could work at a topic until they understood it. We had a potential switch for understanding. I had the research algorithms, real world data and now user feedback. I could write a really important paper, even if I had to give way to my genius sixth form student. I started to write the first draft:

> *Title: Ureka Potential: An objective EEG measure that can measure cognition for use in and Immersive Education Environment*
>
> *Authors: Archie Medes, Paul McCullagh, et al.*
>
> *Text:* How can we be sure that the students attend to our lectures? How can we be sure that the student has understood a topic? These two questions were the holy grail of pedagogic research…….

Now for my next challenge, potentials for measuring knowledge, even artistic "genius", like Bowie. I thought of a Bowie lyric:

> *"….Knowledge comes with death's release"* [2]

Better leave that one - for now.

4. Conclusion

The prototype investigates the difference between recall and acquisition of knowledge or cognition, in education. Future technology may be able to help here. Intelligent glasses could have a clear role with measuring engagement between learner and teacher, but the application of hybrid EEG technology, while existing, is much more speculative at this stage. I'm sure the former will find use in immersive education very soon.

There is a spectrum between recall, cognition, knowledge and finally creative genius. In this paper the Eureka potential taps into cognition and the acquisition of knowledge.

The fictional prototype can serve to apply hybrid BCI technology into immersive education, much like a futuristic 1970s language laboratory, which used advances in magnetic tape recording to allow a student (and their instructor) to listen to their pronunciation of a foreign language. The prototype suggests similar feedback that can report on understanding, in a subject way.

The motivation for the work is the worry that in digital age education where storage of materials can comprise a link to the cloud, students utilize this learning paradigm and simply recall their work (for assessment) without sufficient understanding. Memorizing is necessary but not altogether sufficient for understanding.

Acknowledgements
Thanks to BCI colleagues who worked on the hybrid BCI eye gaze system, colleagues who attended the 'David Bowie Is' exhibition in London in June 2012 and to colleagues at Essex for providing inspiration in immersive education and a plausible scenario.

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Teaching Earth Science in Muve

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Abstract. This research is focused on building an e-learning path on the theme of the teaching Earth science using Muve (Multiuser Virtual Environment) as a new perspective in education. An virtual island was created in 3D, where, through a role play, learners cross the various steps, activities based on inquiry Based Science education (IBSE) and acquire scientific skills.

Keywords. Virtual Worlds, Earth Science, IBSE

The 3D virtual worlds (multi-user) provide educational opportunities to learn in a socially-interactive learning community. Many authors claim that "immersive" methodologies produce an improvement in cognitive and perceptual dynamics (1).

In recent years the development of technologies and the educational scenario has prompted a change in the design of environments in which the experience training takes place. To experience this approach, this research will introduce digital contents on natural phenomena and on Earth science (Fig.1) using a MUVE, addressed to students of various ages. The project starts from the methodology of the Inquiry-Based Science Education, applied in 3D virtual environments. An island was created in 3D on Unicam server, it has an online access, where, through a role play, learners cross the various steps, activities based on inquiry. The level of inquiry chosen for the path is “structured type”. Learners (student of various age groups 13-15 and 15-18) following and answering to questions acquire scientific skills. A virtual island, using software Open Sim (2) will be dedicated to Earth Science where students, in a role-playing game (serious game), must pass ability and expertise steps/tests, solving various questions placed on their path (Fig. 2). The steps of the project are: 1) to build learning paths on

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earth science with MUVE; 2) to experiment and test a learning path; 3) to analyze the collected data for comparison between immersive and non immersive education. The results of this methodology will be tested in a training program which integrates the constructivist theories, the testing labs and the virtual learning environments, in order to: a) improve the quality of the training, b) activate the motivation, enthusiasm and participation, c)increase the effectiveness of learning, d) increase the knowledge of natural phenomena to make the students aware of natural hazards, as a way to improving the good practices of civil protection.

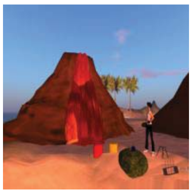

Figure 1. Eruption in virtual worlds.

Figure 2. Simulation of eruption.

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The Turing Shroud

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Abstract. Immersive environments, by merging physical and virtual experiences, allow both local and online participants to meet and collaborate, as well as allowing thoughts and ideas to be collaboratively viewed, discussed and interacted with. Current developments make possible the extending of these environments to incorporate all the senses and increasingly include the use of direct interfaces to the brain. The Science Fiction Prototype uses a story about an attempt to explore the life of the scientist, Alan Turing, to envisage a future where developments of these techniques allows the implementation of systems that can create and recreate past and present reality as authentic collective experiences that can transform the nature of learning, research and life generally.

Keywords. Science fiction, Immersive environments, Virtual worlds, Collective intelligence, Brain computer interface, Interdisciplinary research, Alan Turing

1. Introduction

"The Turing Shroud" explores the possibilities that could arise in the future in learning and other areas through collective intelligence and the contribution of immersive environments and experiences to this. Attention is often focused on the potential of computers and other technologies. The intention is not to ignore this, but to consider their impact together with and in the facilitation of people thinking, learning and working together. Specialisation and its attendant knowledge and organisational silos and barriers, whether it is related to learning, research or work, often limits and restricts our potential. Technology and technique can however be used to help overcome these limitations and barriers as well, facilitating collaborative activity and work across disciplinary boundaries. In the same way that a brain is more than the sum of its individual neurons, so too the collective brain has enormous potential if its power can be harnessed. This Science Fiction Prototype is about some of these possibilities, illustrated and explored in a rather unusual context.

2. Background

2.1. Current Systems

Work by the authors relating to the theme of the story was carried out under several projects over a number of years, both individually and together. Virtual worlds have

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been used in learning within many disciplines and in many different ways. Nevertheless, most systems have concentrated on content and the learner's interaction with this, rather than the collective experience and interactions between learners. Coventry University is currently leading a consortium on work particularly aimed at students who go to work on projects in developing countries. An online virtual world environment used in support of this, developed by a co-author of this paper, is used to give students an understanding of wider issues, the cultural and social context for instance. Although the environment can be used for learning about technical and other aspects of work they will be taking part in, the focus is on facilitating group discussion and interaction. Videos providing an overview of this, as well as a longer introduction are available[3], as well as a demonstration of a similar environment[4] that can be flexibly adapted for many learning and research purposes. In other work the authors were involved with, for the Eden Project in Cornwall for instance, social networks such as Facebook were seamlessly integrated into a virtual world environment, providing a range of techniques for group interaction that complemented each other.

A different strand of work centred on Virtual Research Environments (VREs) and included looking at how immersive spaces, which merge physical and virtual environments, could be used to facilitate collaborative thinking, discussion and working. Extensive user requirements gathering had shown that there was widespread interest in cross disciplinary collaboration, but researchers often raised the issue that they didn't know with whom or on what topic they could do this. Earlier work [1] had developed techniques and tools to help deal with this issue. For instance, starting with cancer researchers, links were found to areas including metallurgy, geographical information systems, graphic design and even wallpaper! One development, part of a project called Inspires[5], looked at how tools like this could be integrated into immersive spaces and used with physical groups in real time to facilitate collective engagement and interaction.

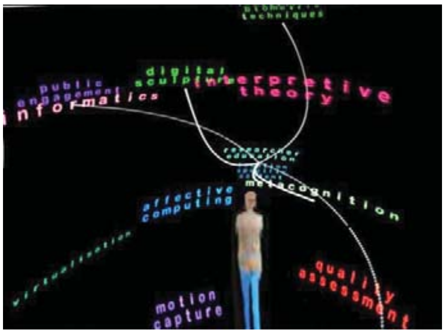

Figure 1. Immersive Visualisation Environment

Figure 2. Interaction with Avatars

Figure 1 shows one setup implemented using a large screen 3-D projection facility, allowing a group to interact in various ways with word clouds representing ideas they are discussing. Words displayed are drawn from what people are saying, using voice

[3]vimeo.com/55523534
[4]vimeo.com/72878340
[5]www.jisc.ac.uk/whatwedo/programmes/di_research/researchtools/inspires.aspx

recognition in some cases, together with information from text messages and social media. Some of the tools mentioned earlier and others interface to the visualisation system through web services to generate new concepts based on the expertise of the participants, visually linking similar concepts together, and allowing collective filtering of ideas through user interaction. A video of the system in operation is available[6].

Immersive space techniques like this have been used for many different purposes. One system[7] using a variation of the technology was used for crowdsourcing, in particular for obtaining public feedback about a major activity being developed for the 2012 Olympics. It was part of a physical event held over three days and provided a visualisation, in a virtual space that mirrored the physical surroundings, of a word cloud - including texts from mobile phones, Twitter and e-mail contributions that people made locally, as well as allowing similar contributions remotely. Another system, called Insert/Extract[8] (see Figure 2), was part of a 3-D immersive installation set up in a Museum, that allowed users to interact with avatars in a very natural way, with added facilities for people in the physical world to appear in the virtual world and vice versa. Many thousands of members of the public participated in this and it demonstrated how easily people, particularly children, adapted to this environment, with important lessons for its potential use in learning.

2.2. The Future - SurroundMind

Immersive systems such as the ones described here to facilitate collective thinking are intended to form a small part of a very general and long-term objective to consider how the internal mental configurations of individuals can be externalised and communicated using all the senses to allow collective intelligence, perception and consciousness to be realised in a group setting. This concept, which has been given the title "SurroundMind" in an allusion to the audio system called SurroundSound, in its widest sense is what the story which is part of this Science Fiction prototype aims to depict. It is obviously something that can only be realistically considered very much in the future. However, a number of aspects of it can be seen at the present time, even if in rudimentary form.

The VRE work carried out by the authors described above falls broadly into the category known as knowledge visualisation [2], which is related to but can be distinguished from information visualisation. Other senses in addition to the visual need to be included and integrated to provide additional sensory inputs and outputs. For example, music and sound can have a powerful effect on emotional state and thus in conveying emotional information. Considerable research is taking place into algorithmic methods to implement this [3]. Other senses also have a role to play. For instance, the well-known VARK classification of learning styles [4], considers the kinaesthetic sense as being of key relevance to learning. Brain interfaces are of course still at an early stage of development, although some developments referred to in the story, such as controlling the narrative of virtual world based soap operas through a direct brain interface, are factually based [5].

[6] vimeo.com/49155054
[7] vimeo.com/15598938
[8] vimeo.com/58571590

3. The Story

3.1. Prologue

The man in the white coat sounded anxious, “Look, Prof, I know you’ve been given special approval, but we’ve not done anything quite like this before. We don’t know whether we’ll be able to get you back to the way you are now. At least let us keep the emergency emotional level cut-outs on in case we detect something potentially dangerous”.

“No safety nets”, Jeff Lee said firmly, “and if I come back as I was, I probably wouldn’t have learnt anything”.

Today he would get into the mind of Alan Turing. It was a risk worth taking. He smiled at his two younger colleagues, Maria and Cheng. He could see they were nervous, even though they were trying to hide it. What he was doing was a day-to-day part of learning and research, not to mention leisure, using what were generally referred to as “Experiences”. But two things were different.

“It would not normally be allowed with someone who committed suicide”, the ethics adviser had said when he had first raised this.

“That’s disputed”, he had insisted, “and maybe this is the only way to find out”. But Jeff had his misgivings as well.

What was completely unknown though was something else. Two years previously, among some household items being auctioned, some letters had turned up, supposedly written by Alan Turing towards the end of his life. Most mysterious were pages with series of numbers on, that been found together with them. These had been expected to be some sort of encrypted writing, but even the best quantum computer crackers had got nowhere with them. But various analyses established that the numbers were not random, that there was probably meaningful information there. Some scientists speculated that it could be a computer program of some kind, perhaps for some device that had not yet been invented. Of course this had further inflamed the controversy about whether the letters had been genuine or not - and had led to intense media interest around what had been called the “Turing Shroud”, after the crucifixion relic. If this had been anyone else, the number data would have been strong evidence that it had all been a forgery. But this was the man who had invented computing itself. The man some of whose security related papers were considered so far advanced that they were not declassified till over 70 years after he wrote them. He had also worked extensively on biological systems. What if he had discovered some general principles in this area equivalent to the Universal Turing Machine he devised that could carry out any computation? What if he had been able to represent something, perhaps about himself, which could only be implemented in a system in the future and left this for posterity? The trouble was that the only way to really find out was by what Jeff was going to do. And that was something he had to admit to himself, he wasn’t entirely comfortable with. As the final preparations were being made, he thought of how he had got there.

3.2. Jeff’s Story

When Jeff was starting out as a graduate student, there were high expectations of the impending “technological singularity”, when computers would pass the point where they would surpass human intelligence - with consequences difficult to envisage. But there were sceptics as well, one of whom, Joseph Gratsky, was to become Jeff's mentor and shape his future career. He remembered Gratsky's virtuoso performance in a packed out lecture hall. "This humble device I have here", he said, holding up an antique device few of them had ever seen, "is one of the first pocket calculators". "The chip it uses", he added, opening up the device, "is so simple that it was once issued in a single bit version. So only marginally more intelligent than some of my more vociferous critics". This always went down well - everyone knew who he was talking about. "But it still was faster in what it did than any human past or present. Very significant, but no singularity. Fast forward to 1997 when a computer beats the world chess champion. Still no singularity. Today we have reached computing power difficult to even imagine then. But the principle is the same. The philosopher, Thomas Nagel, wrote a famous paper entitled, 'What is it Like to be a Bat?' With all our intelligence, this is something we cannot know. Similarly computers, for all their intelligence, cannot imagine what it is to be like humans."

Gratsky of course had not been a technological sceptic, far from it. What he had argued for had been the development of collective human intelligence, augmented and facilitated by machines. Was it machines augmenting humans or the other way round? This had been one of the questions often posed. Jeff, as he had continued his own research, had been happy to consider this an open question. He had even entitled one of his courses, "Humans and Computers – Is There a Them and Us?" What was beyond dispute, was that the combined intelligence and creativity of human-kind and machine-kind together, finding the best combinations and synergies to solve problems and expand knowledge, had demonstrated what could certainly be described as a singularity. Jeff wondered whether some of the questions now being answered could have even been imagined a generation earlier.

He began to feel the effect of the equipment taking hold and closed his eyes. Soon he would be in a mental state similar to lucid dreaming, where he would be in a dreamlike state but still be aware of this and with some conscious control over it. Some people had a natural ability to go into this state, but now it was part of education generally from an early age and with suitable equipment very easy to do and used widely in many ways. Jeff felt a sense of extreme anticipation, but also through his detached self knew what he was feeling - a peculiar sensation. He wondered whether Maria and Cheng could see the smile he had on his face in his internal world.

3.3. Cheng's Story

Cheng had been fascinated by the work that Jeff was doing even as a child. When he was given the opportunity to work in one of Jeff's teams, he was very pleased. Developing techniques for collective intelligence and better interfaces between humans and computers had gone hand in hand, each building on the other. In the past, work on virtual environments for learning and research, combined with knowledge about factors in physical spaces that supported creativity, had led to the increased adoption of composite environments that facilitated different aspects of collaborative working. An important part of this related to immersive spaces which merged the physical and the virtual, allowing physical meetings in one or more locations to be enhanced and facilitated through features in virtual space, which used interactions through all the senses to support collective thinking and learning. These multisensory collective environments had increasingly also utilised brain computer interfaces. The original large and unwieldy FMRI devices for real-time analysis of brain patterns had become increasingly more portable and precise, utilising nanotechnology and related techniques. Together with massively increased computing power, brain activity and corresponding mental states and thoughts could be increasingly analysed and correlated even down to individual neuron levels in some cases.

The other side of the equation, how to directly alter what was happening in the brain, was more difficult, and he was particularly proud of the work he had been able to contribute to in taking this forward. Jeff had explained the principles of this to him the first time they met. "Evolution has developed sophisticated interfaces to our brain over millions of years through our senses. So our five senses and others, such as our kinaesthetic sense, will always be the starting point when we look at how to influence what's going on up here. But we had got an idea of what was possible a long time ago. As you know, individuals who had brain injuries which left them severely disabled in one or more of their faculties have been able to recover them through other parts of the brain taking over the required functions. So we know the brain has a surprising degree of plasticity. It was the work I did on prosthetic devices when I was starting out that made me realise how much further this could go. Some of the pioneers of devices such as cochlear implants didn't initially believe what they were doing would be possible."

"My father was profoundly deaf and had one of those", Cheng interjected, "and I know we took the technology for granted by then. But I can remember being puzzled when I first started thinking about it."

"Yes", Jeff said, "the key question was how electrical signals generated by sound could be connected to the brain's auditory system. In the early days particularly, the resolution of the sensors used was very course, and the connections made almost random. Yet the brain was able to adapt and learn over a period of time and users were able to recover surprisingly sophisticated powers of hearing. As devices and our ability to monitor the brain got better we were able to improve the quality and the learning process dramatically to what we have today, where we can effectively restore normal hearing as well as sight and other senses. Of course that work was just a start in a way, because we also wanted to be able to connect to higher order mechanisms - thoughts, feelings and emotions."

Since Cheng had started working with Jeff, things had moved a lot further. Wearing comprehensive augmented sensory interfaces, such as active contact lenses for vision, was now as normal as wearing clothes. In fact a common product slogan was "I feel naked without my …", for whatever device was being promoted. A brain interface was now an easily attachable external device, normally hidden under the hair - although also available as a fashion accessory. All the interfaces were seamlessly integrated to provide an experience that could blend the physical with the virtual to the requisite degree depending on the particular requirement. You could have your normal physical experience subtly augmented with appropriate information, or have an experience that was effectively completely virtual, using different states suitable for what was required. This could be anything from what would seem to be a dream, through lucid dreams, to one's where you were fully awake but all your sensory interfaces controlled virtually. The direct brain interface could also be used in different ways depending on the requirement. This could be from selecting options and controlling communication and other devices, to facilitating complex collective experiences. Cheng was an extreme sports enthusiast and in developments he had been involved with in this area was able to combine both his work and leisure interests. Using smart reactive clothing together with the sensory and brain interfaces, it was possible to simulate these experiences to a high degree. This meant, for instance, that the friends he went skydiving with could each experience in their own location all the interactions of a group skydive. Of course, although this was an exciting experience in its own right, they used it primarily to develop their skills for when they came together to do it in real life. Where some of these new developments really came into their own was in learning, and this was an area Cheng felt that had been most transformed by the work he was part of.

3.4. Maria's Story

Maria had started working as a teacher in her own country and been sent on a course to learn about some of the new techniques being introduced. As part of this, there had been a special lecture on the future of learning. That was where she met Jeff Lee and got fascinated in what he was doing. Experiential learning, aiming to provide learning experiences in as authentic real-world settings as possible, was the norm at all levels of education. This used the kinds of technology Jeff was working on to augment the experience and support learning. As the technology advanced, virtual experiences, including using brain interfaces and dreamlike states, were also increasingly used. But from her own use of these in teaching, Maria wasn't sure whether they were always as effective as intended. She quizzed Jeff about this after his talk.

"Even with all the personalisation features, the systems seem to work better with some kids than others. Sometimes it's not just about ability, more about interest and motivation."

Jeff nodded his head. "You have hit on one of the key areas we're trying to address. As you know, game-based learning is a key element in all education now. This uses the fact that gameplay is instinctive and one of the key ways we learn from birth. There was a time when some people seemed to believe that there was some kind of cut-off point after which it was no longer important for learning, but of course it is important at any age and now a key part of education at every level. But we acquire other motivations and interests as we grow up, which associate emotions with different activities, including learning. This can be negative or positive in various degrees, and is affected by a whole raft of things, cultural, familial, peer influenced, and so on. How we can use some of the new brain interface developments to work with this is a key focus area for us."

"It also seems easier to apply the systems to some subjects compared to others", Maria continued.

"You're also right there", Jeff added, "we would love to be able to help create a few new Shakespeares or Mozarts for instance, but we're not as far advanced in areas like that."

This had got Maria thinking, and led eventually to the path which would take her to where she was now, working with Jeff in this area. There had been work going back many years which had identified emotional states based on brain monitoring in real time which had been used to modify user experiences. Maria smiled when she thought of early experiments she had read about that controlled the narrative of virtual world-based soap operas this way. But it worked, and further developments had led to increasingly sophisticated applications, including in learning. Live action role play, where participants enacted different scenarios had become very popular in both entertainment and learning and newly developing combinations of virtual and physical experiences were able to take this further. Advances in interfaces to directly influence the brain could enhance what was done through sensory input, but also go in new directions. One of these was in influencing emotional state, which had become a major field of work with applications in every area from medicine to entertainment. Some of the work in the earlier days was inevitably controversial, and Maria remembered the heated discussions she had with her flat mate at that time, Sophia.

"So let me get this straight, you want to reinforce positive emotions associated with learning. Isn't that very … behaviourist. You know, you give the rat an electric shock if it's doing it wrong and a piece of cheese if it gets it right."

Maria laughed, "If only it was as simple as that. Emotion got bound up with thinking very early in evolutionary history. Emotional correlates with things like learning are incredibly complex and learning itself has many different aspects. The overall aim is to get the student to want to learn, to find what they associate with a good experience and then work on linking that to what they feel about learning."

Maria had been originally teaching in the area of the humanities and this now also formed a focus for her research. Because work in this area concentrated on generic factors, such as creativity, this also had a major impact on learning experiences in other disciplines, as well as in environments for research and more generally. Distinctions between different disciplines were increasingly blurred as concepts and methods that went beyond traditional boundaries increasingly became the focus for learning and research. The distinctions between learning and life generally also had changed dramatically. For a long time most learning had to take place after anyone's formal period of education, but now the concept of lifelong learning had an even more fundamental importance and learning had to be intimately integrated into work and all aspects of living. This was not a passive process - the aim was that people would contribute to the creation of new knowledge. Every stage of learning was linked to the real world and real problems, so that the transition from formal education to work was mainly a change in emphasis rather than a structural break.

This seamless transition was aided by the varieties of experience that were available. Maria's own research itself was increasingly conducted in a collaborative thinking space which used a variety of different types of experience and included other researchers from a wide variety of areas, students and the public. In fact with regard to the development of knowledge generally, research, learning and public involvement had increasingly merged, with aspects distinct to each, but also many environments where interactions took place between them, which she found very stimulating. Maria particularly liked the free-flowing collective dream experiences where new ideas could be formulated, modified and connected - and using the rapid prototyping facilities integrated into it, tested and evaluated, sometimes all within the same session. Particularly exciting were the new connections that could be made during these activities, often from researchers, research and other areas that would seem to initially have no apparent connection to the subject under discussion. Links could be created which could then sometimes re-divide and redefine the whole topic in a dynamic and developing ecosystem of knowledge. Her own work had often made dramatic changes in direction and scope through this process, and had been enormously aided and enriched because of it. She also enjoyed participating in sessions of this type initiated by others, which her brain interface would connect her with when she wanted to. These excursions could not just involve thinking and discussion but any area of creative activity - collective art, music, writing or media production, for instance, aided by the wide variety of brain controlled devices that existed.

One area which she had originally got involved with in this way appeared to be a diversion - albeit an interesting one. This was digital biography, which was to have some surprising repercussions for her work. This had originated as just a means of including digital materials within the biographical field, but increasingly the emphasis was not just on finding out about somebody, but getting to know them, and with the development of experiences, this began to include being able to meet them, even if they were no longer alive. This work intersected with role-play gaming where real or hypothetical situations were recreated for players to interact in, with the biographical subject effectively being a simulated non-player character in this genre. But one factor, which affected a wide range of other experiences as well, always acted as a limitation. How could we know what they felt like? If we were part of an experience where we were in the role of someone from that time, it would not be authentic for us to feel, believe and understand like someone from today. This was where some of the more recent work in directly influencing the brain came in. Maria had appeared on a media program, called "Inside the Minds of the Past" explaining this.

"Tell me how I can feel like someone else?", the interviewer asked.

"If I was deaf and used a hearing prosthetic device, it would have simulated what a person without that disability could hear. Now consider what would happen if a spider was put in front of me. I have no problem with spiders, so my emotional arousal signal in relation to fear would be small. But supposing we amplified that signal greatly and stimulated the locations in my brain which aroused fear with it. I would then feel like someone who had a phobia for spiders", Maria replied.

"I presume the aim of this work isn't just to find ways of making us scared."

"In practice, quite the opposite of course. This kind of technique is extensively used in treating phobias. And we can't usually just increase or decrease certain emotions. Sometimes we need very complex translations between different emotions combined with other stimuli", Maria answered.

"What about people from the past. You can't go and stick one of your monitoring devices on Alexander the Great can you?"

"This relies on building up a model based on historical materials and analysis. Of course people had significantly different attitudes and beliefs then, but also similarities. We still read and use the works of Aristotle, who tutored Alexander. We still laugh at the humour of Aristophanes."

The experiences that were now available made learning about the past and across cultures and languages much more authentic and were also extensively used across disciplines. In the sciences it allowed students to take part in the experience of some of the great discoveries and inventions of the past. In geography and related areas, historic explorations could be relived, and so on similarly for other subjects. Experiences could be personalised to fit the prior knowledge, interests and motivation of the students, but were also usually collective. Maria explained this to a group of research students who were about to do their internship as part of her team.

"Our activities, whether at work, at school or at home, are predominantly carried out with other people, so it is sensible that we learn that way as well. We can still tailor things to individuals, but construct collective experiences around these. It's all part of making the learning experience authentic. But it also teaches students about the mutual benefits they get through learning interactively and collectively with others."

