

iLRN 2016 Santa Barbara

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

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Main Conference Preface

ILRN 2016 is the second annual international conference of the Immersive Learning Network. It follows on from the inaugural conference held in Prague in July 2015. The topic is becoming increasingly relevant as the power and affordability of suitable computers, mobile devices, network connectivity and interface technologies has made virtual and augmented reality environments more accessible than ever before. ILRN's mission is to stimulate the use of, and share knowledge about, these exciting technologies as they are applied effectively in education and learning scenarios. This requires both fundamental and applied research. ILRN aims to develop a comprehensive research and outreach agenda that encompasses the breadth and scope of all the learning potentialities, affordances and challenges of immersive learning environments. To achieve this, the ILRN has invited scientists, practitioners, organizations, and innovators across all disciplines to report on their research in the ILRN 2016 international conference. Twenty-three papers were received for this event and after a rigorous reviewing process nine were selected as full papers for a Springer published volume and 2 as full papers for this online proceedings volume, which also includes the texts of three posters. Papers in the main conference report on the use of immersive learning environments to address a variety of educational challenges and environments, with the use of virtual worlds in corporate training and programming using immersive environments as the foci. The authors of these papers hail from Austria, Australia, the UK, Germany, Portugal, Scotland, and in the United States, North Carolina and Oregon.

The main conference includes a keynote by Informatics guru Crista Lopez (University of California at Irvine), as well as featured lectures by Virtual Reality psychologist Jim Blascovich (University of California at Santa Barbara), McKinsey Social Initiative's Ben Erlandson, Daniel Livingstone (Glasgow School of Arts Digital Design Studio), Geoff Pepos (StoryclockVR.com), Wiggle Planet's Jeffrey Ventrella, and Learning Technologist Scott Warren (University of North Texas). Posters cover fascinating topics such as the immersive aspects of EcoCities and collaborative games. The Science Fiction prototyping methodology workshop this year is sponsored by Creative Science Foundation and led by Vic Callaghan (Essex University).

We hope you will find this collection of papers informative and engaging. We encourage you to join ILRN and participate in future events.

Colin Allison and Leonel Morgado,
ILRN 2016 Main Conference Programme Co-Chairs

Keynote and Featured Speakers

Designing for Attention in Virtual Environments (How a Camera Changes Everything)

Crista V. Lopes

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Abstract. 3D virtual environments are a new world for user experience design. Unlike 2D media, they include the 3rd dimension, which gives people a lot more degrees of freedom with respect to what to pay attention to. And unlike the physical world, they can be programmed. This talk focuses on the latent, yet largely unexplored, use of programmable cameras for designing user experiences in virtual environments, and how this can affect learning environments.

Keywords: Virtual cameras, 3D interaction

Some time ago, two of my PhD students were facing the prospect of going away to do their research elsewhere for a few months. In both cases, and for different reasons, it made a lot of sense for them to go. But we needed to stay in touch, and I needed to keep tabs on what they were doing. These days, with tools like Skype and Google docs, collaborating over the Internet is really easy. However, neither Skype nor Google docs are designed for supporting the specific kinds of interactions that go on between advisor and student, and within small academic units (aka “Labs”). First, we need to run them both independently. Second, and more importantly, we can’t really share a PDF or Powerpoint document in the way that we do when we are working face to face going through a paper or a presentation — pointing, highlighting, using words like “here”, “this paragraph”, “this picture”, “go to next page”, etc. So I built my own virtual lab.

Google docs allows for shared editing, and it is very good at supporting independent interactions on the same document — that’s its value proposition. But that’s also its weakness: my interactions on the document are independent of yours. I can be looking at the beginning of the document and talking about text in there, and you won’t know what I’m referring to unless you happen to also be looking at the same part of the document and I use absolute references like “paragraph 3”, etc. With Google docs, we may not even be on the same page, literally, and this is quite different from the interactions that happen face-to-face over someone’s computer or a projector. Both forms of interactions (i.e. independent editing of the same document and shared visualization of a document) are valuable and serve specific needs. Google docs just happens to serve the former very well, but not serve the latter too well. I needed the

latter, because that's what we do in my Lab when we meet to work on papers and presentations.

So I decided to use a virtual world with voice. I happen to be a developer of a Second Life -like server, OpenSimulator, and this seemed like a great opportunity to eat my own dog food, now that there's enough good 3D content out there that I don't need to go build 3D models myself (an artistic skill that I don't possess). I also took advantage of Vivox's generous donation to indie games, so my OpenSimulator environments all have voice. I started with the Universal Campus, a Creative Commons build done by someone we hired. But as I viewed the virtual environment through my students' eyes, it was pretty clear that these 3D virtual worlds are also not enough to support the kinds of interactions that I wanted.

First of all, the UI of 3D world viewers is such that it gives way too much freedom to the users, more than they can handle, especially if they aren't experts of these 3D UIs — and very few of my students are. The concept of the camera is really foreign to someone who is not used to free-roaming 3D environments. Even for people who are used to them, there is no standardized way of moving the camera; each virtual world viewer / 3D game does it differently. In the case of OpenSimulator, the Second Life viewers do it with a non trivial combination of keystrokes and mouse manipulation — physical coordination that requires a lot of practice! People who are new to these environments get lost very easily as to what exactly they should be paying attention to — a classic UI failure mode. It was clear that if I wanted to build the virtual collaboration environment I had in mind, I had to do it myself on top of an existing one.

I first considered building on Mozilla's JavaScript PDF viewer. It's great, because it's all JavaScript, runs everywhere. I quickly gave up, though, because making it multi-user and programming the multi-user interactions was going to be a daunting (albeit fun) task for which, unfortunately, I had no time. So, I came back to OpenSimulator, because it already has all the server-side infrastructure for multi-user interactions. I just needed to make the UI more constrained than what it normally is. I also needed to figure out a way of supporting PDF documents. After studying possible approaches, I was able to do both of these things.

The camera constraints are done with an existing function (`llSetCameraParams`) for the server to control the user's camera. SL and OpenSimulator aficionados may not like this kind of control, because they know how to control the camera, but it is so useful for new-comers who don't! It eliminates much complexity when it comes to pointing people to where they should be looking at.

Having these technical pieces in place, I then proceeded to the other fun part of the project, which was to model the specific face-to-face interactions that go on when I work with my students in the real world Lab. There are basically four kinds of things we do: (1) we do dry-runs of presentations over a single computer screen or projector;

(2) we work on papers together, again sharing a single computer screen or a projector; (3) we work on the same paper independently, on two or more computers; and (4) we browse the web together on a single computer screen. My virtual Lab (vLab, for short) has 4 “stations”, each one specifically designed for these 4 kinds of interactions. In my talk, I describe my experiences with designing and using these stations.

Self-Animated Characters in Augmented Reality for Emotional Intelligence and Personal Empowerment

Jeffrey Ventrella
StoryclockVR.com

Some people say technology is morally neutral - it's the humans that take it in a positive or negative direction. The problem with this idea is that humans are the ones who make the technology in the first place, so it's never really neutral.

Most would agree that educational technology is generally focused in a positive direction. However, when educational technology borrows tools and components from the commercial world (which is almost unavoidable), some bad comes along with the good.