"What about evaluating individual work?", someone asked.

"What individuals do within collective experiences are an ideal way to gauge their level of understanding and expertise in real situations. We can design special experiences to evaluate individuals more comprehensively if necessary and even use certain experiences where all the other participants are non-player characters if we need to compare people", Maria replied.

"How do the experiences take into account people learning at different rates?", someone queried.

"This is where the techniques we have learnt from games and related areas allow us to dynamically modify scenarios and different individual's paths through them. Our ability to use feedback from brain interfaces, so that we have independent information about engagement, arousal levels and so on, also means we can adapt various characteristics of situations and environments to optimise learning as we go along. We also include a lot of sophisticated monitoring of various indicators that the individual will not be aware of, but which we as designers can later use to improve the overall system", Maria answered. Some people also raised ethical concerns. With the increasing power of the devices and techniques being used, many ethical and related questions arose. With the enormous beneficial potential also came it's obverse. Even with the many safety mechanisms and techniques that existed, there were dangers. Dreamlike experiences were usually restricted to having some kind of lucid constraint, so the subject could exit the experience if they needed to. Getting into the mental state of people with certain disorders or who had exhibited certain behaviours was controlled as far as possible, although doing this with special constraints and safety provisions had also led to major therapeutic advances.

3.5. The Turing Experience

When the news about the Turing find became known, Jeff had been very excited. He had always been fascinated by Turing and his work and had published papers about aspects of Turing's research - including his famous Turing test to define thinking like a human. Jeff got together with Cheng and Maria to discuss what they would do.

"We don't even know what the numbers mean", Cheng said, "there is a risk involved."

"I don't mean to pull rank", said Jeff, " but because of the risk I can't allow anyone else in the team to do it first. If it's OK, then others can try it out."

"But what if it's not OK?", Maria queried.

"Nothing ventured", Jeff said, trying to sound unconcerned. "This is a unique opportunity. If Turing actually did figure out something, this might dramatically advance the whole area."

Faced with the challenge, the team had focused on enhancing and extending their systems. The challenge had caught the imagination of some of the best minds around the world and the multidisciplinary team that had been working on the problem had made some key breakthroughs recently which made Jeff feel they were ready to try things out. The fundamental problem was that brains had many similarities but also major differences, especially at a detailed level. What was needed was a way of detecting the high-level thought patterns from one brain and translating these appropriately for another. Sophisticated techniques based on algebraic topology had been developed that could take into account both the spatial configuration and connectivity of any specific brain as well as information from its neuronal state. This was then abstracted into a form which could be translated, using some of the most powerful processing devices yet devised, to stimulate another brain for which a similar analysis had been carried out. This work already had been responsible for dramatic improvements in experiences used in every field. But Jeff felt this was going to be the crucial test. They didn't have Turing himself there so that they could analyse his brain, so they would have to assume that the numbers in the letters was already in some abstracted form that could be interpreted by Jeff's brain interface. He was sure that the systems they had developed were so powerful that any discernible patterns there would be identified and translated sufficiently for him to understand.

Jeff was now deep into his experience. Both the preparation he had done beforehand as well as the sensory stimuli that had been provided as he went into this state allowed him to move easily - first into the setting of Bletchley Park during World War II and then into the post-World War II world. He knew that the brain detectors would not be using the special data as yet, they would wait till they detected he had reached a suitable point, which he could also influence from his lucid state. He was now in Manchester and visiting Turing in a University building. He felt incredibly intellectually stimulated, with many new ideas coming into his head which he was discussing with Turing. He could also sense a feeling of sadness, although the system had been set to influence his moods as little as possible. Now he was entering a house in Cheshire, which he recognised as where Turing lived. Suddenly he knew the time was right and instinctively felt the change as the data started kicking in. He could see Turing beckoning him into a room. He followed. Suddenly he saw it. For a moment he stood there in amazement, feeling as if everything was real, that he was no longer in a dream and in control. Then the lucid dreaming mechanism re-established itself. He had seen what he needed to see. He started pulling himself out. His surroundings seemed to shrink into the distance. He opened his eyes.

"I don't understand." Cheng scratched his head. "How come we never figured that out?"

"Because we were looking for things like text or program codes", replied Jeff, "we didn't think of images. It also used a type of data compression different to ones we use today, but with some similarities. If Turing was responsible, he probably invented that as well. My brain picked it up immediately of course because it was visual."

"I appreciate the significance of an apple", said Maria, " because that was found by Turing's bed and we know he was fascinated by the story of Snow White and all that. But it wasn't an ordinary apple was it?"

"No", said Jeff, "it filled the whole room. It was like that picture you may have come across by the surrealist, Magritte."

"Where has all of this got us then?", mused Cheng. "We still don't really know whether the data was a forgery or not. And we haven't really got into Turing's mind, have we?"

"Maybe not, but if it was him, he certainly lived up to the sense of humour we know he had," said Jeff laughing.

“But wait a minute”, said Maria, “we might not have found out a lot about Turing, but as a by-product of doing the work triggered off by all this, we have made very significant advances in brain interface systems, which particularly will help us in some of our historical investigations, including undoubtedly understanding Turing better. It’s, as if somehow, he realised that this was the best way to help us. To make a contribution to the knowledge of the future.”

“I certainly wouldn’t put that past him”, said Jeff. They all nodded in agreement.

4. Conclusion

The story has been used to explore how the development of technologies to facilitate and enhance collective experiences and intelligence could transform the nature of learning and other aspects of life - which would be increasingly integrated with learning. There are dangers and challenges associated with these developments which the story also aims to raise. Using a science-fiction scenario is an ideal way to explore possible future developments. Of course things we do today will be part of creating that future, but it is also useful to consider what might be possible, to help determine some of the directions we take now. Developments around the concept of what has been called “SurroundMind” it is felt could act as a bridge from current technologies to the future. Beyond this, exploring and working towards a Science/(Art) of Knowledge, which integrates the different aspects of this area in the way that is projected for the future in the story, would be an important endeavour. The story is set in a time around the last decades of the 21st century. Some of the possibilities presented might seem to stretch what could be achievable by then, but it is only necessary to go the equivalent length of time backwards, to a period when computers didn’t even exist, to sense what could be possible in the future. And of course even envisaging the possibility of computers, which the object of the story, Alan Turing, figured importantly in, was key to their future development. Similarly it is hoped that some of the musings about the future we make now can contribute in some way to their achievement.

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Virtual Substitute Teacher: Introducing the Concept of a Classroom Proxy

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Abstract. We describe the concept and a first prototype of a digital replacement for a teacher in class. While earlier work on intelligent pedagogical agents has focused on the development of a generic idealized teacher agent, our focus lies on modeling the identity of a *specific* teacher. This digital replacement is called his "classroom proxy" and acts on his behalf as a personalized, virtual substitute teacher. We evaluate the concept of the classroom proxy in an exploratory case study and discuss the broader implications of digital replacements for educational purposes and other applications. We conclude with a description of future research directions.

Keywords. Intelligent virtual agents, autonomous agents, digital clones, mixed initiative, mixed-reality teaching

Introduction

Like every other human, teachers occasionally become ill, have emergencies, and cannot go to work. It is often impossible to find a qualified substitute teacher [1]. In higher education, classes are often canceled if no short-time replacement is at hand. In order to maintain quality educational standards, it is always desirable that the regular teacher is teaching a class, or at least that the teacher is carefully instructing his/her replacement. However, teachers' absences are often at short notice and a substitute teacher needs to improvise due to the lack of sufficient preparation time. A substitute teacher takes on a great deal of responsibility in holding things together until the regular teacher returns [2]. This means not only to move the curriculum forward but to ensure a smooth-running classroom [3]. The substitute teacher needs to be informed about what needs to be taught in a particular class and what the expectations are, for example, regarding the students' participation. In the current paper, we explore the question of how technology can help to overcome the issue of teacher absence by providing the best replacement possible.

These days we hold many personal and professional meetings that do not take place face-to-face (FTF) but are mediated through communication technologies, such as mobile phones, video conference systems, social networks, or online virtual worlds. This opens the possibility that our representation in the communication medium would be controlled by autonomous software rather than by ourselves. The most well-known digital replacements are automatic out-of-office email replies and call answer machines.

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But also automated avatars (i.e., bots) are increasingly populating social virtual worlds, such as *Second Life* (SL), that are able to initiate or continue a social interaction while the human operator behind the avatar is AFK (i.e., "away from keyboard").

We take the concept of autonomous personal agents into an educational setting, and ask how a virtual substitute teacher could fill in while the regular teacher is sick, attending a conference, or taking care of urgent family business. Our virtual substitute teacher is essentially a digital clone of the absent teacher that resembles him regarding his appearance and behavior. We call this personalized digital replacement of a teacher, his "classroom proxy." As the term "proxy" implies, this replacement will not only resemble him, but is authorized to act on his behalf.

The proxy is a specific type of an intelligent virtual agent, sometimes referred to as a virtual human. The idea of virtual humans is a popular science fiction theme. Science fiction movies often portray autonomous artificial humans, as in *Blade Runner*, or remote control of a virtual or physical representation, as seen in the movie *Surrogates*. Some of these entities are reminiscent of our vision of a proxy replacement; for example, in the book series *Safeload* the writer David Weber introduces the concept of a personality-integrated cybernetic avatar (commonly abbreviated to PICA): this is a safe and improved physical representation of yourself in the physical world, and you can also opt to "upload" your consciousness into it. Such concepts are penetrating popular culture; for instance, the appearance of digital Tupac at the Coachella festival in 2012, which provoked much discussion of the social implications and ethical use of digital technology (the original Tupac was a rap musician killed in 1996).

Clarke [4] introduced the concept of a digital persona, but this was a passive entity made of collected data, rather than an autonomous or semi-autonomous agent. Today we see such virtual identities in online social networks, such as *Facebook* profiles, but these are passive representations. Ma et al. [5] presented a manifesto of something they call a cyber-individual, which is "a comprehensive digital description of an individual human in the cyber world" (p. 31). This manifesto is generic and is presented in a high level of abstraction, and it is partially related to our concept of a proxy. The notion that computers in general have become part of our identity in the broadest sense is being discussed by psychologists [6] and philosophers (e.g., as in the extended mind theory) [7]. In this project we take a step in making these ideas concrete, toward merging the identity of the person with his avatar representation; specifically, the teacher's identity with his virtual substitute.

We can think of many other cases where we would have loved to have a proxy to replace us in an annoying, boring, or unpleasant event. However, in what contexts will such digital replacements of our selves be socially acceptable? Hence, the current paper not only evaluates the performance of a first prototype of a proxy used in a classroom context, but also evaluates the social acceptance of the proxy concept in general.

1. Related Work

1.1. Intelligent virtual agents

Intelligent virtual agents have been studied widely, either as autonomous or semi-autonomous entities [8, 9]. There has been a lot of research on believability [10], expressiveness and multi-modal communication [11], and the role of nonverbal behavior in coordinating and carrying out communication [12].

Semi-autonomous avatars were first introduced by Cassell et al. [13, 14]. Their system enables users to communicate via text while their avatar automatically animates attention, salutations, turn taking, back-channel feedback, and facial expression. Following their seminal work, there have been many attempts at automating nonverbal communication (see [12] for a review). Penny et al. [15] describe a system that incorporates avatars with varying levels of autonomy: *Traces*, a Virtual Reality (VR) system in which a user's body movements spawn avatars that gradually become more autonomous.

Shared control has been discussed in various fields of intelligent systems under titles like "adjustable autonomy" and "mixed initiative." According to Bradshaw et al. [16], adjustable autonomy is when the "degree of autonomy is continuously and transparently adjusted in order to meet whatever performance expectations have been imposed by the system designer and the humans and agents with which the system interacts. (…) Thus, a primary purpose of adjustable autonomy is to maintain the system being governed at a sweet spot between convenience (i.e., being able to delegate every bit of an actor's work to the system) and comfort (i.e., the desire to not delegate to the system what it can't be trusted to perform adequately)" (p. 240). Mixed initiative was defined by Allen [17] as "a flexible interaction strategy, where each agent can contribute to the task what it does best" (p. 14). Both, automating nonverbal behavior and shared control play an important role in our realization of the classroom proxy concept.

1.2. Pedagogical agents

IVAs have also been built for educational purposes, mainly in the area of intelligent tutoring systems, and are typically referred to as "intelligent pedagogical agents" (IPAs) (see [18] for a review). Graesser et al. [19] present an IPA, called "AutoTutor," which simulates an idealized version of a human tutor capable of holding a natural-language dialogue with a learner. They implemented the pedagogical strategy of "deep reasoning" into the agent, which engages in a mixed-initiative question-answer interaction with the learner, and shows context-sensitive synthetic speech, facial expressions and gestures. Others have implemented advanced emotional capabilities into IPAs. For example, Xuejing et al. [20] present an IPA that considers the learner's emotions by adapting to his psychological state throughout the interactive learning and teaching process. Besides such individualized learning scenarios, IPAs can also be used for supporting collaborative learning in collaborative online learning communities. It is generally possible to have multiple students and agents interacting in a shared virtual environment. Dowling [21] describes the complex roles of such a socially interactive IPA.

While common IPA research aims at simulating an ideal teacher, their efforts typically remain within imitating natural learner-instructor interactions. Bailenson, Blascovich and colleagues [22, 23] took the idea of an idealized virtual teacher into an immersive VR environment where both the teacher and the students are represented by avatars and/or automated agents. Following their Transformed Social Interaction (TSI) approach [24], they focus on the unique properties of immersive VR technology in order to create interactions that are not possible in FTF settings. In one of their experiments, they used VR technology in order to design a teacher to appear engaging in mutual eye contact with each of the virtual students simultaneously. Receiving maximum teacher attention through such augmented eye gaze has been found to result in more persuasive instruction. They also used gaze feedback information for teacher training purposes. Participant instructors learned to distribute their attention more evenly to their virtual audience when they received visual feedback about their gaze directions.

In summary, these related lines of research attempt to simulate a human teacher (or more precisely, an idealized, digital version of a teacher), and alter teachers' and students' online representations in order to facilitate learning. However, none of them have attempted to model a *specific* teacher, including his identity, expertise and preferences. This is the main goal of our research into designing a personalized classroom proxy.

1.3. Our previous work

Our first-generation proxy inhabited the virtual world *Second Life*. It is based on our SL bot platform, which enables bots to perform useful tasks, such as automatically conducting large-scale survey interviews [25]. The functionality of the SL bots has later been extended to learn from other avatars' behavior within SL, and imitate them (e.g., social navigation patterns) [26]. An actual proxy in the sense of a virtual clone of a specific person has been prepared for one of the co-authors of this paper to give a talk inside SL as part of a real-world conference (Figure 1): a workshop on Teaching in Immersive Worlds, Ulster, Northern Ireland, in 2010. The appearance of the proxy was canceled on the day of the event due to audio problems in the conference venue, but a video illustrates the vision and concept.[2]

In this paper we take the concept of the proxy to the offline world, though we take advantage of the fact that the offline world is also penetrated with digital sensors (cameras, microphones, mobile phones) and digital effectors (in this case a standard audio-visual display and loudspeakers) that enable a virtual proxy to take part in it.

(a) (b)

Figure 1. (a) The second co-author of this paper at work. (b) The virtual-world avatar, used as her proxy.

2. Proxy Concept

The proxy is part of an EU research project, called BEAMING.[3] The project deals with the science and technology intended to give people a real sense of physically being in a

[2] http://www.youtube.com/watch?v=7RByLajho-w
[3] http://beaming-eu.org/

remote location with other people, and vice versa – without actually traveling [27]. As part of this project, we explore the concept of the proxy in the context of several applications: remotely attending a business meeting, remote rehearsal of a theater play, remote medical examination, and remote teaching. In each of these applications it is useful to have a digital extension of yourself that is able to assist you while you are distracted with other tasks or replace you completely, either for short periods of a few seconds, due to some interruption, or even for a complete event.

In the BEAMING scenarios, we assume a mixed reality rather than a virtual environment. There is a main physical space, termed the destination, and its inhabitants are called locals. Remote users "beam" into this physical space using various tele-presence technologies, and the proxy is expected to operate in the same setup. In general, the proxy can be embodied as a virtual agent or as a physical robot. As part of the BEAMING project, we are exploring both, but in this paper we focus on a 3d virtual agent projected on a large screen.

The long-term goal of the proxy is to capture several aspects of a specific person, so that the proxy would be able to replace that person in various real-life contexts. There are many aspects of a person that we may wish to capture in the proxy: appearance, verbal and nonverbal communication styles, personality, preferences, professional knowledge, and more. In order to fulfill its purpose as a "proxy" (i.e., an authorized entity that acts on behalf of its owner), the proxy does not only need to pass as a recognizable representation of its owner, it also has to represent the interests of its owner. To that purpose, the proxy needs to be aware of its owner's goals and preferences. This is clearly a very ambitious goal, which would require integration of many fields for many years, and in this paper we only present a first prototype of a proxy used as a substitute teacher in a mixed-reality classroom setting.

The main concern in the implementation of our first prototype was the proxy's modes of operation. Other factors, such as physical appearance that resembles its owner and an accurate replication of the owner's body language, were treated as secondary. The proxy has three modes of operation: (a) background mode, (b) foreground mode, and (c) mixed-mode operation.

While the proxy is in background mode, its owner has full control over the actions. The owner can talk "through" the proxy. In this case he is represented by his avatar. Alternatively, the proxy can be idle, and simply record its owner's behavior in the background. The data collected while the proxy is in background mode provides the main source for behavior models for the proxy. Typically, we record the proxy owner's nonverbal behavior; the skeleton tracking data is tagged with meta-data regarding the context. This data is later being used in foreground and mixed mode in order to allow the proxy to have its owner's body language. During regular lectures, the proxy could always be in background mode and learn not only *what* the teacher is lecturing about, but also *how* he is teaching (e.g., movement patterns in the room, eye contact with students, length of turns between lecturing and addressing questions, etc.).

When the proxy is in foreground mode, it takes full control over the actions. In the role of a substitute teacher, the proxy needs to represent the teacher in the best way possible. In the simplest case, this means delivering a lecture and answering students' questions. In some situations, the owner may not wish to give the proxy full control, but decides to control part of the communication himself. In this case of shared control the proxy operates in mixed mode. The spectrum between user control and agent control is illustrated in Figure 2.

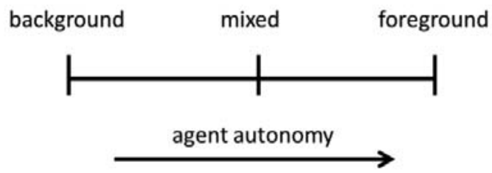

Figure 2. The spectrum from full agent autonomy (foreground mode) on the one side to full human autonomy (background mode) on the other, with mixed mode in the middle.

Our approach aims at a seamless transition between modes of operation throughout a communication session. The decision about switching between modes during a session can be made by the proxy automatically. The proxy should know when to take control of the remote representation (i.e., switch to foreground mode), and when to release control back to the user (i.e., switch back to background mode).

3. Evaluation Study

We evaluated a prototype of the classroom proxy as a proof of concept in an exploratory case study. As pilot tests we sent the proxy to replace the first author of the current paper to give short presentations in two international work meetings of the BEAMING project and in one appearance in front of a small group of students who were aware of the research goals. These were relatively informal pilot sessions, which were used to refine the study. In the evaluation study presented here, a classroom proxy was built for the first author, and was sent to replace him in one of his academic lectures. The case study is documented in a video clip.[4]

3.1. Participants

The evaluation study was conducted in a class of 3rd-year communication students, from an international track at IDC Herzliya. The students were expecting a regular class and did not have previous knowledge of the proxy. We deliberately selected social science students rather than students with a technical background. The class, entitled "Topics in Digital Culture," emphasizes the tension between digital utopias and dystopias. Thus, we expect the students to be aware of the social opportunities and risks of advanced technologies. The study received confirmation of our institutional review board. Twenty-one students of 11 nationalities filled in the questionnaires as part of the evaluation study (ages 21-29, M = 23.9, SD = 2.47, 7 men and 14 women).

3.2. Classroom Proxy Scenario

The prototype scenario included a classroom as the physical destination. The proxy's owner teleported to class from his research lab located in another building on campus (see Figures 3, 4). We tested three modes of operation of the proxy: (a) foreground mode, in which the teacher is in control of the avatar; (b) background mode, in which

[4] http://www.youtube.com/watch?v=43l739kKFfk

the teacher is away and the proxy “covers up” for him, and (c) mixed-mode operation, in which the teacher and the proxy each have partial control.

The classroom was prepared for the session. A machine running the proxy representation system was connected to the projector and loud speakers, and a webcam captured audio and video streams (with standard quality provided by the campus Wi-Fi network) of the classroom, and sent the streams to the lab (for the teacher, when the proxy was in background mode). The camera was positioned on the lecturer podium in front of the class. The lab interaction space includes a "power-wall" setup: a back-projection screen and a few standard sensors intended to capture the teacher: a high-quality camera, a depth camera (Kinect device), and a wearable wireless microphone. The teacher was speaking in front of the large screen, on which he could see the video feed from the classroom, and also a smaller display with the avatar that represents him, as seen by the class. Thus, unlike desktop-based interactions, the body language during this part of the experiment was appropriate and is expected to have resembled the teacher’s body language in front of a class.

Figure 3. Screenshots from the evaluation study. Top left: the classroom. Top right: the proxy representation as projected in class. Bottom: the teacher receiving a Skype call from his proxy.

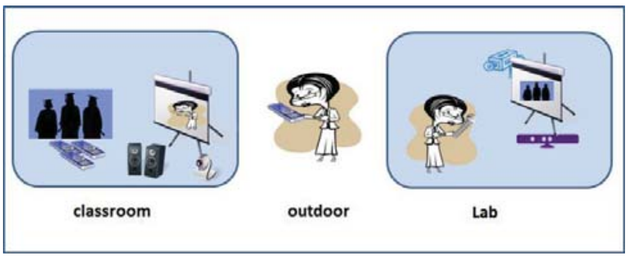

Figure 4. A schematic diagram of the study setup, showing the teacher in the lab presented as an avatar on the screen in the classroom. The students communicate with the proxy using mobile devices. During the experiment the teacher was also outdoors and communicated with the class in mixed mode.

The setup was prepared before the students arrived. At the first stage the teacher teleported into the class. He talked to the class with his own voice and controlled the avatar's body language (as captured by the Kinect device). After a few seconds the teacher left the lab and the proxy automatically took over and switched to the second phase of the study, in which it was in foreground mode. The proxy started reading a lecture from a predefined text. The proxy's body language was based on pre-recorded body movements of the teacher, and the voice was automatically generated with a standard text-to-speech engine (from Microsoft). The proxy has a list of words that should be accentuated when lecturing (prepared manually), and a few slides were displayed in the background in sync with the presentation. The topic of the lecture fragment was post-humanism vs. trans-humanism, with some details provided about the scholar Francis Fukuyama and his views on that matter.

Early during the talk the proxy encouraged the students to ask questions. Since speech-recognition technologies today cannot handle classroom conditions, the proxy instructed the students to send questions by Twitter, using a specific hash tag. Since these were new-media students they were all familiar with Twitter, and all had digital devices capable of running Twitter during class. Five questions were sent during the proxy's talk. The first 4 questions were answered by the proxy automatically after reading the questions out loud. The chat bot was, in general, able to provide reasonable answers to the questions based on the pre-configured templates (e.g., Q: where are you now? A: I am in IDC Herzliya).

At some point toward the end of the talk, the proxy decided that a specific question should be addressed by the teacher himself. In the current case study, this decision was made arbitrarily (based on the duration of the presentation fragment). Generally, a certainty criterion can be obtained from the speech recognition and natural-language understanding components, to allow for the proxy to automatically attempt to transfer control back to its owner. The proxy explained to the audience that it was asked a question that it cannot answer, and that it has decided to consult its owner. At this stage the proxy called the teacher who was now on the way from the lab to the classroom. The class could not see this call take place, but they could hear Skype ringing, the proxy asking the question again, and the teacher answering (using his smartphone). A few seconds later the teacher entered the class and explained that this was a scientific study and that the experiment is over. The whole session lasted approximately 15 minutes, after which research assistants handed out a questionnaire, and three students were randomly selected to provide more details in semi-structured interviews. The interviews were videotaped.

3.3. Measures

The students were first asked to rate the believability (i.e., perceived realism) of 9 variables related to the classroom proxy's performance: "How realistic was…?" (voice, facial expression, speaking style, arm movements, body postures and gestures, timing between speech and gestures, content of the talk, responses in the Q&A session, use of language). Two questions were asked in order to measure the perceived similarity regarding (1) the body language and (2) appearance between the proxy and its owner. Each of these items were rated on a scale from 1=not at all, to 5=extremely.

The following questions included measures of social acceptance regarding the proxy concept in general. We asked the students: "Do you think it is generally acceptable that proxies will replace real humans in the future?" This question was rated on a scale from 1=not at all, to 5=absolutely. We further asked two open-ended questions: (1) “For what kind of social situations would you like to have a proxy that replaces you or wouldn't mind to interact with someone else's proxy?” and (2) “Knowing that you are interacting with someone's proxy, do you think you would behave differently toward a proxy compared to interacting with an avatar controlled by a real person?”

3.4. Results and Discussion

Perceived realism: A median comparison of the ratings of the classroom proxy’s believability revealed the following order (from more realistic to less realistic): (1) use of language (*Md* = 4), (2) content of the talk, voice, speaking style, timing between gestures and speech, and Q&A ability (*Md* = 3), (3) facial expressions, body posture, and arm movements (*Md* = 2). The low ratings for the proxy's body language can be explained by the fact that we have used Kinect as a motion capture tool for both the live and pre-recorded animations. Kinect is intended for gesture-based interaction rather than as a motion-capture device, and apparently the resulting body language was unrealistic due to noise.

A principal component analysis of all 9 variables revealed three distinct factors with the following factor loadings: Factor 1: speaking style (.71), arm movements (.92), body postures (.82), and language (.68), Factor 2: voice (.60), facial expression (.68), and content (.76), and Factor 3: timing (.80) and Q&A (.60). This points to a trend where the use of language (selection of words, grammar) and speaking style are attached to the body movements and postures while the content of the conversation is more affected by the voice and facial expression (associated with the head or face area). This possibly implies that although we must match a person's speaking style to his own body movements, the content of what a person is saying may be manipulated independently, without affecting believability. This would be in contradiction to the classic literature regarding the high correspondence between speech and gesture in humans [28]. Three students further elaborated on their experience during the post-study interviews. These reports confirmed that the main obstacles were the body language of the proxy that was not realistic enough, and the audio quality of the live Skype talks.

Perceived similarity: The perceived similarity between the proxy and its owner regarding appearance ($M = 2.33$, $SD = 1.35$), and body language ($M = 2.38$, $SD = .87$) was about average. The proxy was neither perceived as totally dissimilar nor very similar to its owner. Although a high level of similarity would eventually be expected, a moderate level of perceived similarity can be considered as satisfying for a first prototype. As expected, the perceived similarity ratings regarding appearance and body language were positively correlated, $r = .40$, $p = .04$ (one-tailed). This indicates that body language is perceived as an integral part of one’s appearance. Interestingly, perceived similarity regarding body language was positively correlated with perceived realism of the proxy’s *verbal* behavior, $r = .41$, $p = .03$ (one-tailed). This provides further support for the strong connection between verbal and nonverbal communication styles in creating a coherent, authentic impression.

Social acceptance: The general acceptance of the concept of a proxy was found to be moderate ($M = 2.71$, $SD = 1.38$); indicating some ambivalence regarding its social acceptance. Interestingly, men ($M = 4.00$, $SD = 1.16$) accepted the proxy concept significantly more than women ($M = 2.07$, $SD = 1.0$), $t(19) = 3.97$, $p = .001$.

When asked to specify whether they would use a proxy and for what purposes only two students specified that they would rather not use a proxy at all. The rest of the students suggested that they would like to use proxies for: attending classes (7 mentions), daily errands such as visiting the bank or grocery shopping (4 mentions), work-related activities (3 mentions), or socially-stressful tasks such as public speaking (1 mention) or ending a relationship (1 mention). These answers testify that at least some of the students did not fully comprehend the difference between the proxy and an assistant robot (e.g., shopping), but others clearly grasped the social implications (e.g., ending a relationship).

When asked whether their behavior would be different if they knew that they are interacting with someone's proxy as opposed to a human-controlled avatar, 50% indicated yes, 15% said no, and 35% were uncertain. Those who were not sure about whether or not their behavior would change toward a fully autonomous proxy indicated that it depends on how realistic the proxy was. This finding has important implications in our case of a virtual substitute teacher. We would not only want the classroom proxy to be perceived as realistic and similar to the teacher it is replacing. We would also want the students to behave just as if their real teacher was teaching the class (i.e., treat the proxy with respect, pay attention to what it is saying, etc.).

4. Outlook and Conclusions

We presented an exploratory case study that aimed at evaluating the concept of a classroom proxy used as a virtual replacement of a teacher in class. We deliberately decided to run this case study in a real-world setting rather than in the lab. It is crucial to confront a live audience with the concept of a proxy; in our case the proxy of the students' regular teacher. Only in such real-world scenarios, we can evaluate the social acceptance of the proxy concept as first-hand experience is more informative than being confronted with a merely hypothetical scenario.

For many of us it would be convenient to use proxy replacements, as indicated by the majority of our student audience. However, would we want to live in a society where others are often represented by proxies? There was a significantly higher acceptance of the proxy concept by male participants than female participants, but the majority of both genders would be happy to use a proxy. Based on these preliminary findings we conclude that we are likely to see various kinds of proxies gradually deployed, and envision a future where proxies inhabit our society.

The case study demonstrates that a useful proxy can already be implemented using current state of the art technology. The main drawbacks were in the level of production: the quality of live audio and the animation. The students' ratings are, of course, specific to our implementation of the classroom proxy, and may not be generalized to more advanced technical implementations. However, the evaluation results are useful for ongoing refinement steps of the proxy's development to be used in classroom settings and other types of applications. We encourage the developers of such autonomous intelligent agents to be aware of the social, ethical, and legal implications while pushing the technology further.

One of the main issues for further research, which we have not fully addressed in this paper, is the potential of applying intelligent transformations to the teacher's representation, as proposed in Bailenson et al.'s [24] TSI approach. Since we are operating at the border between the digital and the physical space, an interesting opportunity presents itself: Instead of replicating one's actual physical appearance and behavior, enhancements can be implemented through the use of digital transformations. The proxy can be used to represent the owner better than the owner would represent him- or herself. For example, you may consider a proxy that is based on your appearance with a beautifier transformation applied [29]. Similarly, in our case study the teacher has opted to use a good-looking male avatar, even though a look-alike avatar was available, and text-to-speech was selected to have an impeccable British accent.

Elsewhere we have demonstrated the possibility of a proxy that extends your vocabulary in foreign gestures [30]. For example, assume that the proxy owner communicates with people of a different culture. In mixed-mode operation, the proxy can be configured to recognize that the owner has performed a culture-specific gesture that may be misinterpreted by his collocutor(s). The proxy would then replace this gesture by the equivalent gesture in the target culture's vocabulary or provide an annotation of the gesture's meaning if no equivalent gesture exists. This scenario is particularly useful in an educational setting. Imagine a teacher is invited to give a lecture in a foreign country. Instead of traveling, he may want to send his proxy as a culturally-adapted version of himself. Besides adjusting the proxy's body language to the cultural norms of the audience, it is able to give a talk in any foreign language. The lecture script can be easily translated and presented using text-to-speech software. Considering the constant improvement in translation systems and synthetic speech, this scenario will not be so uncommon in the near future.

In the case of a virtual substitute teacher, it is of particular importance to increase the proxy's awareness of what is going on in the classroom. In its current state of development, the proxy would not even notice if all students left the room. It is certainly one of our next steps to increase the proxy's awareness of the students' (mis)behavior in class, and implement a set of actions that the proxy can take in certain situations. For example, the classroom proxy may want to make sure that the students are taking notes and that no one sleeps while it is talking or showing a movie. "Smart classroom" technologies will help to enhance the virtual proxy's ability to take actions in the physical classroom. Such ubiquitous classroom technologies have been prototyped for automatic capture of class events and experience, as well as for context awareness and proactive services [31].

If in the future many teachers have a classroom proxy, then these personally trained proxies could be synchronized through a network. When a proxy is called to give a lecture on a certain topic, it may search for other proxies' experiences in teaching a similar class. Social tagging could be used in order to identify the best-rated lectures within this knowledge base. This scenario is not so far-fetched since teaching evaluations are already common practice these days. The proxy could then integrate parts of other teachers' scripts and resources into its own lecture. Such a joint knowledge base would also be useful as a resource for questions on the topic that might be asked by the students during the lecture and a selection of quality-rated answers for the proxy.

While substitute teachers generally have the unfavorable image of being "not the real" teacher and may be considered as less qualified than the regular teacher, proxies have the potential to become even better than the regular teachers themselves. However, it has yet to be evaluated whether the proxy holds its promise to be the ideal replacement for an absent teacher. Future evaluations will need to include comparisons between the performance and acceptance of a proxy versus a human substitute teacher.

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Augmenting the Student Induction Experience

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Abstract. During induction students new to University are presented with a large amount of information in a short period of time, as well as being introduced to new locations and new colleagues. Rather than focus induction activities solely around lectures and talks, Augmented Reality and related technologies allow for richer blending of orientation and knowledge dissemination. This presentation details a low cost approach to creating an augmented induction experience focusing on the use of student smartphones and QR codes, and we discuss how experiences like this can enhance the students' opinion of the institution and support socialization.

Keywords. Augmented Reality; QR Codes; Induction;

1. Introduction

The process of induction to University is designed to achieve a number of objectives, administrative, academic and social. On top of this, students have to learn to navigate the physical university campus to find classes and a wide range of services. Induction is seen as being a very important part of the University experience, with an impact on student retention and progression [1].

However, the method of delivery of induction is also important. As an early point of contact with the student it may not only inform and educate, but can engage and inspire also. The use of Augmented Reality can not only enliven the process, but can also impress the student, adding credibility to, and creating a favourable impression of, the university [2]. It was decided to attempt to gain some of the benefits of an Augmented Reality induction, similar to [2], despite being constrained by tight limits on budgets for equipment and development time.

2. Student Induction at UWS

The University of the West of Scotland attracts a relatively large number of mature students, first-in-family students and students from low income families. Research suggests that Universities need to adopt a proactive attitude to improve the retention rates of non-traditional students [3]. Given the particular problems experienced by these student groups, especially at the outset, the induction process is viewed as crucial.

For the last twelve years induction at UWS Hamilton campus has followed conventional lines incorporating information sessions and administrative tasks. Additionally, students are given fun exercises, such as puzzles, riddles and physical tasks as ice-breaking and group-building activities. Four years ago we replaced the traditional campus tour with a treasure hunt. Students were split into small groups, given pictures of eight locations around campus, and sent off to find where each was. Students were asked to take pictures of the group at each site, and the first group back with the correct answers won a prize.

3. Augmenting the Induction Experience

In September 2012, after three successful implementations of the picture based campus treasure trail, we decided to incorporate an element of AR. Evidence suggests that the introduction of AR into education has been successful and popular [4], and, given that the subjects of this study were enrolled on Computing courses, it seemed to be a natural and appropriate progression. As both resources and development time were limited, it was decided to use QR codes to be placed around the campus, with each giving a clue to the location of the next marker by means of text messages, web-pages, pictures or video. The treasure trail activity was moved from the first day of the induction to the third to ensure that students could be given enough notice to download a QR reader app.

39 students were split into eight groups, ensuring that each group had at least one member with a smartphone capable of reading QR codes. Around the walls of the starting room were eight QR markers identical to the ones which we had positioned about the campus. Each group was randomly and uniquely allocated to a marker and it was explained to them that this would give a clue to the location at which they should begin. When they picked up a clue which pointed them back to their starting point they would know that they had completed the tour. Although all groups started at the same time, the different starting points helped to prevent large groups of students creating congestion and from disrupting other campus activities.

It was further explained that at each location they would find a letter beside the QR code and when they had all the letters they should return to the classroom where they would be given a web address which could only be accessed by means of a password formed from the eight letters they had found.

All groups completed the trail successfully. In contrast, in none of the three years prior to this did all groups complete the older version of the activity. In a survey conducted one week later, 72.7% of respondents described the treasure hunt as “useful” or “very useful”, and 54.5% stated that the Augmented Reality approach to the activity specifically had had a positive effect on their perception of the University.

Based on this experience we are now preparing an expanded version of the induction activity and a more in-depth study for the 2013-14 academic session.

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The role of presence in a simulation lab for educator professional development

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Abstract. This research introduces a project to design and implement an immersive virtual world (SimuLab). The aim of this project is to assess university students' knowledge and use of project based learning through two modules developed around curriculum taught in a subject about ICT applied to education in Pedagogy' studies. We explore how the concept of 'presence' supports these efforts, as well as solving problem theory can be used to understand whether these students achieved presence in the modules.

Keywords. Presence, Virtual World, Project-Based Learning

Introduction

The use of 3D immersive virtual worlds and their potential for supporting and enhancing student learning are being given much attention and increased interest in recent years. In the framework of the SIMUL@ research project [1], a significant result was the didactic proposal guidelines about using project-based learning in a virtual world. Students engage with a contextualized problem and use their prior knowledge in other subjects to solve it.

When users interact with a virtual world they get to some extend the feeling of 'being there' [2]. The concept of presence has been the aim of research for over 20 years. Beyond the "sense of the place" that physical presence measures, there is the "sense of being with another," or quite essentially, the "sense of another through a medium." The definition of 'presence' ranges from a sense of "oneself being somewhere else" [3], to "the sense of being in an environment" [4], to "the perceptual illusion of non-mediation" [5] to a subjective sense of being in a place [6,7]. With the advent of Multi-User Virtual Environments (MUVE's), [8] suggest that presence be defined as "being there together."

The focus of previous studies [9,10] have shown that presence in virtual worlds enhances the learning experience that improves learner motivation and allows users to create the collaborative learning content where the user feels a sense of control within the environment and adopts an interactive mode of learning. Virtual worlds can be used to create effective learning spaces. Simulation, role playing, training, exploratory experiences, project- based learning or games are involved educational strategies.

1. The project

The SimuLab is a virtual world based on OpenSim. Through Sloodle, which integrates MUVE's with the Moodle learning management system, it enables the communication process between objects in the virtual world and Moodle activities. [11]

In this laboratory, the students use an avatar to explore the virtual world and to carry out the proposed activities. The platform is currently in beta version while being tested with students. The goal of the SimuLab is the representation of workplaces that are related to education and training. In these scenarios, the student could develop his/her skills as a teacher. In this sense, the didactical proposal has two modules:

This first one involves a reasoned reflection on their professional future and defines the tasks proposed by the students. In groups of 3-5 people, reflect on the possibility of developing two educational products in different areas (formal, non-formal or informal). They have resources and activities to deliver two proposals.

In the second one, each group has to choose one of their educational proposals. The students should interact in the virtual world to build their project inside their own SimuLab Island. The proposals may cover a range of fields: business training, Editorial Company, ICT and media, health, environmental studies, and public services management. The project culminates in the public presentation of their final proposal.

Finally, the student has to deliver a personal journal of the project. Students are asked to participate in a post-module for measuring presence by SUS Questionnaire [12] and a discussion with the teacher about their experiences/perceptions of "presence". This study aims at investigating students 'perceptions of presence through virtual world into Pedagogy subject. The pilot experience counted with the participation of 52 students (76,92% women and 23,08% men), whose average age was of 23,5 (sd=3,44). The teacher is also involved in the experience and he assumes the role as overall coordinator. The students freely learned how to use the environment, how to construct their avatar and how to interact with their avatar, their colleagues and the environment. The experiment was performed with the following steps:

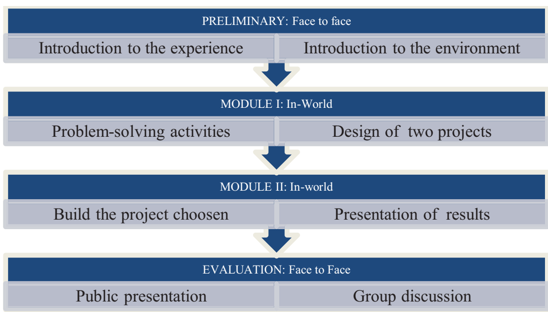

Figure 1. The phases of the project

In the group discussion, many students expressed high interest in using the environment to improve their academic performance. For the next phase of the research, we will study if the level of sense of presence could facilitate learning tasks and skills to real situations through virtual worlds. The goal of this phase is to identify the essential characteristics of learning tasks within a virtual world to achieve a high sense of presence.

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PhyMEL. A Framework to Integrate Physical, Mental and Emotional Learning in Meaningfull Experiences and Multidimensional Reports

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Abstract. The relationship among body, mind and emotions has been widely exploited in high-level sport and dance, but its penetration in academic environments is still very slow. In the other hand gamification and storytelling have been proven to have a high impact on students' motivation socialization and transformation but is difficult to integrate interaction patterns of storytelling (mainly linear) with games (mainly no linear). This work proposes a conceptual framework called PhyMEL that includes physical, mental and emotional dimensions of learning to facilitate (1) the deployment of meaningfull experiences and (2) the creation of multimedia reports. This study proposes to use the scheme of the Hero's Journey created by Campbell as the main thread to integrate elements of (1) the environment, (2) the game, (3) the storytelling and (4) the learning domain to reach successful learning experiences that can be easily recalled when needed. Several elements of the framework has been tested in three different experiences with different target audiences and different learning reports (1) Our Museum for elementary school reported as a game board, (2)The kidnapped Scientist for primary and secondary school reported as a comic (3), PhyMEL-Wheelchair Simulator for adults reported as a machimina. The conceptual framework has proven to be useful, enjoyable, and effective in all these three experiences, but more research is needed to demonstrate the usefulness of multidimensional reports.

Keywords. NLP, Hero's Journey, Simulation, Virtual Worlds, Mixed worlds, Social Awareness, Gamification, Learning, 3DOF, Multiple intelligences, Simulators, Board games, Comic, Machimina, GTD, BMY

Introduction

One of the main challenges of education is to make educational designs that result in significant and easily recalled experiences. According to NLP [1] we are sensory beings. The more senses are involved in a learning experience; the easier it will be to recover this information when needed. Our senses are involved not only in external perception but also in our internal mental processes and the way we communicate with others. Our brain barely distinguishes between external experiences and those that originate internally when we remember an experience or just imagine it. That is why emotions are also so important in the learning process. The relationship among body, mind and emotions has been widely exploited in sport [2] and dance [3] under the concept of *thoughness* [4], but the practical application of the *thoughness and flow state* [5] in academic environments is still very slow. In the other hand gamification and storytelling have been also proven to have a high impact on students' emotions, and motivation [6], but according to Dickey [7] is difficult to integrate the narrative of storytelling (mainly linear to follow the plot) with games (mainly no linear to provide more opportunities of interaction).

This work proposes a conceptual framework called PhyMEL that involves physical, mental and emotional dimensions of learning to facilitate the deployment of experiences and report generation. To achieve these objectives PhyMEL integrates the student and his contextual environment (physical or virtual) with gamification, storytelling and learning using different theories present in the literature. The theory of the *Monomyth* by Campell [8] and its scheme for the *Hero's Journey* [9] has been used to define storytelling elements. The *Bloom Taxonomy* [10], [11], *Burch Stages for Learning* [12] and the Dillembourg literature review on collaborative learning [13] have been used to define the anchors to the learning domain. The theory of the *Multiple Intelligences* of Gardner [14] and Csikszentmihalyi *Flow State* [5] has been used as anchors to the student cognitive state. Several works have been reviewed also to define the elements to include in the game (missions, locations, characters, treasures, hints, rewards, etc.) [6] [15]. The vision of the game as a whole is based on Beck and Wade approach [16] where the idea is not to confront the players with the opportunity to become a winner or a loser but rather with the possibility of being a hero, where part of the reward is to serve a greater cause

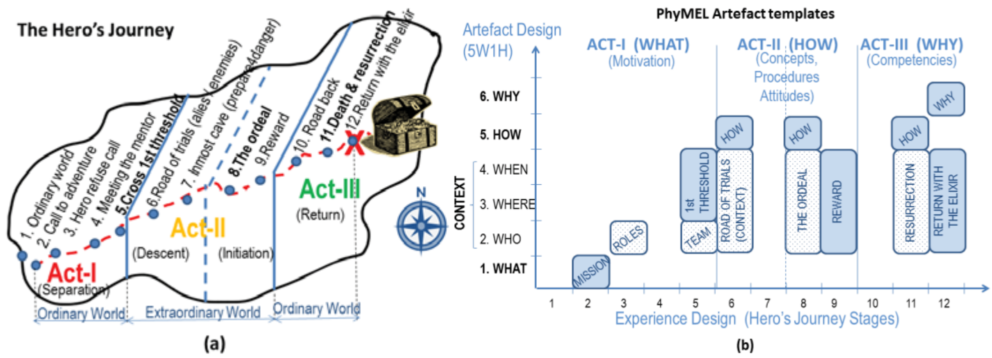

Figure 1. Phymel Experience & Artefact Design: (a)The Hero's Journey. (b) Phymel's Artefact Template: The solid modules represent the fixed part of the multidimensional report and the dotted modules, the info that can be personalized for each student.

Table 1. PhyMEL's Components for Learning Design = Hero's Journey (Transform) + Pedagogy (Learn) + Gamification (Enjoy)

	PhyMEL	ACT-I (Separation)	ACT-IIa (Descend)	ACT-IIb (Initiation)	ACT-III (Return)
STORYTELLING	**Contextual environment** (Physical or virtual) **Storytelling** (The Hero's Journey)	Ordinary World 1-2-3-4-5	Special World 6-7	Special World 8-9	Ordinary World 10-11-12
PEDAGOGY	**Stages of learning** (Burch)	**Unconscious Incompetence** Student does not recognize the need of learning	**Conscious Incompetence** Student recognizes the need but he has not the skills. Mistake as part of the learning process	**Conscious Competence** Student has the skills but requires great concentration to apply them	**Unconscious Competence** Student integrates the skills, perform naturally and may be able to teach others
	Motivation (Csikszentmihalyi)	Boredom	Anxiety ↑	Anxiety ↓	Flow state
	Social Learning (Dillembourg)	**No interaction**	**Asking for support** Peers and mentor are seen as a source of knowledge or feedback	**Team work**. Mentor as coach and peers as team mates. Co-creation & collaboration	**Social Contribution**. User disappears as student and emerges as a teacher. Mentoring to students. and teamworking with other teachers. Stigmergy
	Learning activities (Bloom taxonomy)	Inactivity	Remember Understand	Apply, Analyze, Evaluate	Create
	Prevalent Intelligence (Gardner)	Intrapersonal	Visual, Verbal, Logical, Kinesthetic, Musical, Naturalistic	Interpersonal	Existential
GAMIFICATION	**Gamification Elements**	**Mission** WHAT Game objective, Game locations	**Game Mechanics** HOW WHO-WHERE-WHEN Non player characters, Partial challenges, Competition , Hints, Feedback, Badges	Main Challenge, Rewards, Score	**Vision** WHY Game outcomes Game levels, Player's status in the game's community of practice
	Prevalent Character (Jung-Vogler Archetypes)	Mentor, Herald, Threshold-Guardian	Shapeshifter	Trickster, Shadow	Hero

1. PhyMEL Framework

PhyMEL (Physical, Mental and Emotional Learning) is a framework that allows the creation of meaningful experiences and learning outcomes. The main element of the model is the storytelling represented by the Hero's Journey **Figure 1a**. In order to create the Learning Design, each stage in the narrative structure has been augmented mapping some elements of the most accepted taxonomies in pedagogy and games as illustrated in **Table 1**. The ramifications and nonlinearities associated to the game are introduced when the player has to make a decision about his journey (stages 5, 7, 10, 12) or according to the results of the trials (stages 6, 8, 11). The multidimensional reports templates **Figure 1b** has been created reducing the narrative structure using the creativity technique 5W1H. Each question (what, who, where, when, how, why) includes one or more stages of the journey and can be represented with a fixed or a customizable module of the report. The fixed part of the report is composed by four blocks: (1) the mission (WHAT), (2) the vision (WHY), (3) the game mechanics (HOW) and (4) the partial results at the end of each act (REWARDS). The customizable part of the report is composed by two blocks: (1) character personalization and (2) context. Character personalization (WHO) is performed, individually, in stage-3, and, as a team, in stage-5. Context personalization (WHERE) is documented during the experience by the students. They take pictures, videos or providing feedback in specific time slots (WHEN). To do this, it has been selected the journey's stages in which the student has to overcome some obstacles (6, 8, 11) because they are the most important milestones, in the students' learning process.

The implementation of the framework has been made creating anchor points between different elements of the model and technology. These elements can be replaced by others as technology evolves. The anchor points that link the contextual environment (physical and digital worlds) are implemented using RFID tags (**Figure1b**), QR-codes (**Figure2b**) or peripherals such as 3DOF platform, virtual reality glasses or joystick (**Figure3d**). The anchor points that link the narrative space of the storytelling with learning domain are implemented using game elements such as: characters, locations, mission goals, challenges, hints and rewards. The anchor points that link the experience with the participants are activities related with different intelligences (musical-rhythmic, visual-spatial, verbal, logical, kinesthetic, interpersonal, intrapersonal, naturalistic or existential) and different type of activities (Bloom taxonomy).