I believe that corporate-driven commercial technology is driving us apart at the same time that it is bringing us together. And it is also separating us from our original nature. Mother Nature is our best teacher; we need our technology to bring us closer to ourselves, and the original nature from which we emerge. Our natural ancestry will remain deep in our DNA, even as we ride the fast train to post-humanism. Educational technology needs to take this into account - as we make the slow and painful exit from brick-and-mortar School to the open Commons of technical empowerment.

There is a lot of talk about artificial intelligence these days. But AI is largely built upon language, algorithms, and symbol manipulation - requiring the activation of the outer-most layers of neocortex. The limbic system, cerebellum, and visual cortex are old - they play a key role in how we learn, remember, and navigate the complex world with all our senses. Can artificial intelligence be deployed to engage these ancient and comprehensive facets of our mammalian brains?

Could artificial intelligence be evolved by teachers, students, artists and lovers – and not just by Google engineers? Can it be driven by other goals besides corporate profit?

Wiggle Planet

I started a project over three years ago, which I call *Wiggle Planet*. It is a technology that features self-animated characters (wiglets) who display universal body language. They are built from the ground up to run entirely in software. They are designed specifically for geolocated augmented reality. Wiglets embody the idea of situated artificial intelligence, with *emotional intelligence*.

This technology places the creation of animated character design into the hands of children - who can breed them (by crossing the genes of two wiglets), and place them in arbitrary places in the world (using geolocation technology). Our database currently

holds the unique genotype of each wiglet, along with its geolocation on planet Earth. We will be adding a "memory" component, which will allow situated data of many types to be stored in association with each wiglet, and extracted from that wiglet (in fun and playful ways).

While most forms of digital media expect to be copied infinitely, a single unique wiglet can live in only one place at a time; it cannot be copied or deleted; and it cannot be teleported. These characters correspond to the metaphor of real-world animals, situated in place and in time, perceiving their local realities, and expressing their inner-states.

Wiggle Planet technology is all about decentralization. No expensive animation studios are required to create these characters, and their genetic variations are practically infinite.

Artificial Life in Augmented Reality

The latest *virtual reality* craze will hopefully die down before the lawsuits start flying (as people start getting sick, walking off cliffs, and going crazy). *Augmented reality* is a different story. It's about the real world with an extrasensory overlay. Our eye-inner-ear-brain systems are much better at handling a coordinated mixture of real and unreal. Besides, augmenting the real world has healthier educational implications than escaping into an orchestrated hallucination.

Imagine seeing and engaging with artificial beings, who not only can breed and evolve, but can also provide situated, meaningful information about the locations in which they live. When we are all wearing AR glasses a decade from now, it will be a joy to have virtual companions with emotional intelligence. They will carry their own ancestry, and a connection to their places and times they've experienced with other humans. They might even become teachers of the future.

And most importantly: they will grow with us and for us. They will flourish in the Commons, outside the power-regimes of large established institutions (such as Google, Disney, or a national government).

Social motivation in immersive environments

Jim Blascovich

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Immersive virtual environment technology can greatly aid our understanding of social influence, social interaction and other areas of research in social psychology. This technology allows researchers to test theoretically-based hypotheses and maintain complete control over a variety of factors in social situations, from the physical appearance of the virtual world to the behavior of virtual others in the world. This degree of experimental control is not accompanied by the usual decrease in the realism of experimental settings that are associated with traditional research methods. By allowing researchers to increase the realism of social situations, this technology also promises to enhance the generalizability of results obtained in experiments to the natural world. Furthermore, virtual environments can also be used to implement "impossible" experimental manipulations such as changing the physical (i.e., skin color) and social (i.e., gender) identity of research participants. Finally, what we learn about social interaction by using this technology may be leveraged to enhance the realism and utility of immersive environment technology.

Jim Blascovich's two major research interests are social motivation, and social influence within technologically mediated environments. Relevant to the former, he has developed a biopsychosocial model of challenge and threat. He has validated patterns of cardiovascular responses as markers of challenge and threat using them along with subjective and behavioral measures in empirical investigations guided by his theoretical model. He has applied his model to various social phenomena including intra-individual processes such as attitudes and dispositions as well as inter-individual processes such as stigma, stereotypes, social comparison, and social facilitation. Jim is also co-Director of the Research Center for Virtual Environments and Behavior with Jack Loomis, a perceptual scientist in the department. He uses immersive virtual environment technology to empirically investigate social influence processes within virtual environments including conformity, non-verbal communication, collaborative decision-making and leadership. This work is guided by his formal model of social influence within immersive virtual environments.

Selected Publications

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Blascovich, J., Mendes, W.B., Vanman, E. & Dickerson, S. (2011). *Social Psychophysiology for Social and Personality Psychology*. London: Sage.

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Mendes, W.B., Blascovich, J., Lickel, B., & Hunter, S. (2002). Challenge and threat during interactions with White and Black men. *Personality and Social Psychology Bulletin*, 28, 939-952.

Mendes, W. B., Reis, H.T., Seery, M., & Blascovich, J. (2003). Cardiovascular correlates of emotional disclosure and suppression: Do content and gender context matter. *Journal of Personality and Social Psychology*, 84, 771-792.

VR Glacial Lake Missoula, 10,000 years in the past, or 10,1000 years into the Future

Geoffrey Pepos

StoryclockVR.com

Geoff is one of “The Versatilists.” What was the process of becoming one? What struggles were faced and continue to be faced on the journey? Are there any shortcuts? Compromises? Tricks? Is there a key? How does one learn to be one? Is there a way, a method to help educate fledgling versatalists?

During the first half of the session, utilizing “VR Lake Missoula” as a live lab, he’ll explore utilizing an interactive story with sound, music, graphics and code.

During the second half, rather than a traditional Q & A, Geoff will facilitate a “Lean Coffee” Session, a structured, but agenda-less meeting. Participants gather, build an agenda, and begin talking. From the lean coffee web site: “How much time do you waste in meetings? If you’re not facilitating and didn’t write the agenda, are you fully vested in the meeting? Wouldn’t it be great to eliminate some of the waste (and get your time back)?”

Pepos, who founded next-generation media company **StoryclockVR.com**, has a diverse field of interests, which includes documentary and feature filmmaking, sound design, music composition, interactive art installation, and software development. In 2001, he served as producer, cinematographer, editor and composer for “Some Body,” which was picked as an official selection for the Sundance Film Festival Dramatic Competition. It was the first film in Sundance Competition to be completely created and projected digitally. He was also an organizer for Startup Weekend Missoula and is on the board for the Open Space Conference MACHmissoula.org, Montana Agile Culture House.

He also produced and edited a compelling PBS documentary, “South Central Farm: Oasis in a Concrete Desert,” about the struggle to save a Los Angeles urban farm from destruction by a property developer.

His first foray into art and technology was to record saxophone and clarinet duets with himself using a pair of cheap cassette recorders. As a kid, his father brought home a PC and asked him to build an accounting system for his business. While Geoff did not build the first iteration, he was keen on learning from the programmers. Subsequently he did continue the development and reimagining of the system through four languages and three operating systems. Mr. Pepos began working in virtual reality in early 2015, a medium that ultimately blends his skills in film, music and code.

Transmedia for Immersive Learning: The Design and Study of Alternate and Augmented Reality Play Experiences

Scott J. Warren

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Henry Jenkins popularized the term *transmedia storytelling*, emphasizing the role of narrative as a learning support structure. Various authors have noted stories function as important cognitive events, collected to meaningfully synthesize information, knowledge, context, and emotion in a concise delivery platform. Transmedia storytelling and learning game play involves systematically distributing narrative elements, communicated across multiple delivery channels to create an integrated experience. Related literacies include play, performance, simulation, distributed cognition, collective intelligence, and negotiation, akin to what present in other immersive learning games. When used in education, transmedia learning involves cross-platform storytelling and play experiences that make cognitive connections to content, language, and media affordances. This talk will discuss what immersive transmedia is and how it has been applied to support learning multiple forms of literacy through matches among. It will explain the rapid design and development approaches taken over the years to design alternate, augmented reality, and transmedia learning experiences in *The Door*, *Broken Window*, *Villainous*, and others. Further, he will talk about how we can validly study these complex, distributed learning experiences with the goal of understanding how they can support higher order thinking and modern digital literacies.

We can design with story using the concept of *transmedia*. Lebrecht (2010) explained transmedia as a form of shared, social, media experience rather than a “social media” experience. He attributed the term to Marsha Kinder and her 1991 book *Playing with Power in Movies, Television, and Video Games: From Muppet Babies to Teenage Mutant Ninja Turtles*. The popular use of the term transmedia is credited to Henry Jenkins, who also posited the idea of “Transmedia Storytelling” for cross-platform collaborative, narrative development.

This presentation first discusses the role of transmedia as it has evolved as an educational approach taken from what was once a marketing tool in the 1990s and early 2000s. Early concepts ranged from *The Blair Witch Project's* distributed web sites and associated video clues to AI's professionally developed alternate reality game *The Beast* to today's multi-platform augmented reality games that support movies and television, touching upon nearly every form of available media. From this discussion, we will examine how to design and manage the rather complex task of developing a distributed a story-based transmedia game that spans the Internet. This

will come through examples from educational transmedia games and experiences used in higher education settings such as *The Door*, *Broken Window*, and *The 2015 Project* (Warren & Najmi, 2013). This leads finally to a discussion of how one studies games distributed across the web to determine their learning efficacy.

Depending on one's view, transmedia encapsulates distributed short experiences with minor narrative flow to large scale alternate reality games like *Year Zero* and *World Without Oil* (McGonigal, 2011), and augmented reality games such as *Ingress*. Transmedia experiences can help students "actively seek out content through hunting and gathering processes which leads them across multiple media platforms" (Jenkins, 2010). They blend story, characters, and narrative, each extended through the use of social and other media or everyday productivity tools to solve problems, hunt down information, or interact with fictional characters and classmates. When learning with transmedia, students are often given a story by the teacher, and develop their character and collectively further the plot through their interactions with virtual, role-played characters. In others, the story evolves in response to real-world actions that shape it in the form of news stories, social media responses, and student collaborations (Warren & Wakefield, 2014).

In collaboration with the instructor, the transmedia story plot may begin through the reading of a designed textbook, watching a video, or listening to a presentation. The learner learns base knowledge and norms needed to succeed. They build themselves as a character in the story (them/not them) as they collaboratively communicate, explore subject matter, discuss, share experiences, collectively building the story with the instructor, in our case, using theory geared towards fostering media-based "communication towards instructional and learning goals" (Wakefield, Warren, & Alsobrook, 2011). It further helps shape both the designer and instructor's point of view as to what it is to learn, teach, assess, and design instruction, without the limits of learning management systems or other systemic constraints.

Transmedia can further free designers from individual media constraints that come with video or digital text blended in a 1990s "multimedia" fashion. Instead, educational transmedia can combine construction activities and tools such as the use of linked media, cell phones, and videos with the compelling narrative that emerge through student interactions. Students can play alternate and augmented reality games designed for them or may learn to design their own in order to show mastery of digital literacy skills and/or tools, showing what they know in place of tests and papers that may be unengaging or turn students away from learning.

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Immersive Learning: Realism, Authenticity & Audience

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1 Overview

Advances in 3D and immersive technologies have, to a large extent, prioritised the production of photo-realistic 3D spaces. Added to this, the past decade has seen audio increasingly recognised for its key contribution to immersion in both games and 3D immersive learning. Through a range of projects, the Digital Design Studio staff have been producing immersive and detailed photo-realistic 3D environments for almost 20 years, now supplemented with work in 3D sound. However, we also recognise that there are problems and limits inherent in the use of photo-real and acoustically real environments for education and learning.

A photo-realistic appearance may have more visual detail than other modes of representation and definitely implies greater accuracy, but the greater detail might not be useful, and the implication of accuracy may not be wholly warranted and can even be misleading. Representative sketches harness the power of abstraction – simplifying or removing detail to allow greater focus on relevant content and reducing cognitive load. Similarly, in engaging with a photo-realistic model of, say, a Roman villa, the level of visual detail provided might lead users to assume that similar levels of detail apply to the behaviours of virtual actors in that environment and that their actions and interactions are similarly grounded in a deeply researched understanding of the social lives of Roman civilisation.

In tandem with the issues arising from an unwarranted impression of realism there are other, intangible, aspects of real places and artefacts that are more difficult to capture and recreate digitally. From open to close, daily, at the British Museum, there is a near constant press of bodies vying for a glimpse, through glass, of the Rosetta Stone. A replica, produced from a cast of the stone, sits in relative obscurity nearby – as a copy it lacks both ‘aura’ and a sense of authenticity, and is treated as little more than a curiosity. What extra value does the original hold that justifies the jostling crowds hoping for a few seconds of unimpeded viewing through glass? What hope do we have of being able to capture this quality digitally?

Immersive learning is thus pulled in different directions, and faces some genuine struggles in meeting conflicting aspirations. Striving for photorealism results in costly development processes, and while we can look to technologies such as photogrammetry and co-production processes to reduce costs, it can result in

immersive learning environments that are themselves problematic in interpretation. Whether or not we are able to reproduce some semblance of authenticity (c.f. [1]) – as opposed to realism – in our immersive environments, there remain key questions on the extent to which our use of 3D games, virtual worlds and Virtual Reality is helping learners to understand and evaluate the complexities of the world around them.

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Finding Learning Everywhere: Learning Systems Design, Implementation, and Research Collaboration

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As we continue to solidify the Immersive Learning Research Network, what are some practical ways forward for collaboration across key stakeholders with various levels of participation in this network? Highlighting several key exemplars presented at iLRN 2016 as well as additional examples from ongoing development projects at McKinsey Social Initiative, Dr. Erlandson will look across learning environments, modalities, and spaces to discuss a learning systems approach as a pragmatic way forward for better understanding and continued support of lifelong learning (or, life as learning) across the spectrum of immersiveness. Major topics covered include learning systems, assessment, communities of practice and social learning, systems thinking, and how practical collaboration to solve real eco-socio-technical problems can actually manifest between designers, developers, researchers, and governments.

Learning systems design treats learning as purposed communication requiring continued arrangements of people, information, technologies, and spaces over time. Designing for assessment, guidance, and personalization in these systems requires a keen attention to data flow about user and system behaviors (performances) for which a standardized framework, the Experience API (or xAPI) is explored from the perspective of extensibility for scalability. Assessment design as a continuous, integrated, iterative process for learning systems is discussed in terms of the cognitive models of evidence centered assessment design (ECD) as well as its four-process architecture for delivery in a variety of technical and non-technical environments. Tasks and work products associated with these design and delivery frameworks are explored through the lens of the four space model of simulation-based assessment, and how xAPI data can be structured around a learner's behavior/performance in these spaces and contexts, including the usefulness of these data for assessment decisions by both the human assessors/evaluators and the systems themselves as sets of artificially intelligent algorithms.