2. Study Cases. Results and Discussion

Phymel framework has been used in three different experiences with different aims and target audiences to test its feasibility and its two main features: (1) instructional design and (2) design of multidimensional reports. Experiences' setup is summarized in **Table 2**

Table 2. Study Cases. Objectives and target groups

Case Study	Objectives	Target group
I. Our Museum	Develop an exhibition of painting for parents and other members of the school community. Apply project based learning to integrate physical, linguistic, and logical skills of the elementary school curriculum with transversal contents (art history and digital competence)	Two groups of 25 students 4-5 aged in elementary school.
II. The kidnapped Scientist	Resolve a fictitious mission interacting with artifacts in the museum and applying scientific principles belonging to the primary and secondary school curriculum. Improve the experience of learning science integrating formal and informal learning. Gamify the visit to the science museums.	3 trials: (1) Pilot-trial: voluntaries 7-14 years. (2) School-trial: 3 schools secondary level 12-13 years. (3) Family-trial: Parents and children 7-14 aged in the same team
III. PhyMEL Wheelchair simulator	Trial-1: Raise awareness of the difficulties faced by a person in a wheelchair.	Generic audience (adults)

2.1. Case Study 1: Our Museum

This experience (**Figure 2**) was developed during 3 months in an elementary school. The exhibition includes original famous paintings and copies made by the students using different techniques. The exhibition is augmented with RFID tags that contain 1-2 minutes video tutorials of the students explaining the painter's life and its work. Students explain also in these videos the techniques used by them to reproduce the paintings. The visitors in groups explore the physical museum deployed in the school hall and they can see the augmented content using NFC-mobile phones provided during the experience. During the exhibition visitors can provide feedback about paintings, videos and the whole experience in physical panels distributed through the exhibit.

2.2. Case Study 2: The Kidnapped Scientist

The kidnapped Scientist experience (**Figure 3**) was developed with different secondary schools and families (more than two hundred users) visiting the museum installations in sessions of 2-3 hours per visit. During the visit 6 groups of 4-5 people are formed to accomplish a fictitious mission: to discover the identity and location of a kidnapped scientist. When the scientist was kidnapped, all things in our world that depends on his discoveries have begun to disappear, but he left some clues in the museum to facilitate his rescue. Each group hast to find 3 clues and face 3 challenges to rescue him. Each challenge implies interact with artifacts in the museum, see videos with reproducible hands-on experiences, solve some questions applying scientific principles, and report the experience using the group-tablet to take some pictures and write reports.

2.3. Case Study 3: PhyMEL Wheelchair Simulator

This study is part of a larger project [17] which investigate the use of PhyMEL Wheelchair simulator for different audiences in 3 trials: (Trial-1) generic audience to raise awareness of the difficulties faced by a person in a wheelchair, (Trial-2) wheelchairs users to improve their driving skills, and (Trial-3) medical professional staff to serve as support tool for prescription and evaluation of patients in a wheelchair. For the moment, only the first one (**Figure 4**) has been finished.

This third experience was deployed with 23 voluntaries adults during two months in sessions of 2-5 minutes per subject. The trial consisted of a route in a virtual world containing main barriers that a person driving a wheelchair has to face daily (curbs, narrow corridors, stairs, wheelchair lifts, slopes, ground irregularities, bad parked cars and take on a bus). The system offers guided or unguided modes to perform the journey. On the guided tour the wheelchair is moved automatically by the system during a two minutes tour. User experiments kinesthetic sensations through the three degrees of freedom motion platform and visual sensations through virtual reality goggles. In the unguided tour a joystick is provided to the user so that he could drive the wheelchair and face the obstacles freely and the system only provides visual navigation support using a arrow to indicate the user the location of the next challenge.

The successful deployment of the experience with real users demonstrates that Phymel Framework is useful to design meaningful experiences and reports. Part of the data gathered during the experience (quantitative and qualitative) using surveys, field notes, interviews, log files and video recordings is still under analysis. Preliminary results denote that the PhyMEL conceptual framework is useful, enjoyable, and effective for different target audiences but more research is needed to demonstrate learning gains and to analyze user opinions about the effectiveness of multidimensional reports to recall learning experiences.

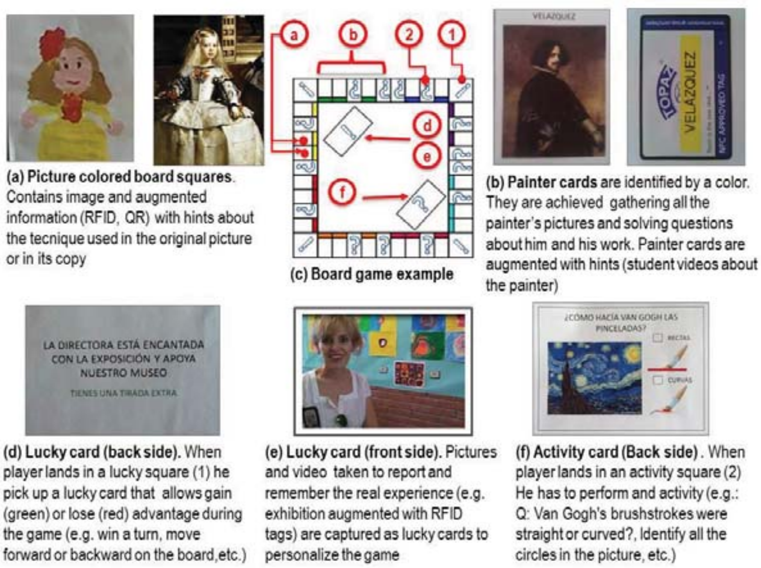

Figure 2. Our Museum. Multisensory learning experience, using hands-on activities and tagged spaces, to learn art. Multidimensional report using board game (c), (a) and game cards: painter-card (b), lucky-card (d) and (e) and activity-card (f)

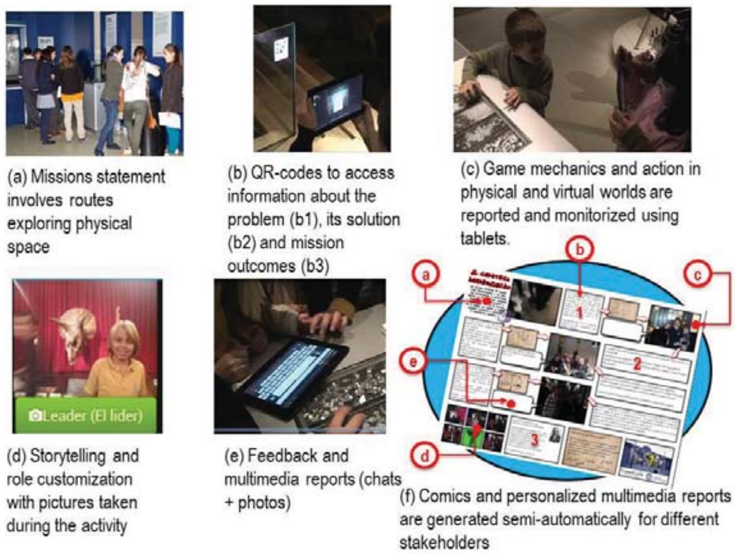

Figure 3. The kidnapped Scientist. Multisensory learning experience using tagged spaces to learn science. Multidimensional report (f) using comics

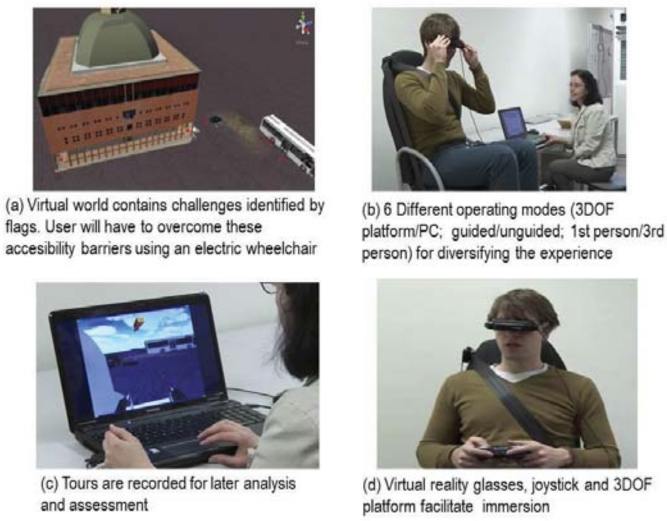

Figure 4. PhyMEL-Wheelchair Simulator. Multisensory learning experiences using hardware simulation to reach social awareness. Multidimensional report using Machimina (c)

3. Conclusions and Future Work

To reach a meaningful learning experience for educational communities it is necessary that all participants involved are clear about the subject to be learn (*what*) its significance (*why*) and how to use the acquired knowledge in their own life (*how*). If we also want the experience to be easily recalled when needed is necessary anchor as strong as possible in our minds involving the five senses and all our intelligences (musical-rhythmic, visual-spatial, verbal, logical, kinesthetic, interpersonal, intrapersonal, naturalistic and existential). To achieve that it's very important to define the context (*who* will participate in the experience, *where* and *when* the experience will took place). PhyMEL addresses all these questions in the methodology to design experiences **Table 1,** and summarize their answer in multidimensional reports **Figure 1, 2, 3** and **4**.The deployment of three different experiences that has involved more than three hundred people allows as to assess that PhyMEL framework is applicable in the real world to deploy meaningful experiences for different target audiences (elementary, primary, secondary school, and adults). The generation of multidimensional learning reports for this experiences has allowed creating three different models: board game (**Figure 2**), comic (**Figure 3**) and machimina (**Figure 4**) that can be used as templates for other experiences. Preliminary results points to the satisfaction of the users that consider these kind of experiences and reports useful, enjoyable and instructive.

Regarding future work several templates are under development: (1) new games, (2) real or fictitious films to document workshops for entrepreneurs and (3) personal roadmaps based on the GTD planning system by D. Allen [18], the BMY approach of Clark and Osterwalder [19] and contextual maps using in PNL coaching. More research is needed to demonstrate the usefulness of multidimensional reports.

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PhyMEL-WS Weelchair Simulator: A Preliminary Study to Increase Awareness about the Problems of Living the City in a Wheelchair

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Abstract. Accessibility barriers for people driving a wheelchair are a societal challenge that has to be faced globally, but the way to deal with this problem is different for different stakeholders (generic citizens, wheelchair users or medical staff). Multiple wheelchair simulators have been developed during the last three decades, but most of them are partially focused to a very specific a target group and have problems to perform quantitative analysis on driving skills. This paper has to aims: (1) Present the PhyMEL-WS simulator as a global approach for all the stakeholders and (2) Present the first stage of the research: an study that analyzes the experience of 23 generic citizens using the PhyMEL-WS Wheelchair Simulator to reach awareness on accessibility problems. The tool consists of an immersive environment comprising a motion platform of 3 degrees of freedom, virtual reality glasses, and a joystick connected to a computer with Unity3D to simulate the experience of driving a wheelchair. Preliminary results show that the simulator is easy to use, realistic, instructive, and enjoyable. All users stated that they have found it useful to become aware of the problems of disability and would like to use it as training before using a real wheelchair. Most users expressed that the experience would gain if it included elements of gamification such as competition or rewards as part of the training. PhyMEL-WS allows recording the experience for quantitative and qualitative further analysis.

Keywords. Accessibility, Simulation, Wheelchair, Virtual Worlds, disability, social awareness, Learning, 3DOF, Unity3D

Introduction

The issue of accessibility barriers in cities for wheelchair's users has been widely discussed in the literature [1]. The increase of the number of people with mobility problems due to the demographical change has made this problem more acute. The European Commission, in the Horizon 2020 [2] identifies several priority challenges related with these issues (Health, Wellbeing and Inclusive Cities). Multiple successful wheelchair simulators have been deployed during the past three decades with different technological support. Simulators have been proved to be an effective learning tool to

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address physical problems (drive a car), and to deal with role play situations that requires mental toughness (conflict resolution) or emotional control (phobias). However there are two main problems that remain unsolved in the literature: (1) most of the wheelchair simulators are partially focused (one specific audience, one set of skills, one disease, one scenario, one assessment method, etc.) and (2) lack of mechanisms to perform quantitative analysis on acquired skills after the simulation.

The aim of this study is two folded: (1) present PhyMEL-WS (Physical Mental and Emotional Learning Wheelchair Simulator) and (2) Show preliminary results obtained in the first stage of the research using the simulator with one of the three target groups of users. PhyMEL-WS is a global approach that deals with the problem of accessibility for three different stakeholders: (1) general public to reach awareness, (2) wheelchair users for training, and (3) medical staff to perform patient's evaluation and support for the prescription. PhyMEL–WS exploits the widely accepted idea that meaningful learning experiences requires involve as many senses as possible. To reach this goal the simulator uses physical (3DOF motion platform), mental (virtual world) and emotional (role playing and gamification) resources and activities in an integrated way called PhyMEL framework. The system provides feedback during the experience and allows recording the route in a machimina for further analysis. The first phase of the research consist of study that analyzes the experience of 23 people of the first target group (general audience) to explore (1) acceptance of simulator's characteristics, (2) user's perceived difficulties facing accessibility barriers and (3) users' prospect about intention of use and gamifiying content.

1. Related work

Several learning domains that uses physical training such as sports [3] [4], dance [5] or medicine (especially in Easter philosophies) [6] have exploited widely the relationship among body, mind and emotion to improve the effectiveness of learning activities. General psychological theories such as Gardners' Multiple Intelligences [7] or Neurolinguistc Programing by Dilts et al. [8] shows that this approach is applicable to generic learning experiences not necessary oriented to the physical domain, but this approach has not been fully exploited. This trend is also observed in the literature about wheelchair simulators [1] where most of the simulators that contains motion platforms [9] are oriented exclusively to physical training of people with disabilities, and those other oriented for generic users to reach awareness about accessibility problems [10] only has the virtual counterpart. According with Gardner and Dilts, we think that physical, mental and emotional dimensions can be integrated to reach a meaningful learning experience. To reach this goal we have used the PhyMEL [11] model that is a framework to facilitate the deployment of meaningful learning experiences and multidimensional reports. This framework connects the student, its contextual environment (physical or virtual), the game elements, and learning domain using the narrative of the storytelling as the main thread to integrate all of them. This framework have been used previously in other experiences with childrens in primary and secondary levels using augmented reality in tagged spaces.

In this paper we present (1) main components of PhyMEL-WS and (2) the preliminary results of a trial with 23 users where we try to take advantage of passive and active physical training to reach awareness in generic users without physical disabilities.

2. PhyMEL Wheelchair Simulator (PhyMEL-WS)

PhyMEL-WS has been designed as a particular implementation of the PhyMEL model. Elements in the simulator have designed to be modular, safe and easy to use. The following sections describe the components of the simulator.

2.1. Hardware and Software elements

The simulator hardware consists of a computer to control de simulation and a set of peripherals illustrated in **Figure 1**. The industry has developed a voluntary standard called ANSI/RESNA WC-19 [12] to grant the security of wheelchairs as motor vehicles. The standard was approved and issued in April 2000 but wheelchair manufacturers are slowly incorporating WC-19 in their product lines. The requisites imposed over wheelchair are lower than those imposed over car seats. In our study we have chosen a real car seat with a three-point seatbelt, to grant safety onboard PhyMEL-WS. The simulator only works when seatbelt is fastened.

The simulator software consist of (1) a set of javascript and C# modules for Unity-3D and (2) a set of dlls that control peripherals (joystick, VR glasses[2]), communication between 3DOF platform and the computer and synchronization between the real and virtual wheelchairs. Software has been developed using Unity3D. This software allows creating (1) a developer's version that requires the installation of Unity 3D engine for its execution and (2) a compiled version for different platforms that does not require the installation of the engine. For this study we have used both developer and compiled version for windows 32. In the next sections we will detail differences between them.

2.2. Interface

User interface consists of two elements: (1) the *configuration panel* and (2) the *navigation support*. The configuration panel allows the user to select the operation modes described in **Section 4.3**. The navigation support is composed of three elements illustrated in **Figure 2**: (1) *Tool tip* that shows messages that help the user to interact with the simulation for example "press the A-button on your joystick to use the bus-lift"; (2) *Moving arrow*. This arrow is oriented automatically based on the user's position and indicates the direction to follow to face the next challenge in the planned route; (3) *Challenge Flags*. Identify the challenge location in the virtual world. Flags change its color to indicate whether the challenge has already been overcome (green) or not (red).

2.3. Operation modes

The simulator supports 6 modes of operation: (1) 3DOF, (2) Computer, (3) Guided, (4) Unguided, (5) 1st person and (6) 3rd person that are presented to the user as three bi-valued options. All of them are available in the compiled version of the software. In addition, the simulator has a seventh mode of operation (7) Monitoring, only available in the developer's version of the software that allows to record the user's route in unguided mode and generate a file that captures the experience. Al recorded routes can be reproduced later in guided mode. The user options are: (1) 3DOF /

[2] Vuzix iwear VR920 (http://www.vuzix.com/consumer/products_vr920.html)

Computer .These modes allow to uncouple part of the hardware (3DOF, Joystick and VR glasses) when not needed for training or for lowering the cost of the final product. This allows the user to be trained first mentally using only the software version (computer) and then physically using the hw-sw version (3DOF-motion platform). (2) Guided / Unguided. These modes allow the user to experience the autonomous movement of the wheelchair without his intervention (guided), or to control the wheelchairs' movements by himself using a joystick (unguided). (3) 1st / 3rd person. These modes have been oriented to different target audiences. 3rd person is recommended for trainers in conjunction with the computer mode. This configuration allows trainer monitoring trainee performance as an observer with a wider perspective Figure 3 (b). 1st person mode is recommended for trainees to experience the sensations in 1st person gaining a better immersion.

Figure 1. PhyMEL-WS hardware

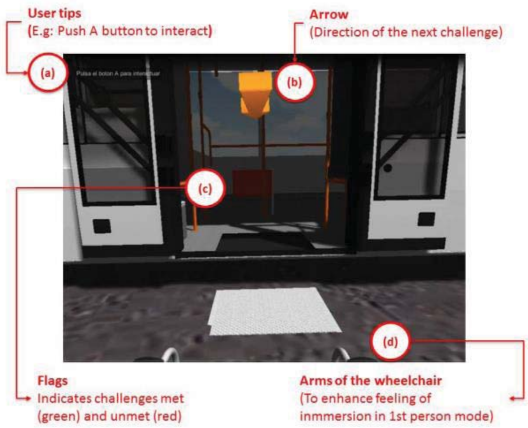

Figure 2. PhyMEL-WS Interface in 1st person mode

3. Study Design

The research about PhyMEL-WS has been planned in three stages with different objectives: *Trial 1: Generic audience*. This trial is oriented to people without disabilities to raise awareness of the difficulties that a person driving a wheelchair has to face daily. *Trial 2: Wheelchair users*. The objective of this trial is to train people with disabilities to improve the safety, reliability and driving skills of the user before or during their experience with real wheelchairs. *Trial 3: Medical staff*. The objective is to serve doctors, nurses, physiotherapists and psychotherapists as support tool for prescription and assessment of patients' performance using a wheelchair. The simulator allows evaluating the user capacities and determining the most appropriated wheelchair to his handicap and navigation environment. This paper focus on the first phase (Generic Audience) and this article presents the preliminary results collected during trial 1

3.1. Participants

The experience was deployed with 23 adults voluntaries among people who participated in the IV eMadrid Workshop[3] and those who visited the Gradient group[4] during the months of June and July of 2011. Information about participants is summarized in **Table 1**

Table 1. Users' characteristics

Characteristics	Frequency (n=23)	Percentage (%)
Age (years)		
0-20	1	4
21-30	8	35
31-40	8	35
41-50	5	22
>50	1	4
Gender		
Male	16	70
female	7	30
Previous mobility problems		
None	10	43
Wheelchair	1	4
Walker/crutches	6	26
Baby Stroller	3	13
Other	0	0
DK/NA	3	13
Tour mode		
Guided	14	61
Both (guided-unguided)	8	35

[3] http://www.emadridnet.org/en/iv-emadrid-workshop-on-e-learning
[4] http://gradient.it.uc3m.es/

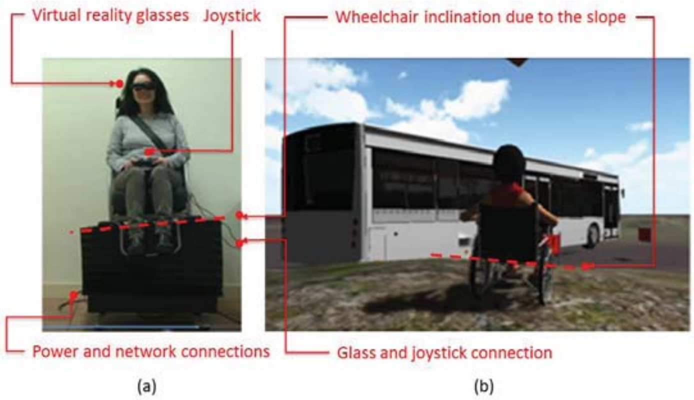

Figure 3. PhyMEL-WS. (a) Real image. (b) Virtual image in 3rd person mode

3.2. Methodology

The trial consisted of a tour in the virtual world to overcome some of the main challenges that a person driving a wheelchair has to face daily. Some of them are illustrated in **Figure 7** and **Figure 8**.

Table 2. Data gathering techniques

Data Source	Type of Data	Label
User survey	Questionnaire with 20 closed + 1 open question + demographic and contact data	[UserSurveys]
User interviews	Interviews to representative users	[UserInterviews]
Field observations	Transcription of notes taken by observers	[FieldNotes]
Multimedia recording	Picture and videos recorded during the experience	[MMRecordings]

During the experience all participants (n=23) used the guided mode and some of them (n=8) were also offered the opportunity to do the unguided tour as showed in **Table 1**. The guided tour takes 2-3 minutes per user and unguided tour takes different duration depending on user skills. The virtual world partially reproduces an outside view of Universidad Carlos III de Madrid (e.g.: buildings, corridors, ramps and curbs), adding some difficulties belonging to the immediate environment such as wheelchair lift and bus, and emphasizing some obstacles such as the narrowness of corridors or the height of the curbs and ground irregularities in some areas. Data gathering techniques has been summarized in **Table 2**. The procedure to gather data was as follows: The user sat on PhyMEL-WS, after fasten his seatbelt, put on the VR glasses and hold the joystick, started the simulation. During the experience an observer took field notes [FieldNotes] to document the situation. When the tour was finished all participants completed a survey [UserSurveys] with their impressions using the simulator. In the case of some participants especially representatives, field notes were completed with multimedia recordings [MMRecordings] and a brief interview [UserInterviews]. The students that performed routes in both modes (guided/unguided) answer the survey only for the guided tour and provided information about the unguided tour in the final open question of the survey and during interviews.

4. Results

The results presented in this section are obtained mainly from the analysis of surveys. Qualitative data has been used to clarify some findings obtained using [UserSurveys] but more detailed and systematic analysis using qualitative data sources is required to complete this study.

4.1. PhyMEL's-WS Characteristics and Intention to Use

All users manifest on average very positive opinion about the simulator characteristics. **Figure 4**. The mean values in a Likert's scale of 5 points (1-nothing, 5-very much) was: easy to use (4.09), realistic (4.45), funny (4.26), instructive (4.39) and helpful for awareness (4,35). Results show also good perspectives about intention to use the simulator as a training tool before using a wheelchair (4.13).

Detailed results attending the operation mode and previous mobility problems are illustrated in **Figure 4**. There is a clear difference in the assessment of the ease of use among participants who took only the guided tour and those that made both (a). The second group perceives the guided route easier than the first one. This is due to the difficulty inherent in each operating mode. The first mode (guided) focuses on the physical perception and the second one (unguided) is more difficult because requires also certain skills for driving. People who have been faced with disabilities in the real world (b) perceive these barriers easier to overcome than those who faced them for the first time using the simulator. Although the difference is not significant from a statistical point of view, qualitative information [UserInterviews] confirms this finding. All users regardless of their profile and the operating mode rate system realism equally. Participants who have used both operation modes and those who have no previous mobility problems consider the experience slightly more fun, instructive and helpful than the rest. They have also more intention to use the simulator for training in the future. This fact can be explained in the first case because of their greater involvement in the experience and in the second one because the challenges faced are new for them. Data collected during trial 1 are not enough to validate this hypothesis and it is necessary to contrast this information with a larger number of users.

4.2. Users' perceived difficulties facing accessibility barriers

User's perceived difficulties are quite high for all the obstacles. The mean scores descending order were: Stairs (4,20), Maneuver in tight spaces, e.g. inside the bus (4,05), curbs (3.90), bad parked cars (3,85), narrow corridors (3,71), closed curves (3,52), get on the bus (3,50), slopes and ground's irregularities (3,35) and finally wheelchair lifts for stairs (2,89).

The general trend **Figure 5** is that users who have not faced obstacles before in the real world (never had mobility problems) or in the virtual world (only use the guided mode) perceive the challenges harder that they are. This statement has been contrasted with qualitative data collected through the experience ([FieldNotes], [UserInterviews]). This trend is reversed only in two cases (1) wheelchair lifts illustrated in **Figure 7** (c) and (d) and (2) narrow corridors **Figure 7** (a) (b) for those participants using the unguided mode **Figure 5** (a). The first case (wheelchair lifts) is because a user with mobility problems would find it harder to reach the center of the platform, and when the lift does not have additional safety measures, the user can fall during the ascent or descent. Participants who have not used these devices before consider them completely safe. This point has been confirmed by the qualitative data. Furthermore direct observation and recordings [MMRecordings] shows how these errors can be experienced in a safe way using PhyMEL-WS simulator. The impact of the fall is minimized by the simulator and the seatbelt ensures user safety during the process.