Exploring life as learning as an ongoing series of systems experiences for individuals and groups of people, learning systems are then explored as communities of practice and social learning systems, and life learners as participants in larger systems in which these learning systems are embedded. From this perspective, systems thinking and systems wisdom are explored, leading to the crux of the issue: practical collaboration between designers, developers, researchers, and governments -- all of us lifelong learners, whether we like it or not -- for solving real eco-socio-technical problems that have arisen in this world, caused by us.

Main Conference Papers

Requirements for the use of virtual worlds in corporate training

Perspectives from the post-mortem of a corporate e-learning provider approach of Second Life and OpenSimulator

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Abstract. Between 2009 and 2011, a joint academia-industry effort took place to integrate Second Life and OpenSimulator platforms into a corporate e-learning provider's learning management platform. The process involved managers and lead developers at the provider and an academic engineering research team. We performed content analysis on the documents produced in this process, seeking data on the corporate perspective of requirements for virtual world platforms to be usable in everyday practice. In this paper, we present the requirements found in the documents, and detail how they emerged and evolved throughout the process.

Keywords: virtual worlds, corporate e-learning, Second Life, OpenSimulator, requirements, training

1 Introduction

Data about use of virtual world platforms in corporate training is scarce [2]. Between 2009 and 2011, a joint academia-industry effort integrated Second Life¹ (SL) and OpenSimulator² (OpenSim) virtual world platforms into Formare³, a corporate e-learning provider's learning management system (LMS). The process was developed by managers and lead developers of this platform at that provider, Portugal Telecom Inovação, now Altice Labs⁴, (PTIn), who develops and provides Formare for training of its own employees and those of other large corporations in Portugal and Brazil, and a research team at the University of Trás-os-Montes and Alto Douro (UTAD).

We collected all documents produced in the process, and submitted them to content analysis, seeking data on the corporate perspective of requirements that virtual world platforms must fulfill to be usable in regular training. Here, we present the requirements found in the documents, and detail how they emerged and evolved throughout.

2 Related work

Virtual worlds enable specific approaches to training, particularly cooperative learning, situated learning activities with visual, concrete contexts for actions and concepts [2], and group learning dynamics in distance learning contexts [3]. However, the affordances they enable for learning and training are often lumped with other simulation-oriented approaches to corporate training, including the use of serious games [4].

This may contribute to the current situation where reports on actual virtual world use for corporate training, beyond mere account of its existence, are few. In 2004, Nebolsky et al. argued for the feasibility of conducting corporate training in virtual worlds, presenting the concept and a leadership training course [5]. In 2008, Hansen et al. collected perspectives from 25 business executives on virtual worlds use for organizations, after experiencing SL, identifying tensions in expectations between benefits and challenges, four related to training and distance learning applications: first-mover status (exposure & risk vs. future stable platforms), sociality (collaboration vs. poor communication), experience (immersion vs. credibility), and social benefit (expressiveness vs. lack of physical interaction) [1]. In 2012, Azadegan et al. [6] presented results of a pilot survey of UK-based corporations, to assess the level of awareness and adoption of serious games, including virtual worlds. From 21 companies responding, only 6 were aware of serious games. Major barriers for adoption were financial, low familiarity with virtual worlds, and lack of knowledge

¹ <http://www.secondlife.com>

² <http://opensimulator.org>

³ <http://www.formare.pt/>

⁴ <http://alticelabs.pt/>

about practicality. In 2013, Massey et al. researched the benefits of virtual worlds in corporate learning, focusing on impact of the feeling of presence into teamwork and from both into learning and performance, extracting empirical measures of this relationship [7].

To the best of our knowledge, there are no published data on actual requirements for virtual world use in corporate training, from a software engineering perspective. One may reasonably take the “practicality” concern identified by Azadegan et al. [6] and hypothesize issues such as integration with learning management systems (LMS). However, known approaches for these issues, such as SLOODLE [8], take a trainer/teacher-centric perspective, not an organizational perspective. Hence, we intend to contribute a first set of requirements gathered from the field.

3 Context

PTIn is an innovation provider then part of the Portugal Telecom (PT) group, and now within the larger Altice business group: it conducts technology research and innovation, yielding prototypes that are marketed to other companies within the group or directly to end customers. Formare LMS is one of its products, targeted at large-scale e-learning clients [9]. This impacts the identified requirements, since concerns reflected in the source documents require consistency with the support of this target group. E.g., administrative management support, not just for trainers and trainees, but also for coordinators of several groups of trainers and trainees, another example is the concern with content management across different courses and different trainers.

4 Data collection

4.1 Overview

For context, we disclose prior contacts between PTIn and UTAD regarding virtual worlds. Cooperation between these organizations became a joint effort after early contacts and informal cooperation. In 2006, individuals in both organizations started exploring SL, which had begun to surge in worldwide interest. This eventually evolved into organizational involvement and by 2007 both organizations had visible activity in SL: PTIn had acquired its own simulator and UTAD was researching the use of SL for higher education and on software engineering that approached SL as a platform for information systems integration.

Throughout this period, informal contacts between these organizations occurred serendipitously, leading to exploratory academic cooperation efforts, namely in late 2007 a successful joint research grant application to the 2008-2009 Innovation Plan of the PT group (which sponsors research and innovation cooperation between universities, research centres, and PT affiliate companies). This was not yet focusing on e-learning platforms, but on systems integration of SL with SMS and messaging

systems, and originated the first exploratory cooperation efforts in generic e-learning systems in early 2008, via joint UTAD-PTIn supervisions of undergraduate projects, and subsequent successful joint research grant applications to the 2009-2010 and 2010-2011 Innovation Plans of the PT group, focused on integrating SL and OpenSim with PTIn's own Formare LMS, with the ultimate goal of enabling PTIn to offer virtual world-based activities and spaces as part of its corporate e-learning management services offering. These projects, MULTIS and MULTIS II, form the core data collection sources for this paper. A third unsuccessful joint research grant application to the 2011-2012 edition of Innovation Plans of the PT group provides the final set of data.

Table 1. Data collection events timeline

Event ID	Date	Summary
E1	2008-Feb	Joint undergraduate project proposals
E2	2008-Sep	Joint grant proposals to the PT group innovation plan
E3	2008-Oct	MULTIS - grant contract consolidating E2 proposals
E4	2009-Apr-30	MULTIS project kickoff meeting – MULTIS meeting 1
E5	2009-Jul-09	MULTIS meeting 2
E6	2009-Sep-03	MULTIS meeting 3
E7	2009-Oct-30	MULTIS meeting 4
E8	2009-Dec-16	Presentation of MULTIS in internal PTIn seminar
E9	2010-Jan-31	Joint grant proposal to the PT group innovation plan
E10	2010-Feb-03	MULTIS final meeting – MULTIS meeting 5
E11	2010-Feb-24	MULTIS II grant contract
E12	2010-Apr-30	MULTIS II kickoff meeting – MULTIS II meeting 1
E13	2010-Jun-18	MULTIS II meeting 2
E14	2010-Jul-23	MULTIS II meeting 3 and resulting documents
E15	2010-Sep-09	Formare business unit seminar at PTIn
E16	2010-Oct-06	MULTIS II meeting 4
E17	2011-Feb-11	MULTIS II design report
E18	2011-May-05	MULTIS II final meeting – MULTIS II meeting 5
E19	2012-Mar-08	Workshop of the PT innovation plan