Direct observations gathered in [FieldNotes] and [MMRecordings] has shown that the second case (narrow corridors for users in unguided mode) is due to the fact the challenge has two parts. The corridor is bounded on one side by a wall but is limited in the other by columns. This challenge has two parts the difficulty to maneuver and the driving skills needed to avoid falls. The corridor is bounded on one side by a wall but is limited by the other columns **Figure 7** (a) (b). When the user maneuvered back he could pass through the gap between two columns and fall or get stuck depending on the height of the curb in that area. The PhyMEL-WS has shown to be useful and safe to reduce user anxiety in training situations with physical risk (e.g. falls). It would be useful to create two new situations to train these two obstacles separately before training both simultaneously.

4.3. Prospects about gamifiying content

All users surveyed expressed their interest in gamify training (average score 4.13 in a Likert scale of 5 points). They are also interested to introduce game elements such as competition (3.83), rewards (3.39) and feedback about their performance (4.04). In this case the qualitative data provide no light on the small differences found. In this case we believe that a study with more users neither will bring more information in this point since interest in gamifiying techniques does not seem to be necessarily related to mobility problems.

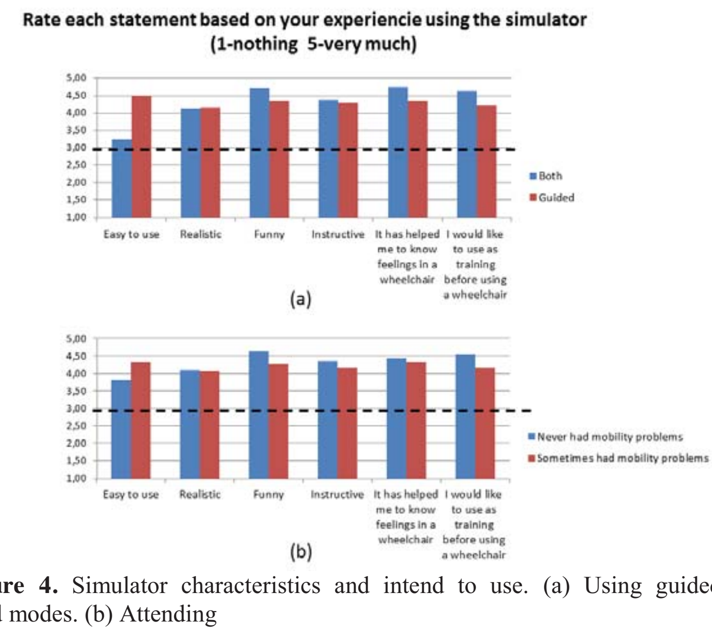

Figure 4. Simulator characteristics and intend to use. (a) Using guided and unguided modes. (b) Attending

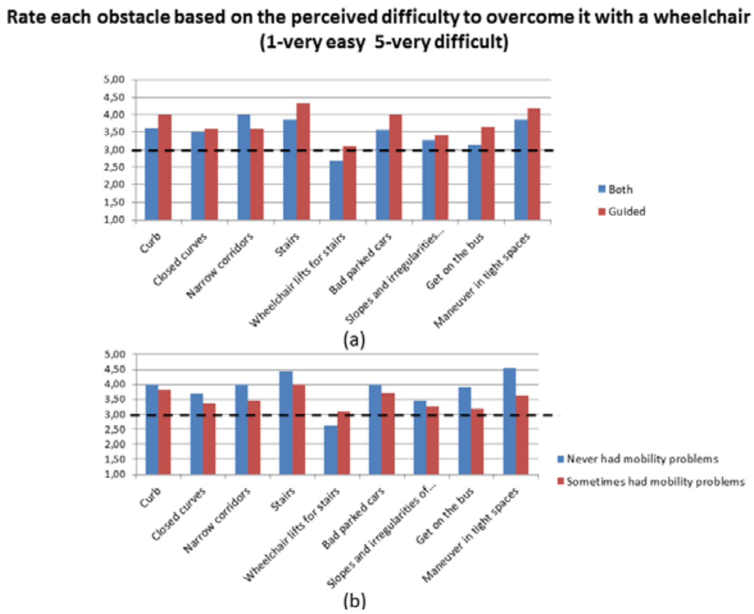

Figure 5 . Difficulty of accessibility barriers. (a) Using guided and unguided modes. (b) Attending previous mobility problems. Grading has been done using a likert scale of 5 points (1-very easy, 5-very difficult)

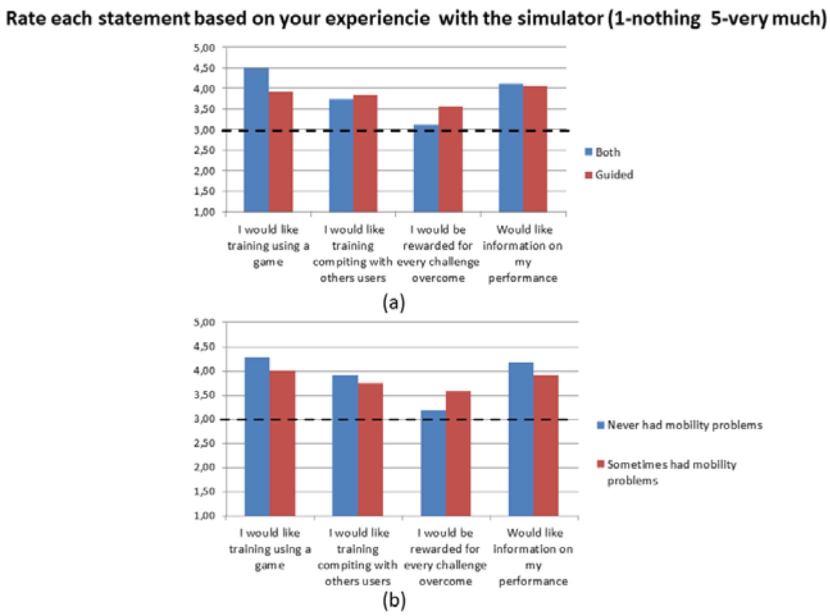

Figure 6. Prospect about gamifiying content. (a) Using guided and unguided modes. (b) Attending previous mobility problems. Grading has been done using a likert scale of 5 points (1-nothing, 5-very much)

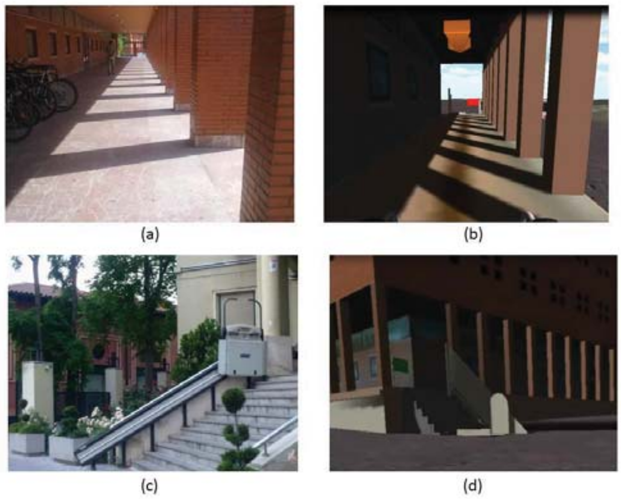

Figure 7. Accessibility barriers. (a) Real corridor, (b) virtual corridor, (c) real wheelchair lift, (d) virtual wheelchair lift

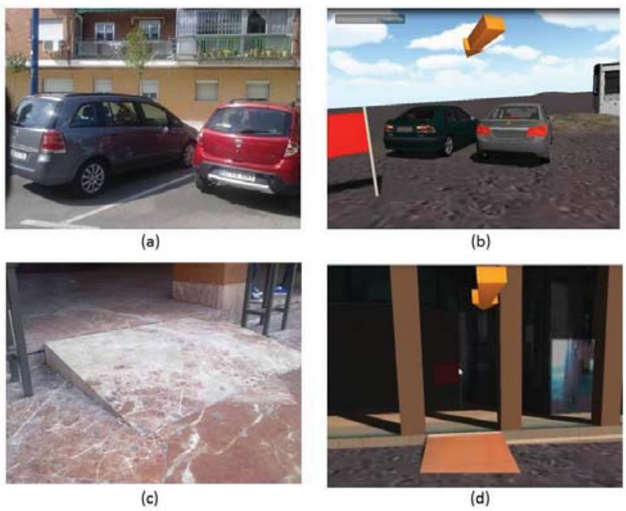

Figure 8. . Accessibility barriers. (a) Real parked cars, (b) virtual parked cars, (c) real curb and ramp (d) virtual curb and ramp

5. Conclusions and future work

Dealing with accessibility barriers is a societal problem that has to be faced globally. In the other hands, objective to reach are different for different target groups. PhyMEL-WS allows demonstrating that it is possible to create an integrated solution rigid enough to be presented as a global solution and flexible enough to be adapted to different stakeholders. This study is part of a wider research that schedule three trials with different target groups: (1) general audience to reach awareness, (2) wheelchair users for training and (3) medical staff to assess patients. This paper summarized results obtained during the first trial. The main findings of this study are: (1) Users consider the simulator easy to use, realistic, funny, instructive and helpful for awareness, all this characteristics was evaluated over 4 in a Likert's scale of 5 points, (2) Users perceive that accessibility barriers are in general harder to overcome. The most difficult barriers in descending order are: stairs, maneuver inside the bus, curbs, bad parked cars, narrow corridors, closed curves, get on the bus, slopes and ground's irregularities and finally wheelchair lifts. (3) Regarding future prospective users express their interest in using the simulation for training and in gamifiying the experience (4.13 over 15) in both cases. Secondary findings attending user profiles and operation modes requires more in depth analysis of qualitative data and in some cases a greater number of user to confirm hypothesis. The simulator is flexible enough to provide different experiences to satisfy the need of different stakeholders. This aim is reached using six modes of operation included in the user interface (3DOF / computer), (guided / unguided), (1st and 3rd person). The recording of the experience (7th mode – monitoring, available only in developer mode) is a first step in the generation of quantitative information to be analyzed after the experience, but more research is required at this point. This is an advantage over the real-world training because makes it possible to take quantitative information (time, position, velocity or acceleration) to overcome each obstacle or to facilitate diagnosis if a system or driving error occurs.

All the elements in PhyMEL-WS have been introduced to fix real problems for example: (1) Preliminary qualitative analysis shows that errors in driving can be experienced in a safe way. The user interface provides also a "panic button" that allows user exiting from conflictive situations (falls, getting stuck.). (2) the compact design of the simulator allows recreating large environments (e.g. a city, or a building), in confined spaces (schools, colleges, hospitals) and including expensive elements such as a bus or a wheelchair lift that are common in real life but would be difficult to get and deploy in a physical training circuits. (3) The seventh operation mode (monitoring) allows decoupling physical and visual sensations. Physical sensations are experimented through the 3DOF platform and visual sensation with VR glasses or PC. This functionality allows for example shortening rehabilitation times because the user can we trained mentally first (with only visual information) and physically later. Therefore he has not to wait for full physical recovery to begin the mental training with the wheelchair. (4) The security measures allow the user facing more dangerous problems such as attacking a hill or facing a fall. The simulator have been developed modularly to be able to create different training program such as intensive training for different versions of the same obstacle or extensive training that combines different types of obstacles in the same training program. Regarding the future work, authors are working in hardware elements such as the integration of a IR head tracker to uncouple the movement of the user and the wheelchair, and in a new version of the platform with the joystick integrated in the arm of the chair. Next steps in the research will be (1)

Conduct trials for the other two stakeholders (wheelchair users and medical staff). (2) Perform a study using pretest and post-test to demonstrate learning gains. (3) Integrate the 7th mode (recording) in the compiled version of the simulator and analyze its usefulness for quantitative and qualitative user's assessment. All these evidences allow us to assess that PhyMEL-WS is a successful implementation of the PhyMEL framework and an effective tool to increase social awareness of general public about the problems of living the city in a wheelchair.

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The Dream Machine

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Abstract. This Science-Fiction Prototype ruminates on a post-singularity world, where transhumanism practices are in widespread use. In particular, the discussion focuses on a form of transhumanism that involves reengineering the brain, and associated reality experiences, as part of an educational process. The SFP links dreams and imagination into learning, by seeing them as a type of '*natural immersive education system*'; a "Dream Machine". The paper uses two short SFPs to explore some consequences of transhumanism for immersive education ideas (the focus of the host conference). The article concludes by postulating that we may, perhaps unwittingly, already be on a path to such a future with the advent of technologies like augmented reality glasses and wonders where we might draw a line that we shouldn't cross.

Keywords. Science fiction prototyping, futurology, singularity, transhumanism, virtual reality.

"*Inside this room, all of my dreams become realities, and some of my realities become dreams*" - Willy Wonka in Roald Dahl's story of 'Charlie and the Chocolate Factory').

Background

1.1. The Storyline Inspiration

This Science Fiction Prototype (SFP) was inspired by an incident in my childhood, when I was around 8 years old. I was the son of Irish immigrants and each summer, for our holidays, we returned "home" to the farm in Ireland where my mother was born. Those were amazing days, full of adventures on an old fashioned self-supporting farm that produced wheat, hay, vegetables, eggs, milk and meat. In those days horses powered the crop cultivation tools and water was fetched by hand from a nearby well. While the farm was a source of food and income to my family, to me it was akin to an exotic amusement park, a treasure trove of exciting adventures ranging from playing boats on streams, through trampolining on hay, to tending animals such as ducks, hens, pigs, cows, horses dogs and cats that roamed freely around the land. What made the experience even more exciting was the journey between England and Ireland which involved a long multi-stage steam train journey, broken by an overnight boat trip across the Irish Sea. The soundtrack of the journey was orchestrated by a choir of randomly conversing travellers accompanied by a strong percussion section made up of a puffing engine and the rhythmic noise of the train wheels crossing track joints. All in all, it was a powerful emotional and educational journey that became a life changing annual pilgrimage that I longed to experience each year, and now lives on inside me long after

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the main players made their final journey from our mortal world. So strong was my longing to return to that idyllic farm that it led to an experience that has inspired this SFP.

1.2. Days of Future Passed

One of my holidays was especially happy, the sun was shining and I was having lots of fun playing with a mountain of sand that was part of a small building project on the farm. My favourite collie dog (Chep) was sitting near me and my grandmother was going about her work in the distance; life on my farm holiday was, as always, good. However, little did I know that this idyllic world was about to be shattered in the most extraordinary way, by something equivalent to a Richter scale-9 tremor that shook my world with so much force that I ……… *woke up*! The world I awoke in was one of total misery, as towering above me was my mother, shaking me, and saying "*wake up, wake up, you need to get dressed for school, or you will be late!*" (school was not my favourite place in those days!). To this day I vividly remember that moment and the shock of being, in an instant, transported form my idyllic holiday setting, on the west coast of Ireland, back to the reality of my non-holiday school life, in southern England!

1.3. Home Thoughts From Abroad

Finding I was not on holiday was a massive disappointment but the much bigger and more long lasting legacy was the realization that dreams and real life can be indistinguishable and, worse, it's never possible to be sure you are awake and not in your own, or even someone else's dream! That thought, and the nature of reality, has haunted me ever since. Perhaps you have had such an experience, if you have then you will probably be able to relate to the motivation driving this SFP; if you haven't, don't feel you have missed anything of value as I'm sure it's more comfortable to be able to accept your physical existence rather than to always question it! Apart from this incident, as a young boy I always looked forward to going to bed, so that I could dream interesting stories. Many were fantasies, which I would dream in a serialised fashion, picking up one night where the previous night left off. Some involved inventions of wonderful futuristic devices, wrapped up in an imaginative scenario, in which I had centre stage. Perhaps I dreamt this way because we had no TV back then, rather just books, the glowing lights of valve radios with their faltering signals and a lot of imagination. In this respect, my dreams were a type of deliberate simulation, or virtual role-play where I was able to explore potential real life scenarios. I guess that's not how it works for everyone, but that was how it worked for me, and how I link dreams and imagination into learning, by seeing them as a type of '*natural immersive education system*'. Undoubtedly computer science is the perfect vehicle to peruse such interests as, on the one hand, it provides the means to create virtual worlds, and, on the other hand, it provides an opportunity to investigate natural intelligence and consciousness as it strives to emulate the capabilities of the human brain, an issue picked up in the following section. With hindsight, maybe those experiences were the recipe for what was to become my interest in Creative Science and, of course, the general theme of the tales that follow!

2. The Singularity and Transhumanism

Almost since the beginning of time, people must have wondered about the nature of our reality. We can imagine that our ancient forefathers might have stared up at the night sky and wondered what those twinkling lights were, where they were, what greater realities existed beyond their perception and whether there was anything special about us and our place in the cosmos. Although science has gone some way to answering a few of those questions, there are still many more which challenge us. Above us is the seeming infinity of physical space and within us are the mysteries of our own consciousness and existence. One of the most basic of these challenges is whether physical matter actually exists or whether we are part of some other reality. As odd as that question may appear, it is a question that has been asked by people for almost as long as recorded history exists being traced back to great philosophers such as Plato (~423-347 BC, Greece), Descartes (1596-1650, France), Berkeley (1685-1753, Ireland) or more modern philosophers such as Russell (1872-1970, UK). Many of these philosophers have pondered if we were, in fact, just part of someone else's dream. For example, Bishop Berkley's idealism (or "immaterialism") argued the hypothesis that we are all simply the imaginings in the mind of a greater being, God. More recently this argument has been extended to questions as to whether we might all be part of a simulation on some powerful future super computer (perhaps, our lives being authored by some newly graduated computer scientist in a future world, as depicted in the movie "*The Thirteenth Floor*" – see appendix)!). Readers that are interested in a more rigorous or academic insights to these propositions are pointed to Nick Bostrom's recent paper that sets out the issues eloquently [1]. From the perspective of this SFP our interest lies in the brain's ability to assemble knowledge (memory), create sophisticated abstractions (models) and run reasoning processes (simulations) so as to function effectively in the real physical world (eg imagination, ideas, innovation, dreams and foresight etc). The SFP links dreams and imagination into learning, by seeing them as a type of '*natural immersive education system*'; a "Dream Machine".

Beyond philosophy, the functioning of the brain is, of course an important area of study for artificial intelligence, which seeks to emulate or exceed its capabilities. Whether that will ever be possible is a somewhat contentious issue, but one group that believes fervently that this is possible, is the singularity movement. One of the principal advocates for the singularity is Ray Kurzweil who rather provocatively identified a date of around 2050 as when artificial intelligence will exceed that of human intelligence (the so-called technological singularity) [2]. In pragmatic terms, the consequence of such a singularity occurring would be profound, but are debated elsewhere [3] [4]. As mentioned above, one of the possible applications for such a super intelligence might be to generate soft or hard replicas of people, to enable them to live on beyond the natural biological end of their lives, thereby bringing humanity closer to finding the fabled elixir of life (elixir of immortality) that could stave off aging and death. Another possibility, and one that will be picked up in the SFPs in this article, is the potential for advanced technologies to augment our organs so as to radically enhance people's intellectual, physical, and psychological capacities; a movement labelled 'transhumanism' which manifests itself in various forms, such as the Cyborgs and Androids described in popular science fiction. The following SFPs will explore aspects of 'transhumaism' related to education, motivated by the fact that the human brain is the seat of knowledge, skill and learning. Of course brains are complex entities and remain somewhat of a black box to current science with many mysteries, not the least being the nature and reason for dreaming. While many theories exist, no single consensus has emerged [5]. Perhaps that is hardly surprising since science remains unclear about exact purpose and function of sleep itself! Despite that, the SFPs presented here operate in that mysterious time zone, while people sleep, experiencing dream-like visual and memory effects.

3. Two Short SFPs – The Dream Machines

These two short SFPs are set in the post-singularity period and address facets of transhumanism. In many respects, they are extensions of ideas for wearable technology, such as augmented reality glasses. Mostly they were inspired by various statistics of the working of the human brain and its critical role in making us what we are. First there is the sheer scale of the human brain with almost 10^{11} neurons, each connected to up to 10^{4} other neurons. Second the finding that human brain finishes building most neurons before birth (apart from some small neurogenesis continuing, mainly in the hippocampus, a region involved in learning and memory) growing in size thereafter only by continuing to weave its complex web of connections, being regarded as fully developed by around 25 years (but mostly complete by age 7). Estimates for the memory capacity of a human brain range from 1 to 1,000 terabytes (10 terabytes of data can store almost 20 million books). Apart from structure, many of the mechanisms at work in the brain remain defiantly mysterious, such as the purpose of dreaming which, given its prominence in our lives, seems baffling that we know so little about it. Of course these descriptions are gross simplifications (and a little contentious), as the wealth of published models and theories on the brain are testament to, so this SFP doesn't set out to provide a scientific treatise, but rather to use this topic as a fascinating backdrop to our SFPs. In connection with these ideas the first SFP explores the idea for injecting artificial nanobots into the body, to alter a person's knowledge and skills (creating in-body immersive experiences) by making direct adjustments (a processes somewhat akin to sculpturing) to the brain, bypassing the usual learning routes. The following SFP builds on these concepts.

3.1. The Education Pill (aka Sculpturing Memory)

Prologue: This story occurs during the post technological singularity period (after 2050). At this time the development of intelligent machines had taken two different directions; those that believed the future lay with developing intelligent robots to service the needs of people, and those that feared the development of such robots and preferred to use technology to enhance the capabilities of natural people. The world was almost equally split between supporters of each, with sizable sections of the community enjoying the services of their new age slaves, while others treasured and trusted only natural biological people. Of particular importance to this story was a small group of scientists in Mexico (part of a company called '*Addictive Technology*') who were working on ways to harness the services of technology to help people compete against their artificial counterparts. Their priority had become to provide people with the required mental ability and skills to match the increasingly intelligent androids and cyborgs. To these ends they had devised an innovative technology, called the "*education pill*" (*ePill*) that could, overnight, give people new knowledge and skills.

In other words, training and re-training had become a simple overnight process during sleep. The pill contained a swarm of nanobots that entered the blood stream, reaching the brain where they rewired and reprogramed it to emulate the skills and knowledge required. All the pills were identical, they simply needed to be reprogrammed before swallowing to adjust the brain appropriately; the tool that did this programming was called *The Dream Machine* made by *Addictive Technolog*y. *Additive Technology* had sold one of their '*Dream Machines*' to '*Jobs+*', one of the growing number of 'learning free' training and education organisations! However, they were an education company with a twist, they were actually a jobs agency, and were using the *ePills* and '*Dream Machine'* to provide a "*skills on demand job service*".

A day in the life of Tom ….
Another day started with the faint hiss of a 'conveyancer' as it glided up to Tom's apartment door. The sound was caused by the atomic imbalance drives that provided levitation and lateral motion. Wheels and even thrust drives had been consigned to the garbage bin of history since the discovery of mechanisms to unbalance the motion of sub-atomic particles (eg the orbit of electrons) so as to cause net motion (someone likened it to an 'out of balance' washing machine vibrating across a floor, others muttered things about gyroscopes!). Anyway Tom always enjoyed his ride on the 'conveyancer' to and from work, as he felt he was riding on a magic carpet from 'Tales of the Arabian Nights', a cherished book from his childhood. The gleaming body of the 'conveyancer' contrasted starkly with the gloomy surroundings of the run-down down neighbourhood where *Jobs+* had its offices and where he worked on the front desk finding jobs for needy people. This side of town was made up from a mix of people, some who had taken a principled stand against the rising tide of super-intelligent robots, and others who were just disenfranchised from society by poverty or ignorance.

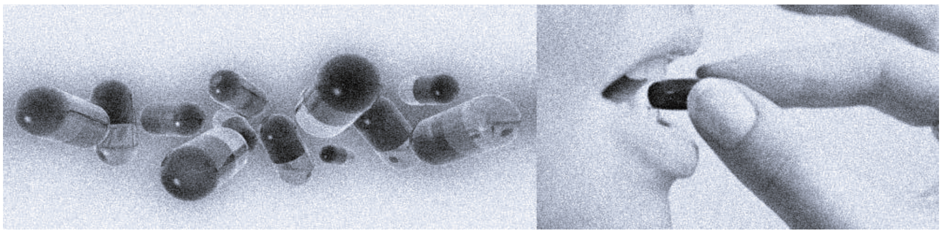

Figure 1 - Addictive Technologies ePills

More than a college …
Jobs+ was a new breed of agency; part education establishment, part job shop. It was one of the innovative business that was built on the range of super-intelligent robots in the post singularity world; but with a difference, they were nano-sized (of the order, one thousandth of a millionth of a metre – very, very small!) and highly dexterous opening up numerous new possibilities. To-date these nanobots had been used mainly for non-invasive surgery and correcting some minor mental problems. In this case, the visionary founder of *Addictive Technology*, Aura, a neural scientist from Guanajuato, had been experimenting with a new type of super-nanobot to correct a wide range of brain disorders. However, her early clinical trials with new bots indicated they could do some amazing things; potentially altering aspects of the brain that determined people's aptitudes, skills and even knowledge. Of course, in the pre-singularity world none of

this would have been possible but thanks to the super-intelligence available in the post singularity, which supported both design and operational activities (including intelligent swarm management), she was able to create a revolutionary product. All that was pretty clever but her eureka moment, was equating physically altering the brain (crudely put, rewiring and reweighting connections) to learning, allowed her to offer a new type of '*learning free education*'. In natural learning, connections and weights are changed over long periods by repetitive and often tedious training cycles, but, in this new nanobot driven learning, the lengthy and tedious cycles of acquiring new knowledge and skills was simplified to swallowing a capsule (*ePill)* containing millions of nanobots which, while the student was sleeping, compressed a year's learning into a single night! Of course, these were smart capsules whose nanaobots were programmed to activate and die at precise times, and do very precise jobs. This was important as people had to be asleep when this brain transformations were underway (the capsule also released a sleeping drug to subdue the 'learner'). The next step was just simple business acumen, linking education with jobs; so if a job came along, you just found any person who wanted a job, and reprogrammed their brain. After that, it was over to companies such as *Jobs+* to revolutionise the job and education market!