4.2 Data procedures

We started by collecting documents from project teams' archives. These were organized into a timeline to identify documented events. We numbered each event as En (Table 1). As presented ahead, we identified documents in each event by a lower-case letter after the event name, e.g. "E1a" for document "a" of event "E1". We analyzed each document for requirements identified either directly or as underlying (stated features and objectives). We also looked for data providing indirect identification of requirements: screen prototypes, screenshots, written rationales for decisions, and descriptions of implementation-related details. Every first occurrence of an element was identified with the letter "R", the event number, and a lower-case letter, and associated with the source document. E.g., "R2f" means: requirement first

identified as the sixth new data element ("F", following alphabetic order) of event E2, and we recorded in which document(s) it was found. Whenever analysis of further documents clarified a prior requirement with extra details, those details were lifted as sub-requirements of the first one, with the same requirement label and appending a hyphen and sequence number. E.g., "R2f-1" means: sub-requirement 1 of requirement R2f. We also recorded in which document(s) each sub-requirement first occurred.

4.3 Data elements summary

2.1.1.1. E1 - Joint undergraduate project proposals

Data elements: undergraduate project proposal documents (E1a, E1b). Following earlier informal contacts, we proposed these, developed Feb-Jun/2008 with joint supervision by UTAD faculty and PTIn's Formare team members. E1b stemmed from UTAD research interests, was not corporate-originated, hence we only mention its occurrence because the joint supervision included PTIn's Formare team members, and its impact is noticeable in requirements identified in subsequent events E2 and E5, where the PTIn team acknowledges E1b as the source of inspiration.

2.1.1.2. E2 - Joint grant proposals to the PT group innovation plan

Data elements: research grant proposals (E2a, E2b). Following E1, on Sep 2008, these were submitted to the innovation plan of the PT group. E2a proposed making 3D virtual world platforms available within a large-scale distance training service. It acknowledged E1b as inspiration for its requirement of recording the behaviors of actors (R2a) or other elements (R2b). The explicit purpose of E2a was enabling a trainer to request them during a training session (R2c), and executed entirely (R2c-1) or step-by-step (R2c-2), using small, trainer-oriented, specific-purpose applications (R2c-3). A final requirement (R2d) was that the recording methods should be generic and thus applicable to other professional training scenarios. A stated goal, which we interpret as a requirement, was the creation of focused and efficient methods for the development of simulations (R2e) in SL and OpenSim, to enable agile development of short simulation modules. E2b proposed to automatically create and manage synchronous training sessions (R2f) in SL and OpenSim. Mentioned shortcomings were the scheduling 3D training sessions (R2f-1), selecting features of the training space (R2f-2), and defining participants (R2f-3). The need to conduct these tasks at the administrative level, without encumbering training coordinators with technical issues (R2f-4) was explicitly mentioned, as was automated support for the administrative workflow (R2g), clarified as: sending notices to trainees with a link to access the space (R2g-1); supplying trainees with the 3D elements for each session (R2g-2); tracking attendance of sessions (R2g-3). The stated goal was to achieve an integrated solution for using virtual worlds as part of the LMS (R2h).

2.1.1.3. E3 - Single grant contract (consolidating E2 proposals)

Only E2a was selected for funding, alongside a recommendation by the Formare LMS business unit that it should be combined with E2b to generate a single project (later named MULTIS in E4). Data element: the contractual agreement (E3a). Prior requirements were included: R2f, R2h, R2a, R2c, R2g-3, R2f-3, and R2c-3. A new requirement was introduced: recording trainers' use of virtual world tools (R3a).

2.1.2. E4 - Project E3a kickoff meeting – MULTIS meeting 1

Data elements: meeting minutes (E4a), and PTIn team’s slideshow (E4b). In E4b, requirement R2f and R2h were the main goals, but in E4a the emphasis was R2h.

2.1.2.1. E5 – MULTIS meeting 2

Data elements: meeting minutes (E5a) and a technical report (E5b). In E5a, development priorities shifted to requirements R2f-3 and R2f. In E5b, earlier requirements were detailed and subdivided. R2f was interpreted as virtual world sessions being a new type of synchronous session besides existing chat/video conferencing. This required as properties: location of a preexistent space (R2f-5) or specification of the space to be created (earlier: R2f-2). R2f-2 was clarified to include the spatial arrangement of the virtual space, its size, available interactive elements (e.g. slide projectors), and the list of authorized participants (earlier: R2f-3). Further R2f sub-requirements: virtual world user identification done via LMS credentials (R2f-6), LMS usernames having SL/OpenSim usernames automatically assigned (R2f-7), and users able to provide preexistent usernames (R2f-8). E5b clarified R2a as “3D choreography” and R2g-2 as “3D model”. R2a and R2g-2 are clarified as new content types of the LMS. E5b mentions making choreographies available (earlier: R2c), and requires the system to accept content provided by/for trainees: choreographies (R5a) and 3D models (R5b). Choreographies are clarified as comprising the behavior of several avatars and their encompassing space and objects (subrequirement R5a-1). E5b also includes further planned features, identifying sub-requirements of session management (R2f): text chat (R2f-9) and audio recording (R2f-10) during sessions; the ability to split communication among subgroups of participants (R2f-11); and the ability to edit room features after its creation, even while a session is ongoing (R2f-12). Still in E5b, storage of 3D models and choreographies is required independently of sessions (R5c), and reusable across sessions and courses (R5d).

2.1.2.2. E6 – MULTIS meeting 3

Data elements: meeting minutes (E6a), a set of prototype images of a training room (E6b) and a set of use case and sequence diagrams (E6c, no new requirements). E6a established new features. The virtual 3D space was seen as a course feature, independent from sessions (R6a), and with history of visits (R6a-1), controlling access (R6a-2), and the ability to select features of the space (R6a-3). Earlier requirements R2g-3 and R2f-9 are mentioned as having been discussed and validated. Earlier requirement R2h is clarified with a list of LMS features required in the 3D space: warning & notices (R2h-1), multimedia content projection (R2h-2), location to access LMS-stored 3D content (R2h-3), delivery of text documents (R2h-4), presentation of summaries (R2h-5), a box for trainees’ to send doubts and feedback to the LMS (R2h-6), and an object to support inquiries (R2h-7). A new trainer heads-up display tool is mentioned for limiting trainees’ audio communication, in case of conferencing disruptions. We extracted: ability to mute audio communications (R6b) and the tool to manage this (R6b-1). E6b yielded: a “welcome” area in the virtual world with doors serving as links to other areas of the training space. SL/OpenSim users will recognize it as a teleport hub, i.e., a location index for orientation of virtual world users (R6c).

2.1.2.3. E7 – MULTIS meeting 4

Data elements: meeting minutes (E7a), and two documents: Requirement analysis (E7b) and a design (E7c, no new requirement). In E7a, sub-requirement R2h-7 was abandoned to minimize development effort, due to reported minimal use. A new 3D feature was requested: a course information panel, sourced from the LMS (R2h-8). E7b organized earlier elements and clarified details, but introduced few new requirements: that authentication data should be identical between the Formare LMS and the OpenSimulator platform, which we interpreted as federated authentication (R2f-13); that elements of the virtual space should adapt to the number of users, e.g. seating spaces (R7a); that users have a note-taking tool (R7b); a private trainer tool for controlling slideshows and videocasting (R7c).

2.1.2.4. E8 - Presentation of MULTIS in internal PTIn seminar

The data element for this event is its slideshow used, including video demonstrations (E8a). It provided further clarification on prior requirements, but no new ones.

2.1.2.5. E9 - Joint grant proposal to the PT group innovation plan

Data element: new joint grant proposal for the PT group innovation plan, named “MULTIS II” (E9a), as the MULTIS project neared completion (its final meeting, E10, was three days after E9). A requirement expressed in it is that the LMS must be the source of control and management of virtual world educational activities (R9).

2.1.2.6. E10 – MULTIS final meeting

Data element: meeting minutes (E10a). No new features or requirements, but clarifications such as Web services and settings files as modularity strategies. This led us to define a new requirement: virtual world features should strive to be implemented with separation of concerns and modularity regarding the LMS platform (R10).

2.1.2.7. E11 – MULTIS II grant contract

Grant proposal E9a was approved with modifications and specified in a grant contract which is the data element for this event (E11a). A new requirement is the existence of tools and methods to track the deployment and user adoption process (R11).

2.1.2.8. E12 - MULTIS II kickoff meeting.

Data elements: project presentation slideshow (E12a) and meeting minutes (E12b). E12a new requirements: existence of a virtual platforms training plan for users (R12a) and tools to support it (R12b). The minutes didn't bring any new requirements.

2.1.2.9. E13 - MULTIS II meeting 2

Data element: meeting minutes (E13a). They clarify control of trainees by the trainer (R6b). New requirements: users may take on different roles in each 3D session (e.g., participant or moderator), regardless of their roles in the course (R2f-14); avatars should always be associated with real names (R13a); there should be alternatives for user identification using avatar appearance (R13b), with sub-requirements being avatars without visual user identification (R13b-1), with an ID badge (R13b-2), and with user facial photos on avatar faces (R13b-3). Further, moderators should also be clearly distinguishable among other avatars (R13c). A clarifying sub-requirement for R11 was found: a dashboard for quality monitoring (R11-1). More requirements: preventing users' from changing their avatars' appearance (R13d) or their virtual world login passwords, bypassing the LMS (R13e). R2f resurfaced, consolidating

recording of chat, audio, and choreographies of a full 3D session (R2f-15) and replaying them (R2f-16). Another requirement: ability to annotate raw data from a session recording (R13f), enabling different detail levels for reproduction, such as full events or only key points (R13f-1). Finally, for audio conferencing, there should be alternatives (R13g) using in-world spatial audio (R13g-1) or an external system (R13g-2).

2.1.2.10. E14 - MULTIS II meeting 3 and resulting document

Data elements: July 23rd meeting minutes (E14a) and a technical report (E14b). E14a provided no new requirements, but mentioned that details were discussed and a report would be produced within a week. One of the collected documents is titled “Requirement Analysis” (E14c), and dated July 29, i.e., 6 days after the meeting. Thus we included it in this event. Months later in event E16 it is mentioned as “validated”. E14b discussed prior requirements and we identified new sub-requirements: the ability to reset users’ avatars appearance (R13d-1) and to reset users’ virtual world login password (R13e-1). E14b also introduced new ones: better-looking avatars than the default OpenSim ones (R14a) and recording and displaying of elapsed session time (R14b). E14c is much richer in data. We extracted from it new requirements and clarification of early requirements, as new sub-requirements: providing users with avatars prepared in advance (R13b-4); detecting trainees’ presence in areas of the 3D space not related to the ongoing session (R2g-4); 3D objects should have user-based permissions (R2g-5); 3D objects should have user profile-based permissions (R2g-6); and users should be able to request automatic return to a session space, if lost (R2g-7). The existence of a “modular HUD” for users was required (R14c), and R3a changed from recording trainers’ use of tools to recording all users’ use of tools. This means that a subrequirement of R3a is recording use of the HUD tool (R3a-1). Besides previously identified management dashboard, a trainer-oriented one was required (R11-2), and visualization of session data was clarified as relevant in bi-dimensional and three-dimensional modes, changing R2f-16. New subrequirements were found: sessions may require audio conversations to be muted outside the sessions’ space (R1-1); the LMS may impose an avatar naming conventions (R13b-5). And a requirement: minimum of 31 concurrent participants, 1 trainer plus 30 trainees (R14d).

2.1.2.11. E15 – Formare seminar

Public event for organizations which deployed the Formare LMS. Data element: a slideshow of developments on 3D/Formare integration (E15a, no new requisites).

2.1.2.12. E16 – MULTIS II meeting 4

The data elements for this event are the meeting minutes (E16a), which yielded no new requirements, but validated the earlier requirement analysis document (E14c).

2.1.2.13. E17 – MULTIS II design report

In the previous event (E16), minutes E16a mentioned the development started on a “design document”, which we retrieved in several versions, the latest from Feb 11th, with records of reviewing by elements of both organizations. The following meeting (E18) only took place months later, so we deemed the creation of this report (E17a) as an autonomous event. E17a mostly follows E14c, describing its proposed

implementation, but includes architectural proposals and implementation aspects which lead us to extract new requirements: the LMS system should be able to record and replay data from various virtual world platforms (R17a); and the LMS should include an abstraction service for virtual world data recording and replaying complexities (R17b).

2.1.2.14. E18 – MULTIS II meeting 5

Data elements: meeting minutes (E18a). No new requirements, but a clarification on privacy issues, defining a new subrequirement: privacy management support when hosting several e-learning providers in the same virtual world platform (R1-2).

2.1.2.15. E19 - Workshop of the PT innovation plan.

Public results-presentation event for PTin-funded projects. Data element: slideshow presenting MULTIS II (E19a). Yielded a final requirement: the LMS needs to be notified of events occurring in the virtual world platform (R19).

5 Results

Table 2 presents the raw list of 39 requirements and 54 sub-requirements, alongside events/documents where they were identified and clarified.

Table 2. List of requirement categories, requirements and sub-requirements

Reqs.	Description (& documents)
C1/R1	Privacy of training sessions (E1a)
R1-1	Sessions' audio conversations may be muted outside sessions' space (E14c)
R1-2	Privacy management if hosting various providers in the platform (E18a)
R6a-2	Controlling access to the course 3D space (E6a)
C2	Record and replay behaviors of actors and other elements
R2d	Recording methods are generic, applicable to different 3D scenarios (E2a)
C2.1/R2f-15	Recording the full events of a 3D session or generic 3D space (E13a)
R3a	Recording users' interactions with virtual world tools (E3a, E14c)
R2f-10	Ability to record audio chat during sessions (E5b)
R2f-9	Ability to record text chat during sessions (E5b)
R2a	Recording actors' behaviors as a 3D choreography (E2a, E1b, E5b)
C2.1.1/R2b	Recording the behaviors of other elements (E2a, E1b)
R3a-1	Tracking activity/status of individual users' HUDs (E14c)
C2.2/R2f-16	Replaying the full events of a 3D session (E13b)
C2.2.1	Replay the events in 3D
R2c	Trainer can replay behaviors during a training session (E2a)
C2.2.2	Replay the events in 2D (diagrams, overhead view, etc.) (E13b)
R2c-1	Behaviors can be reproduced entirely (E2a)
R2c-2	Behaviors can be reproduced step-by-step (E2a)
C3	Support for virtual world content development
R2e	Creation of focused/efficient methods for development of simulations (E2a)
R2f-12, R2f-2,	Distinct management of generic 3D space and training session-