A day in the life of Lizzi …..

Lizzi was a gorgeous woman who never went unnoticed and the day she arrived in the *Jobs+* office with her large Alsatian dog (Remy) was no exception. Tom fell instantly in love with her, although he couldn't say the same about her large Alsatian! Unfortunately, for Tom, Lizzi was oblivious to his loving gaze as she simply enquired about the vacancy for a 'head chief' for the upmarket chain of "*Cooked by People*" restaurants. Of course using the new breed of intelligent kitchens and robots was cheaper than using people to cook food, but there was still a demand and even some snobbishness about people-based services, even though it was not cheap in this highly automated age. Lizzi had no cooking knowledge or skills but for *Jobs+* that was not a problem. Cooking skills was a standard library pack that could be quickly loaded into an *ePill* using their *Addictive Technology Dream Machine*.

All is fair in love and …..

For a moment Tom looked at Lizzi and wondered, "*what if …. what if …. I added an extra program into the ePill that made Lizzi ... like, ... maybe even love me*"? The thought turned quickly to an action, perhaps a moment of inspiration, or possibly a moment of madness! "*Ok Lizzi, its simple, just swallow this pill tonight before you go to sleep and call back to this office tomorrow morning at 9am so we can do a final check that all is well …. you might experience some dreams, mostly about cooking, but they will all be pleasant"*. As Lizzi left, he couldn't help thinking "*and of course, you will be dreaming of me, which will be extremely pleasant!*".

Eye contact ….

Tom could barely sleep, waiting for the moment his dream girl would melt into his arms. Shortly before 9am a rather large dog, followed by its beautiful owner, appeared through the door of his office and he knew instantly that his dreams were set to come true. Eye contact was made and, in the blink of an eye, he was pressed to the ground with big wet warm lips pressing against his face …….. followed by a wet cold nose ….. accompanied by a voice yelling "*Remy Remy, what is wrong with you, leave that* *man alone*" …. "*I'm really sorry I have no idea what's wrong with Remy today but I wanted to tell you that we had a bit of an accident last night, before I had a chance to take the capsule you gave me, Remy gobbled it up*" . ……

Postscript: In terms of immersive education, this sleep-based reengineering process had supposedly generated a type of in-body immersion via pseudo dreams and memories. The SFP was intended to be a light-hearted tale, if somewhat unlikely scenario for transhuminism. However, in telling this tale, it highlights some generic risks with new technologies, and especially those related to the singularity; they have the power for good and bad. In this story the intentions were simply motivated by love but, of course, human weaknesses such as lust, greed and control could have prompted much darker scenarios, but those are left for another SFP! This contrasts to the following SFP which will look at augmenting the brain with artificial external co-processors, co-memory and co-communications, enabling uploading of knowledge and skills.

3.2. Plug & Learn (aka Painting Memory)

Prologue: This SFP takes the form of a fictional dialogue between the Vice-Chancellor (VC) of a brand new (and somewhat controversial) type of University and a pack of reporters, shortly after its opening. As with the earlier tale, this SFP is situated in a post-singularity period where technology can replace or augment human organs in order to supplement a person's ability or prolong their life; transhumanism. The SFP concerns the possibilities for augmenting the brain with extra processing, memory and communication power (brain augmentation). It supposes that if such fictional technologies came to pass they could have a direct impact on the nature of education as they would open up the possibility of providing people with new skills and knowledge without the usual learning procedures; rather by uploading knowledge or programs directly to the brain-augmented co-memory and co-processors. The supposition is this provides a type of deep immersion, where an altered reality is generated from within the mind (akin to painting memory). This story debates some of these issues by imagining that a transhumanist university was created where students attended to have new information and skills added and tested. Uploading information and programs to the students augmented memories was seen as a potentially dangerous process that needed to be undertaken in a controlled environment with the students sedated (or asleep). The favourite method (and employed by this University) was to do the uploading overnight as the 'students' slept, which frequently resulted in spurious images fleeting through the recipients minds, so-called '*electric dream*s'. Because the process was a little dangerous and uncertain in its effectiveness, it needed to be carefully managed, checked and certified (the new degrees!). The scenario has similarities to the previous SFP, in that is a post singularity application of transhumanism, but it's critically different in that the learning is stored on artificial brain add-ons, rather than using the original biological structure, as in the first SFP (and of course, the programming processes are entirely different more akin to painting than sculpturing). This SFP takes the form of written notes from a press conference that followed the graduation of the first batch of students.

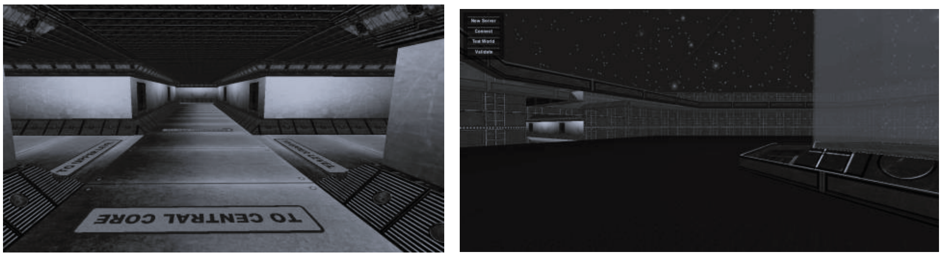

Figure 2 – HEX University (converted "New Lebanon Spacestation)

- REPORTER: *How many students did you graduate today*?
- VC: *38,304, with various skills.*
- REPORTER: *How long did they study with you*?
- VC: *On average, they were with us for 5 nights.*
- REPORTER: *It's interesting you say "on average"; we heard from some of your graduates there were problems and some students took much longer, is that true and, if so, why*?
- VC: *No, there were no problems but it is true that some students need more programming than others. That is because a graduate's ability comes from a combination of their natural biological brain (its abilities and experiences) and the augmented brain, so we have to personalise our augmentation programme to ensure the holistic brain meets the education targets which may require additional uploads*.
- REPORTER: *How can the public (and indeed the students being 'treated', if you will forgive that euphemism) be assured that this programming process delivers graduates that are fit for purpose; after all, you are claiming that with just 5 nights programming they are fit, for example, to fly an advanced star-fighter or design atomic imbalance drives! Literally, our lives may be in the hands of some of your graduates, so how can you assure us they are competent and safe*?
- VC: *Actually, it's just 2 nights programming, max! The remaining 3 days (and nights) are for validation and certification. During that time we perform the Zamudio stability check which has two aspects; one a mathematical proof (the processes we program into our students are deterministic) and an immersive reality consistency check; you may have heard of that, as it's called an 'induced lucid dreams' test – one reason it's been dubbed the 'dream machine'*.
- REPORTER: *There have been reports that these so-called dreams are more like the chemical (drug) induced hallucinations of the 1960's and that this dream machine is rather more about legalising drug-like experiences for the idle rich, than its about education; what are these psychedelic dreams students report*?
- VC: *Those so-called psychedelic dreams (by the way, we prefer the term 'electric dreams') are spurious images caused by the side effects of chaotic interactions between the data and programs being uploaded and installed. As you know the students are sedated during this process but the mind is complex and these dream-like experiences are not uncommon, nor unpleasant (as our*

students will no doubt tell you!) but are definitely not the reason people attend our University; this organisation is strictly focused on education!

- REPORTER: *Finally, VC, why was did you chose to build the University on a spacestation, a defunct spacestation, and why is it called "The HEX"*?
- VC: *Aaaagh, at last a question that is dear to my heart; the defunct space station (originally called the New Lebanon) was cheap, very cheap! Also, you might recall from the best-selling book by Brian David Johnson, "21st Century Robot", that the New Lebanon was built as one of the most advanced Intelligent Environments of our time, perhaps a little too advanced, as the AI went out of control (but that is another story, Brian Johnson's story!) but it gave us a high-tech infrastructure (minus the mischievous embedded agents!), and the solace of a silent space based University were perfect for sleeping …. Perfect for creating the ultimate "Dream Machine" !*
- REPORTER: *you didn't say why it was called 'The HEX*'
- VC: *That's right, I didn't, that one is for you boys and girls to figure out!*

Postscript: The idea for brain augmentation is a popular concept in transhumanism which, when coupled with ideas of modularisation and co-processors taken from computing and electronics, raise intriguing possibilities. In many respects, the current wearable computing market, such as augmented reality glasses, are the forerunners of such technologies which, of course, have also been touched on by other SFPs [6]. This short dialogue can't hope to expose or answer some of the deeper issues such as how the technology might be implemented or what important qualities would be lost when brains contain more silicon than biology; these questions are easier to ask than to answer as they raise deep issues about the nature of our own existence. However, hopefully this dialogue might at least provoke some thought about the sort of future we might build (or not!).

4. Background Research

The research that inspired this SFP comes from ideas cultivated in research published in over 300 papers by the author on intelligent environments (see http://victor.callaghan.info) that span a range from future educational environments [7] [8] to simulating real people [9]. Of course the transhumanim theme of these SFPs goes much further than the basic science and engineering from those papers, stretching it into an imaginative world to provoke discussion about directions of new AI technologies and the effects they might have on education. It drills down into interests that the author has developed concerning the potential for a technological singularity [4]. In particular the two short SFPs presented above were inspired by real research. First, the tale of the "*Educational Pill (ePill)*", which was based around nano robots swimming around in the blood came from an EU funded project "*Self organised societies of connectionist intelligent agents capable of learning (Social)*", project number EC-998299 which the author was a principal investigator (see http://www.agingportfolio.org/projects/project/EC-998299). In brief, this project set out to design communities of cooperating autonomous agents for maintenance missions in complex micro-fluidic environments, such as those found in current and emergent platforms of artificial organs (e.g. artificial kidney dialysers). To accomplish this task the project adopted an integrated approach that made use of principles of self-organization found in societies of social insects. Based on these principles the idea was to accomplish a mission using the emergent behaviour of colonies of simple micro-scale robotic agents. To achieve this, the project investigated novel, micro-scale gate evolvable spiking neural network architectures built specifically for the project, so as to permit real time intelligent behaviour at the individual and social level. Of course, in reality, the physical technology remained beyond the bounds of current engineering practice and so the ideas were tested on macro emulations (using actual microfluidic environments) and software simulations. The second tale, "*Plug & Learn*", was inspired by an EU project called "*Extrovert Gadgets (eGadgets)*", project number IST-2000-25240 for which the author was a principal investigator (see http://cordis.europa.eu/projects/rcn/54860_de.html). In brief, this project investigated the possibilities arising from embedding sensing, computing, communication and intelligence into everyday objects, turning them into what the project termed *eGadgets*. The project addressed the design of a generic framework that allowed *eGadgets* to seamlessly collaborate, enabling people to intuitively associate heterogeneous eGadgets so as to compose distributed ambient systems called *GadgetWorlds*. The project motivated later work on the creation of so-called *Virtual Appliances [10]* before, eventually, inspiring the formation of an educational technology company, *FortiTo Ltd* (see www.FortiTo.com), that specialises in rapid product prototyping, which is a core enabler for a student's science and engineering laboratory experience. All of these ideas eventually contributed to a current project which concerns the development of a modularised immersive reality laboratory (see Figure 3) which facilitate students to create intelligent system (eg robots) by plugging together co-modules in a similar vein to the "*Plug & Learn*" SFP above. The FortiTo kit, shown in Figure 3b, is a modularised set of computing modules that allows students to rapidly build modularised appliances, such as smart desktop robots, somewhat akin to the plugin co-gadgets described in Plug & Learn" SFP and the ideas of Makers Activities, covered in an earlier SFP [11] [12].

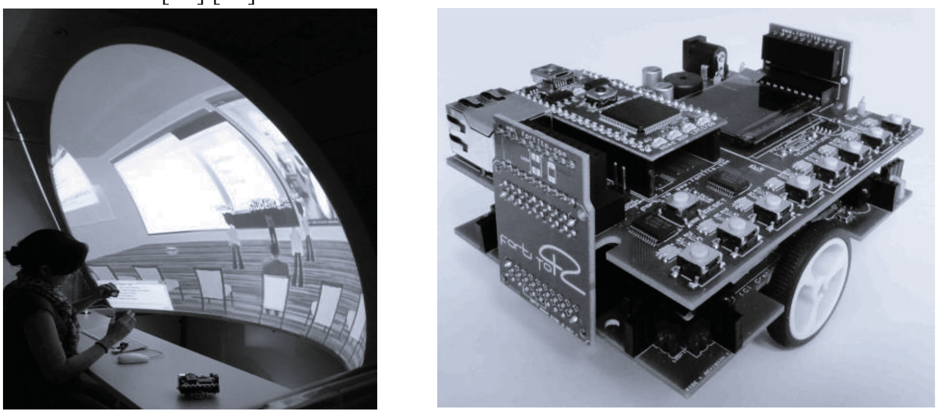

Figure 3 – (a) The ImmersuView (b) A FortiTo modularised desktop robot

Of course these technologies have huge social ramifications, as have been discussed elsewhere [13].While it may seem like a large step is needed to take this forward to augmenting brains, work such as that started by Kevin Warwick at Reading University [14] bears testament that these ideas may not be as distant as we think. Incidentally, the concept for an ImmersaVU arose from an earlier SFP [15], demonstrating that SFPs can have real world impact!

5. Reflections and Summary

Both SFPs presented in this paper imagine a post singularity world where robots, AI co-processors and other machines can be built which, from our current perspective, display extraordinary capabilities. In particular the SFPs look at one aspect of post-singularity worlds, the widespread adoption of transhumanism practices where human organs, can be routinely replaced or augmented. From the perspective of the SFPs presented in this article, we focus on a form of transhumanism, involving reengineering parts of the brain with nanobots, or adding additional processing, memory and communication capabilities to it. Of course nanobots are just convenient vehicles for the SFPs and other means, such as biological, chemical or directed fields, might have been adopted with similar effect. Another major focus of this article was a discussion on the various facets of reality. From the perspective of the arguments presented in this article, transhumanism was regarded as being just another type of tool that could be used to manipulate reality. Furthermore, the SPP regarded manipulation of realities as one of the fundamental instruments of learning and mused on the potential importance of dream-like mechanisms (eg imagination) in both natural and artificial learning schemes (vis-à-vis abstractions, modelling, simplification, simulation and role-play etc), linking dreams and imagination into learning, by seeing them as a type of '*natural immersive education system*'; a "*Dream Machine*". This philosophy was used to connect to the underlying technologies which are seen as ranging from *augmented*, through *immersiv*e to *embedded* realities. In the case of the two SFPs presented here, the technologies are situated at the embedded end of the technological spectrum, being integrated within people; a type of *embedded immersion*. Beyond the technologies, the SFPs raise some interesting possibilities such as '*learning free, education*'! Also, although implanting electronics in people may sound like a distant aspiration, in many respects this vision can regarded as an extension of current mixed reality and wearable technologies, such as the augmented reality glasses being developed by companies such as Google, or the mixed reality environments produced by companies such as Immersive Displays. Of course these technologies are all only at the beginning of their development trajectory so it's impossible to say with any certainty where this work will go. Some variations of augmented reality glasses are already difficult to distinguish from regular glasses thereby, even now, blending somewhat seamlessly into everyday life, as would the implants or brain reengineering described in this paper.

Finally, this article started by recounting the shock arising from experiencing an especially realistic dream; the ideas in both of the SFPs presented here rely on the ability of advanced technology to sculpture or paint sufficiently realistic images into a person's brain concerning the skill, knowledge and wider context of the task being taught. What would happen if, at one extreme, these images were so realistic they could not be separated from the person's reality or, at the other extreme, they were so poor as to appear like frightening invading nightmares? Perhaps, transhumanism plays with the brain at its peril, and all of us need to be a little cautious about letting our enthusiasm for technology go too far. Maybe, somewhere in our research there is a line we shouldn't cross, that we all need to consider?

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Appendix - Related Movies

For your entertainment, these are examples of movies that have resonances with some of the themes in this SFP:

- *Fantastic Voyage* (1966)
- *2001: A Space Odyssey* (1968)
- *The Lathe of Heaven* (1971)
- *Innerspace* (1987)
- *Total Recall*(1990)
- *The Terminator* (1991-)
- *Groundhog Day* (1993)
- *Ashes of Time* (1994)
- *Gattaca* (1997)
- *Abre los ojos (Open Your Eyes) (*1997)
- *The Truman Show* (1998)
- *Dark City* (1998)
- *The Matrix* (1999)
- *The Thirteenth Floor (*1999)
- *Vanilla Sky* (2001)
- *Eternal Sunshine of the Spotless Mind* (2004)
- *2046* (2004)
- *Life on Mars* (2006 UK TV series)
- *The Dream* (2008)
- *Cyborg She* (2008)
- *Inception* (2010)
- *Caprica* (2010 TV series),
- *Amy's Choice* (2010 Dr Who TV episode)
- *The Bourne Legacy* (2012)

Science Fiction Prototypes in Educational and Business Settings

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Abstract

This paper examines the intended purpose of Science Fiction Prototypes (SFP) in conjunction with the significance and use of workshops in business education. We explore why the SFP as a form of education delivery has proven to be popular. Finally we argue that the merits of alternative delivery methods, including the use of science fiction prototypes within different venues or alternative delivery methods can enhance educational engagement with broader audiences outside the traditional classroom setting.

Keywords. Science fiction Prototype (SFP), business education, non-traditional classroom setting

Introduction

To date, Science Fiction Prototyping practice has largely focused around delivery within classroom style workshops or as role playing activities. The tendency within this current practice is to merge two distinct 'parts' of a Science Fiction Prototype; the first, the creative creation of the science fiction prototype introduces a vision or projection of future conditions while the second offer up the prototype for interpretation and encourage participants' to attempt to strategise and operationalise the vision (Figure 1). In this paper we re-examine the intended purpose of Science Fiction Prototypes in conjunction with reflections upon the significance of case studies in business education and the reasons why this form of delivery has proven to be so popular. Finally we argue for the merits of alternative delivery methods such as, for example, the use of science fiction prototypes within a digital shopfront to enhance educational engagement with broader audiences outside the traditional classroom setting.

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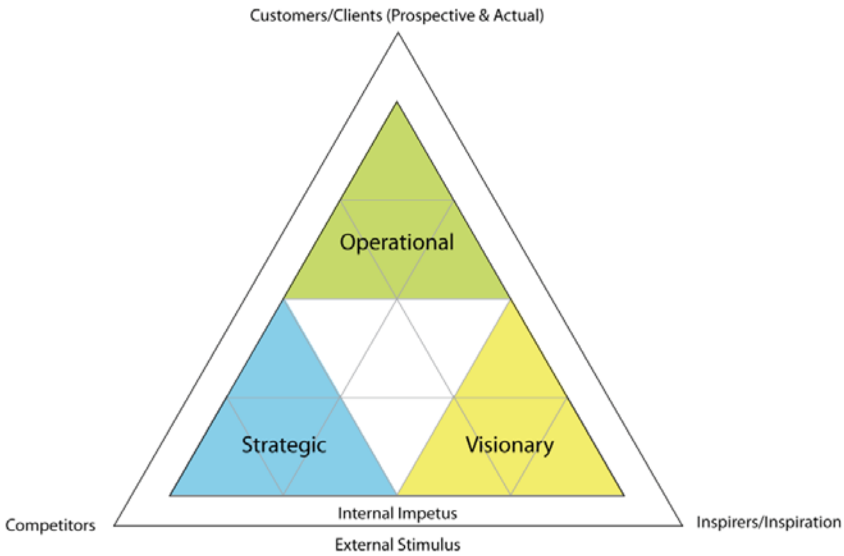

Figure 1: The relationship between visionary and operational aspects of an organisation that are captured within the two parts of the Science Fiction Prototype.

1. Discussion

The case study in business education is a well-established and regularly used practice. At the core of its many claimed benefits, case studies enable the educator to achieve learning objectives that draw upon recognisable but systematised real-life situations. These are situations that are regularly presented as examples of success with the implication that these are the models to follow in other contexts. Argyris (1980) has, however, outlined the benefits of the case study approach as a means for introducing and hearing the views of others; confronting differences; making decisions; and becoming aware of the complexity of reality. Overall the claimed benefits of case methods recognise that there are rarely right or wrong answers and that cases are invariably as incomplete as real-life situations. For all these apparent benefits Argyris (1980) also outlines a critique in the use of case studies. Case-based teaching methods are regularly used by faculty "stars" as their preferred method for management development programs as it facilitates learning that does not question the underlying values of the executives described or the policies in their organizations. At the same time the case study inhibits learning that would enable learners to question their basic assumptions and to improve their application of new learning within their current or future organization. Levi-Strauss (1969, p.18) makes a similar observation regarding cultural practices more broadly, “There is rarely any doubt that the unconscious reasons for practicing a custom or sharing a belief are remote from the reasons given to justify them.” Science Fiction Prototyping pushes this remoteness that Levi-Strauss observes to an extreme position where it can become more clearly evident.

In contrast to case studies, which focus upon historical evidence drawn from actual events, science fiction prototypes develop a future extrapolated from the authors' experiences and knowledge of the present. The vision that is presented through the prototype emphasises the concerns and interests of its author(s). This reversal of perspective arguably offers greater opportunity for the critique of current environments and practices and follows in the spirit of the science fiction genre's longer-term tradition for assertive social and political commentary. The prototyping approach also highlights the separation of two distinct activities that are often merged without acknowledgement in other teaching and learning methods. These two activities can be broadly described individually as the creative and operationalising parts of the whole prototype. The authorship of the prototype is a creative activity that can be an entire workshop itself, part of a series of activities or a discrete workshop with the output then becoming the input for a separate later workshop with entirely different audience and purpose. This is what Papanek (1997: 307) describes as "the omni-directional net of several design 'events'". His perspective highlights the relationship of one event to another by implying a sequential process where alternatively there are a contraction of ideas to a collective consensus or special case followed by the expansion of ideas from a single starting point to a multitude of possibilities. Different sequential design events cycle through this contraction and expansion of ideas (Papanek, 1997: 309). Alternatively, Wu (2013), in his work on SFP imagination workshops, advocates an evolutionary model in what he terms 'cyclic SPF'. This model has a series of processes containing feedback loops in the form of an iterative co-creation process that can include a range of deliverables such as product specifications or business models (Wu 2013).

To date, science fiction prototyping activities have often focussed on the creative parts of the prototype with an implicit goal to 'build something' through the activities (Egerton 2013; Johnson 2011, 2013). Although, as previously acknowledged, Wu (2013) has broadened this vision to create more 'intangible' prototypes. In Papanek's (1997) terms this is a contraction event. The focus on creation reflects the desire of earlier SFP workshops to invent and create new technological and physical artefacts. What could be described as the science of science fiction prototyping? In contrast, we focus here on the less explored aspect of science fiction prototyping that is concerned more with the business of science fiction prototyping. This can be identified (see Figure 1) as an attempt to move from the vision of the prototype to the operationalisation of the prototype and ultimately the potential implementation of the vision. In order to achieve this focus on strategic and future operational issues, the creative part of the prototype for this workshop has been pre-prepared. It draws upon discussions by the authors and, perhaps inevitably, reveals some of their own current interests and awareness. This story is consciously written for science fiction prototyping in its description of a future world in a matter-of-fact style with details that provoke questions rather than providing direct explanation. The purpose then of this prototype is not necessarily to "invent something" from the description of the prototype but to elicit discussion around how to get from a current situation - the present environment - to the vision outlined by the prototype (if, in fact, the described environment is actually considered a desirable situation). The operational workshop - an expansion event - itself then benefits from participants' varied knowledge and specialisms to bring the operational and strategic elements to the aspects of the vision that are already described by the prototype.

We also problematise here, the choice of venue for a workshop. Workshop locations are often an indicator of the approach and intentions of the organisers. The perceived privilege of universities and their distancing from everyday life is commonly represented in the 'ivory tower' description. Yet the choice of workshop location, such as a university building, is usually a matter of convenience for the organisers rather than a conscious selection. Very rarely does a workshop break out of this orthodoxy. One example, a workshop held during the Abandon Normal Devices (AND) Festival was located on an open piece of rough land in the centre of Salford (AND Festival 2010). A venue that could generously be described as, curious. Hosted by Heath Bunting the icebreaker involved throwing rocks at cans and the main event placed the attendees in a simulated air-drone attack that was enhanced with the inclusion of remote control planes and cameras. Similarly, the Rochdale Borough High Street Foundation (2011), with a concern for the number of empty shops in the borough, located their urban planning workshops in an empty shop within a central local shopping centre. Music, theatre and dance were used as inspirational stimuli for the attendees to assist in building an alternative vision of their high street. The intention in both of these examples was to encourage participation from within the locality and purposely drawn away from convenient academic locations.

We describe these combination of factors for consideration as a parallel set of sliding scales (echoing Papanek 1997: 176). This view presents a multitude of combinations (Figure 2) that both charts the approach we are advocating here through the use of Science Fiction Prototyping while also highlighting the relatively small range of combinations that are currently used in conventionally teaching and learning practice.