R6a, R6a-3	specific 3D spaces (E5b,E2b,E6a)
C3.1/R2f-2;R6a-3	3D space feats. manageable independently (E5b,E2b,E6a)
R2f-2;R6a-3	arrangement is a manageable feature (E5b,E2b,E6a)
R2f-2;R6a-3	size is a manageable feature (E5b,E2b,E6a)
R2f-2;R6a-3	interactive elements are manageable (E5b,E2b,E6a)
R2f-2	Training session space features specifiable on creation (E2b, E5b)
R6a-3	Generic 3D space features specifiable on creation (E6a)
R2f-12	Ability to edit 3D spaces' features after creation (E5b)
R10	Virtual world features implemented with separation of concerns & modularity regarding the LMS platform (E10a)
R14a	Better-looking avatars than the default OpenSim ones (E14b)
C3.1/R14d	Support for at least 31 concurrent users (E14c)
R7a	Virtual space elements should adapt to the number of users (E7b)
C4	Automated support for Administration
C4.1/R2g	Automated support for the administrative flow (E2b)
R2f, R2h or generic 3D course space	Automatically create, manage, and delete synchronous training sessions (E2b, E5b)
R2f-1	Ability to schedule 3D training sessions (E2b)
R2f-7	LMS usernames automatically associated with SL/OpenSim's (E5b)
R2f-3	Ability to define session participants (E2b)
R2g-1	Can send to trainees notices with a link to access the 3D space (E2b)
C4.1.1/R11	Tools/methods to track deployment & user adoption (E11a)
R11-1	There is a dashboard of quality monitoring instruments (E13a)
C4.2/R2f-13	Federated authentication, LMS/virtual world platforms (E7b)
R2f-6	User identification done via the Formare LMS username (E5b)
R13a	Avatars should always be associated with real names (E13a)
C4.2.1/R2f-8	LMS users may use preexistent SL/OpenSim usernames (E5b)
R13e	Users can't bypass LMS to change virtual world passwords (E13a)
R13e-1	Ability to reset users' virtual world login passwords (E14b)
R13d	Preventing users' from changing their avatars' appearance (E13a)
R2f-4	Management tasks done at the administrative level, without technical implementation concerns (E2b)
R2f-5	Ability to assign a session to a preexistent 3D space (E5b)
R2g-2	Ability to supply trainees with 3D models required for a session (E2b, E5b)
R2g-3	Tracking attendance of specific sessions (E2b)
C5	Automated support for trainers and trainees
C5.1	Specific-purpose applications to support trainers and trainees
R2c-3	Application in support of behaviour reproduction (E2a)
R7b	Ability for users to take notes (E7b)
R7c	Private trainer tool for controlling slideshows and videocasts (E7b)
R11-2	Trainer dashboard for quality monitoring of ongoing sessions (E14c)
R14c	There is a modular, customizable, heads-up display interface (E14c)
C5.2	Trainer should have control over trainee's audio
R2f-11	Ability to split communication among participants' subgroups (E5b)
R6b	Ability to mute/unmute trainees' audio communications (E6a, E13a)
R6b-1	Trainer-specific tool to manage muting of trainees' audio (E6a)
C5.3	Orientation support for trainees

R2g-4	Detect and record trainees' status outside ongoing session area (E14c)
R2g-8	Users can request automatic return to a session space, if lost (E14c)
R6c	Location index for orientation within the virtual space (E6b)
C5.4	Ability to manage access to interaction with 3D objects
R2g-5	3D objects should have user-based permissions (E14c)
R2g-6	3D objects should have user role-based permissions (E14c)
C5.5/R13b	Alternative avatar appearance identification features (E13a)
R13b-1	Avatars that do not support visual user identification (E13a)
R13b-2	Avatars with an ID badge (E13a)
R13b-3	Avatars with user facial photos on avatar faces (E13a)
R13b-4	Provide trainees with avatars prepared in advance (E14c)
R13a	Avatars real names should be visible to trainers and trainees (E13a)
R13b-5	Ability to impose avatar naming conventions (E14c)
R13c	Moderators are clearly distinguishable among other avatars (E13a)
R13d-1	Ability to reset users' avatars appearance (E14b)
R14b	Recording and displaying of elapsed session time (E14b)
R2f-12	Trainers can edit room features while a session is ongoing (E5b)
R2f-14	Various user roles in 3D sessions, regardless of users' course roles (E13a)
C5.6	Support for training about the use of virtual worlds
R12a	Training plan for users focusing on virtual world platforms (E12a)
R12b	Tools to support training focusing on virtual world platforms (E12b)
C6	Access to the LMS data and services in the 3D space
R2h-1	Availability in the 3D space of LMS warnings and notices (E6a)
R2h-2	Availability in the 3D space of LMS multimedia casts (E6a)
R2h-3	Location/Object in 3D space to access 3D content stored in the LMS (E6a)
R2h-4	Availability in the 3D space of LMS plain text documents (E6a)
R2h-5	Availability in the 3D space of LMS topics' summaries (E6a)
R2h-6	Users present in the 3D space doubts/feedback that feed into the LMS (E6a)
R2h-7	Availability in the 3D space of the LMS inquiry features (E6a)
R2h-8	3D space panel to present information about the course from the LMS (E7a)
C7	Integration of virtual world data in the LMS
C7.1/R5a	LMS accepts choreographies provided by trainees or trainers (E5b)
R5a-1	with multi-avatar behavior, encompassing space, and objects (E5b)
R5c	Choreographies stored in LMS independently from sessions (E5b)
R5d	Choreographies in LMS reusable across courses and sessions (E5b)
C7.2/R5b	LMS accepts 3D models provided by trainees or trainers (E5b)
R5c	3D models stored in LMS independently of training sessions (E5b)
R5d	3D models stored in LMS reusable across courses/sessions (E5b)
R6a-1	Logging the history of visits to the course 3D space (E6a)
C7.3/R13f	Ability to annotate the raw data from a session recording (E13a)
R13f-1	Annotation enables different detail levels for reproduction (E13a)
R17a	LMS system can record&replay from various virtual world platforms (E17a)
R17b	LMS abstracts virtual world data recording & replaying complexities (E17b)
R19	LMS is notified of events occurring in the virtual world platform (E19a)
R2g-2	The LMS is able to supply trainees with 3D models (E2b, E5b)
C8/R9	LMS must be the source of control and management over educational activities in virtual worlds (E9a)

C9/R13g	Alternatives for voice communication in the 3D platform (E13a)
R13g-1	Ability to use in-world spatial audio (E13a)
R13g-2	Ability to use an external audio conferencing system (E13a)

6 Limitations and final thoughts

Data collection is limited to the scope of its provenance under this post-mortem analysis. The authors took part throughout development, and contributed with insights available due to that status. So, an independent analysis may provide complementary perspectives. But the main limitation is lack of feedback from deployment at a trial corporate customer. The core research team was no longer involved at the time of that deployment, and has so far been unable to gather empirical data on the outcome.