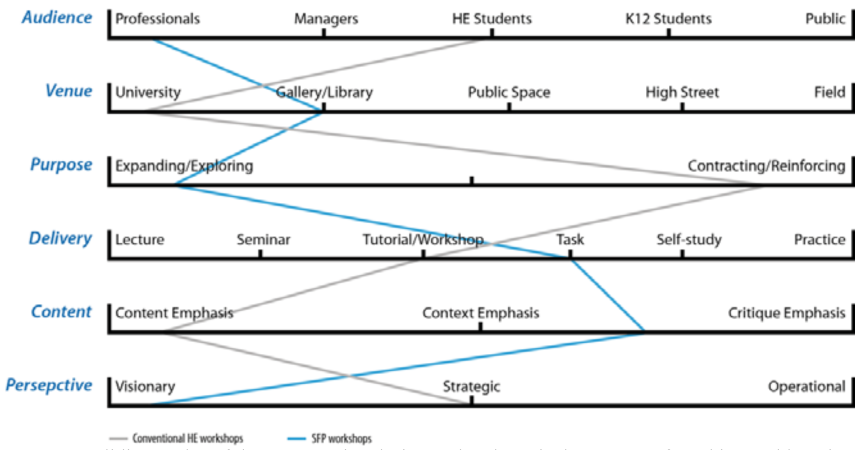

Figure 2: Sliding scales of the comparative design and pedagogical concerns of teaching and learning activities

The following Sci-Fi narrative provides a platform for audience participation to develop an operational prototype (or prototypes) that encourages an imagined future to be achieved. The story has been written to stimulate participants' thinking around a range of key issues and provides a framework world for future imaginings. By writing the narrative as a framework rather than a complete 'whole' story supports attention to the parameters identified in Figure 2 but particularly by enabling a contextualising of Audience, Venue, and Delivery. These, we argue, are the three variables that are most likely to differ within Science Fiction Prototyping workshops. Different workshops will inevitably produce different responses but this emphasised awareness on structural differences provides the basis for comparisons of the results. Workshops that are undertaken with some form of advocacy as a stated outcome, rather than solely educative intent, also benefit from understanding the different bases from which the prototypes emerged.

The story itself depicts a futuristic scenario where money (as we currently understand it) transcends its physicality within a limited financial domain; the notions of 'work' and 'labour' have become increasingly broad to the extent that a contemporary reading might describe these activities as games; and the current conventional arrangements and balance of transport and logistics coupled with manufacture have completed altered. The consequences of these changes have repercussions within the framework world with the hint that there are also shifts in attitudes and cultural practices. The narrative also hints at a more definitely stratified society. These devices all build a framework without being conclusive or definitive about the future. There is no single final conclusion, singular explanations or closed endings. It is a prototype of potentiality. Importantly the narrative does not prejudge the future world framework as being either utopic or dystopic. This judgement rests entirely with the reader and will be among the influences that shape their contribution to the workshop. The operational prototypes that emerge can then just as equally resist or embrace this future overall. More sophisticated prototypes can also identify individual elements of this future world as potential directions to avoid or actively work towards. This potential attends to the need to operationalise and strategise vision (Figure 1) in ways that are achievable and sustainable. Equally, and in direct contrast to the use of cases and case studies in business education, the potential bifurcation of workshop results recognises what Chesterton (1915) described as the fallacy of success. By presenting a framework that does not presuppose the desirability of the future described within the narrative there is no presupposition that the resulting future is itself a successful outcome - albeit necessarily using the judgement and perspective of contemporary experience.

2. Sci-Fi Narrative: "The New Day"

Matthew74NT@dmail stood waiting for the robo-bus. It was still relatively early and Matthew74NT, or "Ant" to his friends, was in a contemplative mood. The heady result of a combination of early morning caffeine shots and the after-effects of late night alcohol shots. It was too early for the smart streetcars to be out so Ant shared the street with just a few energetic cyclists. Almost unnoticed in the background there was the inevitable presence of the street-collecting machines carrying away the remains of everyday life from previous generations that continuously emerged onto the streets. The rush hour - unlike the detritus - was most definitely a thing of the past. Ant gripped his tablet more tightly towards his chest. Despite the evidence of the grey skies and drizzle, today was not any ordinary day and it was a day that Ant had hoped would never happen. He was waiting for the #79 robo-bus. Of course, waiting for robo-bus wasn't the event that Ant had hoped would not happen to him. He might not be a regular traveller on public transport but nor was it the cause for his apprehension.

For the first time in his life Ant found himself unemployed. Standing at a bus stop waiting for the next robo-bus is always a time for reflection and Ant was no different. Up until five days ago he was a relatively successful member of the TwP Guild in the *World of Accountancy*. After a shaky and slow start 10 years ago as a newbie student Guild member Ant had reached chartered level 22. He had even been dreaming of making the big jump to partner level 1. The steady downturn in genecoin production in the past two years had been hitting hard. All of the large guilds in the *World of Accountancy* had shrunk their membership. The overwhelming control that they exerted over accounting practice worldwide made it difficult for individuals to progress in the world significantly and the ability to earn genecoins without the support or protection of a guild was very limited. Ant did admittedly have a ghost account that he had used to get a few extra genecoins but in his alter-ego as a part-time associate level 4 this was really just enough for a few extra luxuries.

Ant absentmindedly checked his watch and instantly recognised the futility of this action. While he normally avoided the robo-buses he knew - as well as everyone else - that one of the effects the genecoin crisis had brought was a revision of robo-bus services. Each robobus on each journey plotted an individual route that optimised the number of passengers it carried. Although the mechanics of the bus system was a secret, speculation was rife about how it actually worked. Some suggested it was based on weight sensors and cameras measuring the number of people waiting at each stop while others said it was simply based on calculations and extrapolations from previous journeys. Rumours also abounded on the local blogs that the bus services were constantly being tweaked to give preference to the filling of robo-buses to capacity rather than passenger convenience. This suggestion was not a surprise to anyone.

Ant sighed quietly at the frustrations of public transport. But he was also relieved to see two others walk up to his bus stop.

Sure enough only minutes later a robo-bus appeared on the road heading towards Ant and his unknown travelling companions. Behind him the man and woman chatted. Their tone was hushed but urgent. Ant tried not to listen out of a sense of privacy and politeness but snippets inevitably came clearly within his earshot. "Fantastic new blog", "actually printed?", "genecoin crisis".

The robo-bus arrived. Ant swiped his accesscard on the door and keyed in his destination. He cursed quietly under his breath. Someone was sitting in his favourite seat. Despite only travelling rarely on the robo-buses, Ant enjoyed the pleasure of sitting in the 'driver's seat' of the robotic driverless buses. It was a simple joy even though the concept of a human bus driver was something Ant only knew from the stories of his parents and grandparents. For Ant there was a nostalgic appeal in having a bus driver to speak to and although he had visited street-collector exhibitions in the past he still felt that there was a massive gulf between seeing the collected items on screen and actually speaking to a driver.

In the perverse logic of bus seating the couple from the bus stop had taken up the seats directly behind Ant. Their conversation had continued on apparently the same topic with some intensity. "Change of government." "Getting the message out there." Ant sank back again into his own thoughts. He was visiting Andrew38EN@keycorp, or somewhat predictably Ben. Ben was a friend, perhaps more accurately an acquaintance who had been a friend at college. Ant had reinitiated contact with Ben through a mutual friend the day after he found out that he had lost his place at the TwP guild. Knowing Ben was useful as he had influence in the HDC Guild within *Logistics World*. Or at least enough influence to get Ant a foot in the door at the Guild with the opportunity to start at student level 6. Ben had offered to guide Ant through the *Logistics World* for a couple of days. Although it was unusual Ben had suggested to Ant that he should visit him at home to meet face-to-face and walk through the world together. Ben had expressed surprise at Ant's desire to change career and wanted to ease him into things. It was still unusual for members of guilds to completely change professions. Most of the victims of the genecoin crisis had stuck to their original careers as it was generally easier to progress back to their original levels fairly quickly. Knowing all of this Ant had readily agreed to Ben's offer, glad to be out of his own flat for a while and away from the reminders of his former guild - the awards, certificates and gaudily coloured paraphernalia that he had printed and collected over the years.

The robo-bus stopped and Ant realised he was already outside Ben's house. A quick Tx and Ben opened the door. Ant and Ben awkwardly shook hands. This was the first time they had stood in front of each for many years. However, both recognised the other immediately from the various images on their walls. Ant had already got himself up to date with Ben's career and family through his wall. Nonetheless they chatted casually for a while as Ben tried to shuffle his eight-year-old daughter out the door. Her school group were having a meet-up today at a neighbour's house and her combination of excitement and nervousness at the prospect of something different meant that she was running late. Ant discovered that Ben's partner, Mary27UC@outward, had already taken a robo-bus to a colleague's house to give Ben and Ant a chance to work together undisturbed on Ant's first day at his new job.

With the departure of Ben's daughter some calm returned to the house. Ben turned to Ant and in a tone that was both a question and a statement of the obvious,
"To work!?"
Ben and Ant logged on and the *Logistics World* screen came up. Ben explained,
"*Logistics World* is a relatively simple interface. Our task is relatively simple too. We have to shift the coloured cubes from their current locations to empty spaces that flash when you move the cube. You are starting on the student levels so the size of the cubes you can move are small but the more you move and the more you work with the guild to move larger cubes you will level up. If you are efficient and move cubes in bigger groups and the minimum possible distance the guild leaders will noticed this in their weekly reports and you will get support from the guild. Obviously you receive a payment for every cube you move."
Ant nodded appreciatively. This felt familiar but he was puzzled by the purpose of the work.
"How does the movement of the cubes relate to logistics?" Ben looked over at Ant. He had been intently staring at his own screen throughout his description. He could see from the expression on Ant's face that this was a question that came out of genuine interest. Ben realised that Ant's previous experience in the *World of Accountancy* had been a bit more - for want of a better word - conceptual. Although Ben had never seen the *World of Accountancy* interface he had always guessed that it mainly involved moving numbers around. Ben patiently continued,

“Oh, each cube relates to different printer supplies. Each colour relates to a different type of supply. I’m not 100% sure but I think the pink and brown cubes are protein and carbohydrate supplies for food printers and I’m pretty sure that the bigger silver cubes are raw graphene of some sort. As you guide the cubes around you are controlling the delivery floats and airtubes between the factory and their destination. Somewhere in the docs there is a full chart of all the item types. Honestly in all the time I’ve been working I’ve only seen about half of all the possible types.”
“What’s that small disc?”, Ant was enjoying the shock of this new world.
“You haven’t changed”, Ben grinned. Working with Ant was bringing back memories of their time at college together. “The disc is a genecoin. They’re not rare but they come in lots of different colours. I think the miners customise them as a sort of branding but it also seems to be connected in some way to the source of the genecoin. You won’t be able to move them until you’ve hit the chartered levels AND gained a gold security badge. But don’t worry,” Ben looked directly at Ant, ”there’s no penalty for trying.”
“I didn’t know you could see genecoins like that. In the World of Accountancy it was a bit more about making the numbers go together. We were always told that genecoins were all basically the same. Same exchange value, interchangeable, unchanging.” Ant’s fascination was coming out in the tone of his voice and he could feel himself being drawn into the mechanics of *Logistics World*. “I think I’m going to enjoy this.” Ben smiled,
“Well it’s always a better day if you actually enjoy your work.”

Ant and Ben toiled on silently. Occasionally they exchanged words around work and life in general. Then Ant in a moment of revelation suddenly exclaimed,
“This all looks oddly familiar. In college didn’t we use to play a retro-game from years and years ago that was a bit like this?” Ben smiled,
“Take a look in the license statement and scroll all the way to the bottom.” Ant did as suggested, scrolling past lines and lines of revision dates and patch information until finally he read verbatim from the screen,
“‘Original codebase Minecraft 2009 Notch Persson.’ Wow, that is old. And if I remember correctly we had to beg the college librarian to release the code to us just to let us play it. She wasn’t happy though. It was of her prized items. Odd to think that code from an old game is still somewhere in there.”

Ant and Ben worked on through the afternoon. Ben’s partner and daughter returned home together and he was distracted by their various stories of both of their meetups. Ben suggested that Ant might like to stay for dinner but the prospect of a late night robo-bus trip encouraged Ant to decline.

On his bus journey home Ant reflected on his day. He took a quick scan of the bus to see if his travel companions of the morning were on the bus too. But, of course, the chances were very unlikely and they were nowhere to be seen.

At home, Ant flicked on the printer. He couldn’t remember what meal he had scheduled for today but he didn’t mind. He left the printer to get on with his meal. He was feeling the combined effects of a day’s work at a new job and the excitement of his tangible progress towards student level 7 with only a few hours of effort. Ant quickly scanned the day’s vinecasts and blogs (failing to spot the photograph of the couple from the morning’s bus ride that was appearing in one the day’s city blogposts). His meal finished being printed and he ate quickly. His rapid pace - such a shift from his normally relaxed evening's activities - was purposeful. Fifteen minutes later the login screen for Logistics World reappeared on Ant's tablet. Ant did occasionally work after hours as a freelancer but tonight he had a different purpose. He quickly logged in and was soon scanning the docs. His target was specifically the description of genecoins and the different meanings associated with the individual miners and item types.

In the entry for "Genecoins, Types and Meaning of" it said,
"...genecoins' colours and sizes are determined by a variety of factors including the importance of maintaining security for individual genecoins as well as the anonymity of the donor. The constant factor for all genecoins of all ages is their size which is automatically created by the miners as an assessment of their initial worth. This assessment of worth is also connected to the colour of the genecoin which the miners use, in part, as an indicator of what they consider as the best potential application for the genecoin itself. Unfortunately each miner guild uses slightly different colours for this assessment and it is generally considered good practice not to consider the colour and size of genecoins for everyday use. To make matters more complex older genecoins will develop a patina over time that provides an indication of their age, their previous usage and relative rarity. Genecoins that persist after the lifespan of their donor will also develop a ridged edge as a mark of respect and as a further indicator of their rarity…"

This was what Ant had wanted to find but the description was also a surprise. His previous experience of accounting had never made any mention of any differences between individual genecoin. The perspective in accounting was that a genecoin was a genecoin unreservedly and completely interchangeable. This principle of universal exchangeability was at the heart of any currency. Wasn't it? Ant found himself considering this founding principle carefully.

Ant scrolled past details of the technical specifications and the challenges that these specifications represented to logistics. He felt slightly guilty for overlooking the very details that related to his new job but that, he reasoned, was why documentation was always available. They will always be there for the one day in the indeterminate future when you need to extract the exact details to solve a problem that you have not yet imagined. The documentation then highlighted a further complexity in the economy of genecoins.
"...it is possible that genecoins will reach the end of their usable lifespan. This is a rare event and will potentially occur only a few times during any one person's involvement in *Logistics World*. A deceased genecoin will become completely black and cease spinning within the *Logistics World* interface. When this occurs the only option available for handling the genecoin is for a minimum of three partners level 10 or higher all with gold security badges to collectively move the genecoin to a black genebin which are themselves relatively rare within *Logistics World*. As a consequence the disposal of deceased genecoins is well-rewarded and competing guilds will often attempt to hijack missions that set out to dispose of them. In periods when the availability of supply cubes is low in some regions guild leaders will instruct lower level guild members to guard known black genebins with the express purpose of preventing competing guild from using the genebin for disposal…"

Ant looked up. He knew it was a silly response but he could feel himself becoming tense. Nobody had told him that there was any adventure in logistics or that genecoins were so complex. Looking back at the tablet and a quick click closed down the documentation to return to the main interface. In one of those strange twists of fate that seem to happen so often, a genecoin had appeared in the interface on Ant's tablet. From his earlier reading it was immediately obvious to Ant that this was quite an old genecoin. Ant watched the genecoin slowly spin for many minutes almost mesmerised by the colour he saw but at the same time he knew he could not move or interact with it.

Very slowly, almost imperceptibly, the old genecoin became smaller. When he realised what had happened Ant almost dropped his tablet. If he had not been watching the genecoin so intently he probably would have not even noticed. He quickly sent a Tx to Ben,
"Do genecoins ever shrink?" The reply came back almost immediately,
"?? No. I think that would be like stealing."

2.1. *Applying the Sci-Fi narrative*

"The New Day", is intentionally incomplete in terms of the explanations it offers and instead provides contextualising and scene setting for the imagination and the workshop.

The expectation is that participants will almost unconsciously 'fill in the gaps' and in this thinking be able to make a contribution in the workshop. The focus of attention from each individual participant will vary and contribute to the richness of the experience. Understanding the overall direction, purpose and audience of the workshop through the sliding scales proposed in Figure 2 will assist a facilitator in maintaining a focus while not stifling the creativity of the contributions.

Of particular importance to the workshop and the use of narrative as a device for discussion and development is the way in which science fiction enables a breaking away from accepted practice and encourages a criticality that always evident in professional workshops or educational delivery. Levi-Strauss (1969, 19) is again instructive when he suggests that, "We act and think according to habit, and the extraordinary resistance offered to even minimal departures from custom is due more to inertia than to any conscious desire to maintain usages which have a clear function."

3. Conclusion

As discussed previously Science Fiction Prototyping practice has largely focused around delivery within classroom style workshops or as role-playing activities, however the workshop proposed here is an expansion event. The workshop focus presented in this paper attempts to move the vision of the prototype to its potential strategic and operational form (shown in Figure 1). As an expansion event, the workshop, therefore encourages participants to read or listen to the story prior to the workshop and bring their thoughts, opinions and critiques (hopefully of the future world rather than the literary style employed by the story). This is in conscious distinction to the tendency within current SFP practice to silently merge the two distinct 'parts' of a prototype; the first, the creative creation and the second to offer the prototype for interpretation. The expansion element of the workshop is possible with the adoption of a critical perspective. The participants are encouraged to consider a number of question for example that may include; Is this future a desirable one? Are aspects of the future described desirable, while other aspects preferably avoided? Is a separation of the positives and negatives realistically possible? What are the social, economic and technical implications for this future? Are there new technologies that could be explored that are drawn from the story? Ultimately, there are two overarching questions. Do 'we' want this future? If 'we' do how do we get there? If 'we don't how do we avoid this conclusion? These questions are themselves precursors to a far wider set of questions including, "How could a business or a council plan to achieve the desirable aspects of the story?"

The many questions posed by the story within the workshop contributes to the authorship of the prototype and as a creative activity can either inform an entire workshop or be expanded to include a series of workshops. Activities presented within the Science Fiction Prototype workshop will stimulate a particular desired output (for the business educator). In a series of rolling workshop events the output and creative authorship then serve as the basis of the input for subsequent workshops with entirely different audiences. A partial parallel to Papanek's (1997: 307) "omni-directional net of several design 'events'" and Wu's (2013) 'cyclic SFP'.

In constrast to Papanek (1997) and Wu (2013), however, we identify an additional purpose for generally iterative educational approaches. By constructing the SFP workshop as an expansion event we argue that alternative questions can also be asked; "How can a business plan to avoid the less desirable results described in the story?" This reverse question can be equally and validly posed as a form of critique and challenge accepts practice. This is a form of question that is very often left unconsidered in conventional business planning which results in a business succumbing to the fallacy of success (Chesterton 1915). With all of these questions there should be no expectation for consensus but rather different streams of discussion that diverge, speculate and expand on the original narrative. Potentially creating new prototypes of the future that can be, in turn, receive the same levels of scrutiny.

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Towards Automated Assessment and Adaptation in Serious Educational Games

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Abstract. Serious educational games are recognized for their value in providing an in-depth learning environment, while engaging students. Automating the assessment and adaptation of these games has significant, practical applications. Here, we present a re-usable, automated approach that is specific to each student, accurate, and broadly applicable to new game development or the gamification of existing applications. Our preliminary results include a Java/AspectJ prototype and a simulation-based validation study with a sensitivity analysis.

Keywords. Serious educational games, assessment, adaptation

Introduction

Educational infrastructures face significant challenges including the need to rapidly, widely, and cost effectively introduce new or revised course material; encourage the broad participation of students; and address changing student motivations and attitudes. Serious educational games (SEGs) have significant pedagogical potential as they provide immersive, engaging and fun environments that require deep thinking and complex problem solving skills [1]. They create interactive student-centered environments that allow students to create a personalized learning experience, progressively incorporating new knowledge and scaffolding it into what they already know. In order to provide such environments, SEGs need to monitor the student's progress and performance and adjust the game as needed – in other words provide dynamic assessment and adaptation (AaA) capabilities.

1. An Overview of Our Dynamic Assessment and Adaptation Approach

Our on-going research project SimSYS, a SEG development platform, recognizes the need for this specialized support [2][3]; the community is actively investigating this area (e.g.,[4][5]). The SimSYS AaA approach is highly automated and re-usable in quiz-based, single player SEGs. The assessment is for each student, to provide a uniquely tailored educational experience. The adaptation of the game is done at the end of every level, so the frequency of adaptation is not too fast or slow. An architectural overview of the AaA approach is illustrated in Figure 1. On the left, the static view shows the Assessment, Adaptation, Scoreboard, Challenge template for quizzes, and

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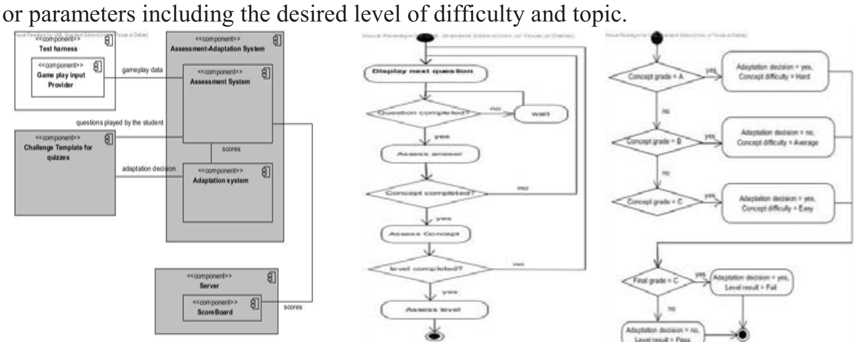
for development and validation purposes a test harness component to simulate player user inputs. The center and right parts of the figure show the dynamic views for the assessment and adaptation activities.

The assessment activity is structured into question, concept and level assessments. A level has a collection of one or more concepts; a concept has a collection of one or more quizzes with questions. The rules for the assessment calculations are configurable. For example, a quiz assessment can be based on the option selected (correct, incorrect, partially correct), time taken, and the number of times the options were changed.

The adaptation activity is structured into difficulty adaptation and level adaptation. Difficulty adaptation addresses the decision to adjust the difficulty of a concept; the decision is based on the concept level grades in the previous level. Level adaptation (or decision whether a particular level is passed or not) is based on the final grade; the final grade is based on both concept and level grades. When a decision to adapt the game is made (either make the game more or less challenging), this is provided to the Challenge template component, where quiz questions are selected based on a collection or parameters including the desired level of difficulty and topic.



Static View
Assessment and Adaptation

Dynamic View
Assessment

Dynamic View
Adaptation

Figure 1. High Level Architecture of the Assessment-Adaptation Approach (static, dynamic views).

The approach has been prototyped using Java/AspectJ; the test harness has simulated 100 players for a mix of good, average, and poorly performing students in a game on design patterns. A sensitivity analysis, showing how the variation in a statistical model's output can be attributed to variations in the inputs, has been used. The results indicate the automated approach holds much promise as a re-usable approach that is accurate, specific to individual student players, and broadly applicable. Future research includes improving the ability to configure the rules, providing reporting capabilities, and an extensive validation study using a rich collection of SEGs.

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ThePedagogical Virtual Machine: Supporting Learning Computer Hardware and Software via Augmented Reality

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Abstract. In this work-in-progress paper, we propose a general model, ViewPoint, for augmented-reality learning which consists of several components such as a learning design specification, a collaborative environment, an augmented reality view, physical objects and a centralised data server. The learning activities focus on the Internet-of-Things, a paradigm that utilises small networked embedded computers (which are largely unseen) to make pervasive computing applications. The core contribution of this paper is a new paradigm that we refer to as a 'Pedagogical Virtual Machine' that aims to extract learning related information from the underlying computers that make up the education focus. The paper describes the information architecture of the PVM explaining some of the key concepts such as data representations of hard and soft objects. The paper concludes by reviewing the main findings and discussing our future research plans.

Keywords. Mixed Reality, Augmented Reality, Internet-of-Things, Cloud-of-Things, Learning Activity, Mobile Augmented Reality, Buzz-Boards.

Introduction

In a previous paper [1] we examined the way in which Augmented Reality (AR) could be adopted in order to make deep IT technologies (ie invisible IT entities) visible so as to create a valuable view for both learners and developers in terms of gaining better

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insight into the abstract concepts of the technology that is woven into the fabric of our everyday lives. In particular we will focus the Internet-of-Things a paradigm that uses small networked embedded computers (which are largely unseen) to make pervasive computing application. To reveal these invisible processes an AR model called ViewPoint, has been proposed to visualise and interact with a small, self-contained eco-system of a networked embedded system referred to as a Buzz-Board [2]. The approach seeks to enrich developers' and learner experiences by providing a view of the invisible embedded-computing elements surrounding us. Moreover, in support of the suggested framework, a 4-dimensional learning activity task (4DLAT) has been proposed, which assists in structuring the study into a number of different stages, through which progress is made from single-learner-discrete-task to group-learner sequenced-task, based on the scenario suggested. Most of the previous paper was addressed education, whereas this paper will describe the underlying computer science. Thus, as part of this work-in-progress, we introduce a new paradigm, which we refer to as the 'Pedagogical Virtual Machine' (PVM) that acts as a manager for revealing educational learning related functions in the computer. Brad Cox [3] explained that; when he started thinking about object-oriented programming he had the vision that everything in this world can be regarded as an object. This inspired us to think about hardware and software in embedded computer as objects as well. This model implies that all computer objects (hardware or software) contain data that represent the object state and can be communicated with other objects. Using these ideas we have framed the following hypothesis for our Pedagogical Virtual Machine (PVM):

> *"It will be possible to create a synchronous real-time computational architecture that link hardware, software and AR events together in an effective way (i.e. that the real and virtualised views are correctly synchronized). More specific by using either virtual machine or proxy-agent technology pedagogical synchronisation between the embedded devices and learners can be achieved."*

In the following section of this paper we start by describing some related augmented reality and embedded computing work, then we present the conceptual of Viewpoint model system before moving on to explain the PVM, before we, finally, introduce the information architecture used to support it.

1. Related Work/Literature Review

1.1. Augmented Reality

As has been highlighted by Pena-Rios [4], some of the technologies adopted in an educational context, namely augmented reality, mixed reality and the virtual environments, have all impacted on learning and teaching from conventional to more innovative approaches. Establishing a connection between virtual and real domains enables augmented reality to form a reality that is not only augmented but also enhanced [5]. Essentially, augmented reality delivers a number of different opportunities in terms of teaching and learning, as has been acknowledged by Wu [6]. In this regard, learners are able to take advantage of the coexistence between the real environment and virtual objects through a number of different aspects. Primarily, it enables learners to visualise complicated abstract concepts and spatial relationships [7]. Secondly, there is the opportunity for learners to interact with synthetic objects—both 3D and 2D—in the Mixed-Reality (MR) setting [8]. Thirdly, it enables phenomena, which are impossible to be experienced by learners or which otherwise are non-existent in the real world, to be experienced by learners. Lastly, it enables learners to develop critical practices that would not be possible in another learning technology setting [9].

Augmented Reality (AR) is recognised as a technique concerned with virtual object overlay in a real-world domain, and can cause users to feel sub-immersed through the interactions facilitated between the actual and virtual worlds [10]. Thus, AR combines virtual objects in a real-world context. From the viewpoint of the user, the objects are rendered complete and harmonised with reality, including presenting the same contextual environment [11]. As such, it is essential that there be alignment between the real and virtual world, which will enable an illusion to be created. Various AR applications have undergone analysis, namely in regard to entertainment, manufacturing, maintenance and repair, medical visualisation, and robot environmental planning [12]. From these studies it was apparent that accurate scene registration is fundamental to AR, which means the consideration of camera pose estimation, in specific consideration to the 3D environment, needs to be taken into account [13].

Markedly, mobile AR is considered a natural platform centred on a number of what are terms to be ‘killer apps’. The work of Wagner *et al*. [14], for example, infers that an interactive AR museum may be defined as ‘a virtual media that annotates and complements real-world exhibits’. In a similar regard, [15] introduced a training application, which facilitates oil refinery employees to review the instructional diagrams located on the top of the tools being learned and used. Various other applications have also been identified, including [16], equipment maintenance [17] and document annotation [18], as well as others. Irrespective of the application, however, there are numerous aspects in common: for instance, all of these applications rest on there being a wealth of data, dynamic and distributed, and there is the necessity to establish all relations between recognisable visual targets and relevant data. These associations will change through the development of the application or otherwise with the development of the underlying data. Importantly, there is the need to ensure a presentation layer is incorporated, which explains the way in which data can be rendered as virtual media. In some regards, it may be advisable to render different combinations of icons, images, texts or 3D objects, although this might ultimately depend on the nature of the data. The precise conversion from data through to virtual content essentially depends on the application type. Different users implementing numerous mobile devices could have the ability to share and collaborate with such data; thus, there is the suggestion that a central data store may be required, which needs to have the capacity to oversee users’ actions, as well as supervising the state of the system overall [19]. Moreover, collaboration in the context of AR may be more valuable, especially when different users discuss and emphasise their views, and interact accordingly with 3D models in unison [20]. On the other hand, in regard to the pursuance of academic development, there have been many studies carried out on collaborative AR, which comprises the use of 3D objects [21,22,23], such as the struct3D tool which, for instance, has the capacity to teach mathematics and geometry[24]; the Web3D instrument, which is adopted to assist engineering students [25]; and magicbook, which can be applied in regard to multi-scale collaboration. The majority of these applications are based on screen-centred AR through the utilisation of transparent displays and head-worn displays. Furthermore, AR can deliver various perspectives of the same object, which can facilitate learners in progressing further than the data available to them would allow [26].

1.2. Internet-Of-Things

Ferscha *et al*. [27] have explained that 'smart things are commonly understood as being wireless ad-hoc networks, mobile, autonomous and special purpose computing appliances, usually interacting with their environment implicitly via a variety of sensors on the input side and actuators on the output side'. As mentioned in the introduction, the concept of deep technologies refers to systems with functionalities that are hidden to humans. Such hidden technologies are incorporated within the environment, and cannot be seen by people but are there nevertheless. They can enhance the perceptions of the users in regard to their surroundings if presented in a natural way. Accordingly, establishing a link between the virtual and the physical world is essential, and can be achieved through utilising a number of different approaches, including AR and mixed reality. For instance, through the work of Ferscha *et al*. [27], a 6DOF DigiScope was developed, which is a visual 'see-through' tablet supporting the investigation of the 'invisible world'. One further illustration of this point is the University of Essex's iClassroom, which utilises a number of different instruments, such as projectors, whiteboards, and wall-mounted, touch-screen and handheld devices, all of which are all networked together to facilitate both teaching and learning [4].

2. System Model

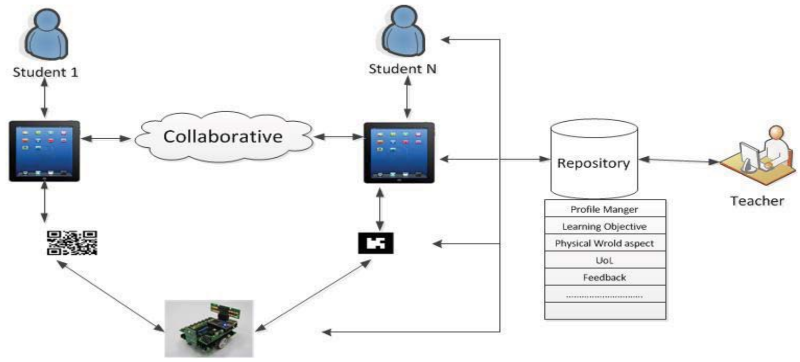

Figure 1 High-Level View of the ViewPoint Model

A high-level view of the proposed model, ViewPoint, is shown in **Figure 1**. This is based on several aspects that integrated together such as the learning design, collaborative environments, the augmented reality, physical objects and the central data that manage the whole system.

Theses aspects can be described as follow:

a) *LD Specification:* the teacher creates the unit of learning, the learning objective, the expected learning outcomes and specifies the task that should be completed by the students. Furthermore, the students perform a sequence of actions to achieve the goal of the activities that set by the teacher. In addition, they would be able to see their performance and score for the task which would be retrieved from their personal content profile and could also can be seen by the teacher.

b) *Collaborative Environment:* This is where multiple users with separate smartphone/tablets can communicate, collaborate and share data during the learning activities. Furthermore, the environment can notify other users for the updating data/information.

c) *Augmented Reality:*

   This consists of the following components

   - *AR Display:* This is the user interface/ the client application/ the output device where users can see things superimposed onto images of the real devices' being studied and digitised by a camera. The images can be overlaid by virtual content such as text annotation, icons, video, image and 3D models.

- *Visual Targets:* These are markers used in order to identify and interact with the real and virtual objects. The interaction can be undertaken by diverse technologies such as Quick Response code (QR), Bar Code, Near Field Communication (NFC), Video Markers, Computer Vision (object recognition), Global Position System (GPS), interactive sensor/effector systems and computer networks (e.g. micro sub-nets).

d) *Physical Objects:* These are the objects the users want to study, track, visualize and manipulate. The physical objects could range from the things that we use in our daily life such as cars, washing machine, TV, aeroplane, robotics, mobile technologies or, in our case, Buzz Boards (**Figure 2**).

e) *Central Data:* This is the repository where the whole system is managed. It contains all the Units of learning, assessments, Roles for users (teachers and students), shared data, virtual content and the physical objects functions/representations.

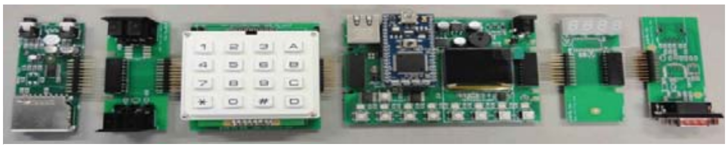

Figure 2 Some BuzzBoard Internet-of-Things Components (an Internet Radio)

2.1. Pedagogical Virtual Machine

The primarily aim of this research is to develop a 'Pedagogical Virtual Machine' *(PVM) which, in simple terms, is* an entity that interprets and communicates the hidden (deep) computational processes for the purpose of helping students or developers visualise functions in a computer. An important aspect of this machine is the unification of the pedagogical needs with the architectural capability. For instance a student/learner would need to be aware (via visualization) of the active software and hardware behaviours. The idea of the pedagogical virtual machine is to provide a platform-independent interface for students and teachers to access information that is pertinent to learning. In this respect it has some similarities with ideas of virtual machine used to support mobile code in web systems (eg the Java Virtual Machine). However, it does not execute code (in a programming language sense) but rather responds to a set of generic commands that gathers system information (or instrumented data) from the underlying hardware about the software executing. It aims to provide students and teachers with a portable, common and familiar interface irrespective of the underlying hardware (in that sense it acts as a virtual machine – the machine being the monitoring apparatus). In addition, it will include some customisable features that allow teachers to filter exactly the type of pedagogical information they need for a particular topic or lesson.

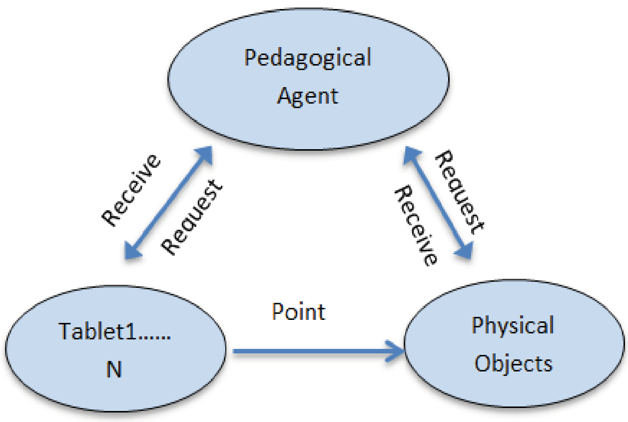

Figure 3 High-Level Conceptual View of Pedagogical Virtual Machine

However, while the details of this component form the focus of our coming research, we have been able to propose the following conceptual view of the main components of the PVM **Figure 3.** A key innovation arising from the use of BuzzBoards is that they provide an internal hardware network that both provides both user driven events (eg plugging different boards together) and signals deep soft and hard behaviors (used by the PVM). Both of these features play a key enabling role in this scheme as they provide a way to get essential system information from the learning objects, without disturbing the system, which most forms of instrumentation would cause. In relation to Figure 3, the main components of the Pedagogical Virtual Machine can be described as follows:

a) Tablets/Smartphones: these contain the augmented reality user interface /client application that allows learners/developers to point at the physical objects via the built-in camera in order to visualize the deep entities/functions/process of the physical objects. Furthermore, each learner can use his or her smartphone

b) Physical Objects: these are the objects that learners can recognize/track so as to reveal the learning related functions within them.

c) Pedagogical Agent: this acts as a bridge between the smartphones/pad and the computing objects, extracting pertinent educational learning related information from the platform under study. Research challenges include defining the pedagogical functions and then determining the best mechanism to gather data from the computational objects under study. For instance, when the learners' point their smartphones at the physical object, and the physical object is functioning, it notifies all the smartphones of this function. Therefore, the learners will be aware of the behaviour of the physical object and aid them to understanding the deep (hidden) functionality of the object concerned. This is similar to the Model, View, and Controller (MVC) design architecture (see 2.2).

2.2. Information Architecture

To support the PVM, there is a requirement for an information architecture to deliver content for complex learning tasks. This is derived from both the technical and pedagogical domains. In the technical domain, the information representation uses an object-oriented approach for defining the physical object data (both software and hardware behaviours). Furthermore, both software and hardware are treated as an object. Thus, the defined physical object contains information such as *<Id, Name, Description, Network IP> and has services/behaviours <input, output>*.

In the user-interface, delivering the content for learners will utilise the Model, View, and Controller (MVC) design architecture **Figure 4** [28]. The description of this component is as follow:

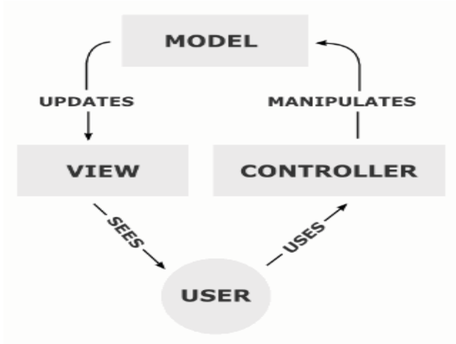

Figure 4 The Model-View-Controller Architecture

- The Model: This contains the 'representation data' for the objects that are managed by the system, such as hard and soft object data, learner profile, learning activity content, learning progress.
- The View: This contains the presentation structure and format that appears on the client/learner display system. The information/data that needs to be presented to the learner is requested from the model. The View consists of a Camera View, AR View, Login View, the main page, and the learning content.
- The Controller: This acts as a bridge between the view and the model. It can send a request/command to the view in order to change the presentation of the model. In addition, if the model presentation is changed in the view, it notifies the model to update its state.

3. Conclusion and Future Work

In this paper we proposed and explained a general model, ViewPoint, which consists of several components such as a learning design specification, a collaborative environment, an augmented reality view, physical objects and a centralised data server. Furthermore, to support the proposed model, we produced a new concept that we refer to as a 'Pedagogical Virtual Machine' that aims to cater for learning or development needs. To support the PVM, we describe an information architecture for the data representations of hard and soft objects.

For our future plan, we aim to continue developing the PVM using the buzz board system as a physical object and pedagogical test-bed for our experiment work. Clearly, this is a work-in-progress paper as there is still much research to be done especially in respect of creating effective AR based learning design activities as well as exploring the learning interaction procedure for deep (invisible) technology. In addition, finding the appropriate techniques for visualizing embedded technology requires further investigation. Furthermore, the evaluation of our work is a crucial factor which we will take it into consideration on our future progress.

Acknowledgements -We are pleased to acknowledge FortiTo Ltd and Anasol Pena-Rios for support with the BuzzBoard technology.

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Towards Personalised and Adaptive Learning Paths in Immersive Educational Environments

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Abstract. It has been considered that when creating a learning module in an immersive educational environment the learning design process is time consuming particularly dictating the rules responsible for sequencing the module's lessons. This challenge becomes more complicated when the sequence needs to be made more adaptive and personalised. Therefore, we introduce our proposed prototype system called iPerSeq –an intelligent Personalised Sequencing system-. This prototype relies on machine learning to intelligently personalise and adapt the learning path for individual students based on their previous contributions and behaviours during learning. This work in progress paper describes the current research being undertaken to investigate this issue and how it can be deployed in 3D Virtual Worlds. In addition, we explain the system's conceptual model.

Keywords. Adaptive course sequencing, immersive educational environment, adaptive educational systems, adaptive learning paths, Learning Design.

Introduction and related works

The use of immersive environments in educational field results in many possible advantages such as: 1) promoting the students' engagement, 2) visualising the learning objects that would be hard to understand in a 2D space [1][2]. There are numerous immersive educational environment proposed to achieve these. However, most of the proposals ignore the differences between students - which can contribute to the students' dissatisfactions. Adaptive educational systems try to overcome this issue by personalising the students' learning experience - often utilising machine learning. Hence, these systems observe students learning and collect the relevant information to extract rules used by pedagogical tutor agent.

To date, some research has been conducted to investigate the issues related to learning design and content sequencing in 3D environments[3]. Some researches explore how to make the sequence between learning activities more adaptive[4]. Our work focuses in solving this issue in 3D immersive environment. We propose a conceptual model for our prototype system (iPerSeq) which applies the adaptive learning path algorithms in 3D immersive educational environment. In an example scenario described below, the student will learn some lessons on Solar System module

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delivered in a 3D virtual space and iPerSeq adapts the sequence of the lessons for this module.

1. Our Proposed prototype (iPerSeq)

In the first use of iPerSeq, student will do a pre-assessment to measure his/her knowledge about the module. The pre-assessment mark will be stored in the student profile as well as other factors to make the decision about the most optimal learning path. In addition, iPerSeq has simple node-based module map. Every node presents one concept (e.g. the planets) and has one of three colours (blue, green and red), which indicates whether the student has opened this node yet, whether the student has achieved the relevant learning objective or not. Moreover, the learner will see the suggested learning paths as shown in Figure 1. Furthermore, every node holds the lesson's location in the immersive space and when the student chooses a node, the system will initiate transition to the lesson's location.

Figure 1: The node-based module map in iPerSeq

1.1. iPerSeq Models

From the earlier description we have proposed the model below.

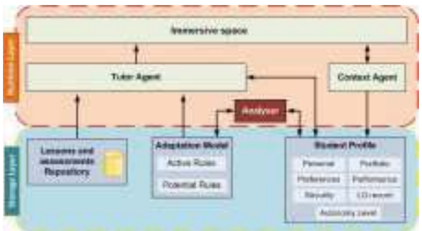

Figure 2. iPerSeq Conceptual Model

The model shown in **Error! Reference source not found.**Figure 2 is divided into two layers: the runtime layer and storage layer. The runtime layer is responsible for performing some adaptive functions and has these components: immersive space, tutor agent, context agent and analyser. The storage layer has these components: lessons and assessments repository, student profile and the adaptation model.

1.1.1.1. Context Agent

This component is responsible for tracking the learner's behaviours and passes the information to the student profile.

1.1.1.2. Analyser

Once enough information is gathered about a student, the analyser, using machine learning, analyses student profiles and observes the patterns of the sequences that students have made in order to generate rules.

1.1.1.3. Adaptation model

The adaptation model contains sets of rules similar of this one (If the previous domain knowledge is poor AND the lesson A mark is good THEN next lesson is B) these rules are generated and refined over time by the analyser. iPerSeq should be trained before used to rich this model.

1.1.1.4. Tutor Agent

This component is the process manager. It guides the learner based on the student profile and the active rules. This agent measures the level of knowledge for the learner before and after leaning the course in general and every concept in specific to determine if the student needs a support.

2. Summary and Future work

As one of the early stages of our work-in-progress research, this paper present a possible way to apply the adaptive educational sequencing in a virtual reality learning environment to make learning path in these environments more adaptive and personalised. This work introduces the proposed conceptual model and a prototype system (iPerSeq) which will applies these models. It is hoped that the functionalities perceived will allow students to better personalise their learning experiences. In the future, we expect to further this work by making all the system's component work in real time (while students learning), investigate the ways of building affective adaptation model and student profile and the fuzzification of the interactive pedagogical space.

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VirBELA: An immersive virtual world for MBA student collaboration, networking, competition and learning

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Abstract. This article summarises the context for a demonstration of VirBELA, a bespoke immersive virtual world developed to promote MBA student collaboration. VirBELA was launched with a successful business simulation competition featuring industry leading simulation technology embedded fully in the virtual world, and with MBA student participants globally distributed, representing the benefits and challenges of working on multi-cultural/multi-national teams. In addition to outlining the objectives of the presentation we also discuss the use of VirBELA as a platform for Global Leadership development and the value of business simulations delivered in a 3D virtual world.

Keywords. Virtual World, Business Simulation, Virtual Team Collaboration, Experiential Learning

Introduction

VirBELA is an immersive virtual world for MBA student collaboration, networking, competition, and learning. Navigating VirBELA's campus is accomplished using a personal avatar. Communication can be achieved using voice and text chat technologies that are embedded in VirBELA (similar to using Skype and gChat).

VirBELA was sparked by two needs:

- The need to break down silos created by universities operating independently. Although there are many advantages to the traditional university setting, the educational community needs to diversify its offerings to be more responsive to today's global information age. We believe breaking down these silos will help cultivate innovation and cross-cultural understanding.
- The need to provide students with more low cost (in terms of money, time, and risk) experiential opportunities to apply what they are learning in their coursework before entering the job market to prepare them to be better global leaders.

Our Response to the Need:

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- To address the needs, we sought to develop an adaptive, inclusive environment. We saw advantages to using 3D immersive virtual worlds, such as SecondLife, to connect students and offer them opportunities for low cost 'practice'. We went to the market to find the best virtual world platform available to build the global virtual MBA environment, but felt current technologies did not meet all of our needs.
- We also wanted VirBELA's design and functionality to remain agile, capable to respond to the community's needs and feedback. As such, we decided to create our own virtual world using the gaming engine Unity3D. With the success of the gaming industry and its rapid technological advances, we felt a game engine such as Unity, was a good train to jump on.

1. VirBELA's Objectives

- To improve collaboration across graduate management institutions globally, in an effort to foster innovation.
- To provide graduate management students with time and cost efficient experiential learning opportunities that aid in the development of global leadership competencies.

2. Global Leadership Competency Assessment and Development

For the last 20-30 years global leadership has been seen as a critical factor on which the future success of international business depends. However, sourcing an adequate supply of global leaders has been a continuous challenge for multinational corporations and international businesses. Today, far from seeing an improving picture, global leadership is rated as one of the least available business skills and is becoming an increasing problem for multinational companies. Greater creativity in seeking new ways of developing global leaders is required.

Mendenhall et al [1] have proposed the following process as necessary for global leadership development to take place:

> For us to learn we must acquire new information and become able to see the same thing from a different perspective. As individuals with certain cultural maps about how the world works and how business operates, we need to experience contrasts to those views and confront our beliefs and assumptions. Without such contrasts that lead to confronting our traditional way of seeing or doing, there can be no change.

'High contact' cross-cultural transformational experiences are necessary for global leadership development to take place and one creative opportunity to generate these experiences is the virtual world. Through VirBELA we are creating an opportunity for business students of different cultures and nationalities to come together to work as teams to undertake a business simulation. The activities students will undertake will be observed by facilitators conversant with the VirBELA Global Leadership Competency

Framework. As part of the learning, facilitators will initiate discussion and provide feedback focused on global team performance and individual behaviour.

We are, as yet, unsure how well the virtual world environment will replicate a 'real world' cross-cultural experience and our intention is to evaluate the virtual world as a learning medium for global leadership. We see this initial phase as a first step in the process of creating virtual world, 'high contact' cross-cultural experiences and anticipate building on our own learning to design additional opportunities and activities that will facilitate rich global leadership development opportunities.

3. VirBELA and Business Simulation

A defining feature of virtual worlds research has been its multidisciplinarity yet in relation to business use there are relatively few examples of specific business activities conducted within virtual world environments. To address this, VirBELA features an embedded business simulation from an industry leading provider, Tycoon Systems. In the last 40 years business simulation games have progressed from being a supplemental exercise in business courses to an accepted and major form of pedagogy in business education. A transition which has been accelerated exponentially by the invention of the Internet and the creation of web-based simulations such as those developed by Tycoon Systems. The challenges presented by the VirBELA project for Tycoon as business simulation developers were many, yet they also represented an extraordinary opportunity.

When an existing 2D application requires implementing and rendering in a 3D environment there is a necessity to retain elements which are visually more effective in 2D while exploiting the boundless opportunities of the 3D environment. Our players thus experience a 2D paper Balance Sheet in the Virtual World alongside 3D representations of logical objects such as company assets, volume in warehouses and so forth. It is this development of a hybrid model where a web-browser based application can be fully operational in a 3D environment which is potentially unique.

Of increasing significance to future applications of the product is the capability for remote events to exist entirely within the medium and be self-contained. Currently, webinar software and web-based simulations allow collective play and communication yet players must move between mediums to exploit the functionality inherent to both. Within VirBELA players can participate in the simulation activity and move to breakout rooms, collaborate and communicate and work in real-time, all without leaving a single environment.

From a research perspective, there is a growing body of work which suggests a transition from traditional approaches to learning, knowledge transfer and dialogic methods of interaction with tutors to the potential of virtual worlds where more complex social interactions, designed learning experiences and role plays can flourish. It is the intersection between this growing research field and concordant developments in the application of simulations in business education which define the research opportunity unique to VirBELA.

4. Objectives of the Demonstration

- To discuss virtual environments and their utilization in immersive education, leadership development and virtual team performance
- To provide perspective on what were and are the challenges to developing a virtual learning environment
- To consider how global leadership competencies can be developed in virtual environments
- To explore how business simulations can be utilized to engage, challenge and develop global leaders

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