Given its singularity as public data on software requirements of virtual worlds for use in corporate training, arising from an actual long relationship between a corporation and a university research team, we believe these results provide a valuable stepping stone for subsequent research and development of immersive worlds for training.

We recommend that researchers pursue from where we left off: pursuing data collection efforts on the use of virtual worlds in deployment scenarios at organizations, to validate or refine this set of requirements.

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Learning to Program using Immersive Approaches: A Case Study

Learning SAS[®], IBM Bluemix and Watson Analytics

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Abstract. Learning to program is an activity which needs the learner to develop a range of new skills. Traditionally, this has been achieved in Universities by presenting a series of structured lectures and tutorials covering the syntax and grammar of the language. This approach often leads to disengagement by many of the weaker students. It is becoming clear that this may not be the most effective approach in the twenty first century because of the continuous development of software packages which leads to the need to continuous revision of teaching materials. In addition, modern students demand engagement in learning that also prepare them for employment. This paper evaluates a directed, immersive, and engaging learning approach that mirrors the real world of employment, and prepares students for lifelong learning, development, and maintenance of new skills and languages. The approach should be applicable to most STEM subjects which require using specialist software packages.

Keywords: SAS, IBM Watson, technical skills, soft skills, engaging learning, STEM subjects

1 Introduction

The traditional perspective of the academic role is as “Domain Expert” who knows more than the students and can, therefore, always provide the necessary technical guidance. However, in the field of computer science this is becoming ever more difficult because of the very rapid rate of development of software packages, especially those that are open source. This leads to ever increasing levels of stress on academics [6].

It also leads to the use of activities that often do not seem to the students to have any relevant context, other than that of learning the syntax and grammar of a new language or package, thus leading to boredom and lack of engagement. It also generally fails to develop soft skills demanded by employers, such as curiosity, problem identification, creativity, problem solving, collaboration, communication and

story-telling [5]. This position is also repeated annually in the UK in surveys of employers of the employability of recruited graduates.

A very different approach is required that develops soft skills and life-long-learning. This requires an academic mind-set of “Academic as Learning to Learn Expert”; as a facilitator of the learning process, rather than a teacher of technical domain skills. It relies on the (modified) observation by Plutarch that “Education is not filling (leaky) buckets but lighting fires (of enthusiasm)” [1].

Fundamental to this approach is the concept that much contact time should be devoted to working with each student to develop their skills in learning rather than teaching the language, for which there are many sources. Once our graduates are employed, they will mostly have to learn software from online sources, rather than from taught courses, using YouTube videos and relevant Technical Fora, alongside self-tutorial materials which are sometimes provided by the software vendor. The necessity of this is regularly commented on by our students on their third year internship placements.

The author has recently been leading two courses with very different types of software using this approach, for students who had not demonstrated significant levels of aptitude for (or even interest in) computer programming. The results demonstrate both high levels of achievement and, in general, good levels of engagement.

The Department of Computing and Maths at the University of Derby in the UK is a member of both the SAS Student Academy and the IBM Academic community. As a result we have strong support from both vendors to help our students to gain skills in the respective product sets.

For SAS our students have access to the Base SAS environment through the SAS 9.3 environment installed on the specialist lab PCs and the SAS Analytics U environment on their own PCs.

For the IBM product set, our students have free access to the whole IBM Bluemix environment and also, on a module by module basis to the full Watson Analytics Professional environment, all of which are delivered via the Cloud. IBM Bluemix provides access to some 100 different products from application programming environments, via Internet of Things toolsets such as Node Red through to significant analytics products such as SPSS, Cognos and Watson Analytics.

2 Pedagogy

Traditional approaches to teaching computer languages and systems are approached from the “Academic as Domain Expert” perspective which leads to a style that emphasizes the language features in the abstract, often without any context as to why the features are important or to what the features might be relevant. This can very rapidly lead to students becoming disengaged from the lectures and workshops and to poor levels of achievement, as found in module reports and student surveys.

In contrast, the “Academic as Learning to Learn Expert” perspective leads to intense engagement in the subject during the supervised learning periods of seminars or workshops or tutorials. It draws on the ideas of experiential learning and the “learn by exploring” [2] variant of “learn by doing” which explicitly employs elements of problem-based learning [3] and enquiry-based learning [4]. It also leads to very high student achievement and satisfaction.

One of the founding principles is that scheduled contact time with students is far too valuable to be used for presenting information that they can easily find elsewhere. Contact time must be dedicated to enthusing the students to research for themselves and to find the right answers and to connect with the overall topic.

It is to be noted that programming skills are, for most people, a tool with which to achieve some objective, whether that be to gain insights from data or to develop application systems; it is rarely an end in itself. As a result, for many students, expertise in the language or system is incidental to being able to achieve some wider and more significant goal.

Another of the key principles is that of the academic teaching questions rather than answers. They want the academic to guide them to find the relevant sources of “how to” experience and knowledge from web based resources provided either by the relevant vendor or in appropriate technical forums, as is common practice in the business environment. Focus groups with students shows that this is their preferred means of getting guidance to solve their technical problems. They were very clear that they did not want the academic to just “give the answer”. They wanted probing and prompting questions to help them learn the answer for themselves (module feedback surveys and focus groups).

3 Case Study Courses

Both modules in this case study which are designed for Undergraduate programs in Information Technology which are related to the application of computer science based tools to achieve business objectives, such as gaining and compellingly communicating valuable insights about businesses from data. As such, the critical learning outcomes are about applying technical and soft skills to achieve these aims [5]. In some respects, therefore, the technical skills of using the chosen software packages are a secondary objective, albeit a necessary pre-requisite to being able to achieve the real objectives. High quality employability depends on both technical and soft skills in our graduates.

The first course results in the students teaching themselves SAS from the official Base SAS course materials and then applying their knowledge to create small information analysis systems. The second course allows the students to choose from a very wide range of software packages from the IBM Bluemix and Watson Analytics portfolio and then, through a blend of on-line tutorial materials and assistance from IBM staff in seminars and workshops, develop analyses which provide insights.

In both courses, the course leader has a broad understanding of the capabilities of the packages but not necessarily with detailed levels of expertise in all areas. The course leader's expertise is in defining significant challenges for the assessment process which will enable the students to develop both technical and soft skills.

3.1 Common Principles

In the UK University system a 20 credit module (or course) represents an allocation of 200 hours of study time, from which 36 to 48 hours will be allocated to scheduled contact time over the 12 week semester, or 3-4 hours contact time per week which will include lectures, seminars and workshops or tutorials.

Both courses rely on the students learning the relevant technical and programming skills, initially during a few scheduled workshops but mainly in their own study time as part of the overall 200 hours of study time allocated to each 20 Credit module.

In each of the modules, students are required to identify a large open data source that is of interest to them and then to identify typical stakeholders who might be interested in gaining insights from the data. They are then required to analyze the data and to identify a small number of valuable insights that can be gained from the data, using relevant tools in the defined product set.

The assessment tasks and related marking rubrics then ensure that both the necessary technical and soft skills are developed and demonstrated.

Both modules lead the students to totally immerse themselves in the product for the duration of the module.

3.2 Introduction to Data Analytics (Course 4CC522)

This is a first year module for students on the BSc Information Technology module and is based around learning "Base SAS" as the tool for analyzing data. The students learn the basics from the standard SAS provided teaching materials. During the first three weeks of the module, the students are supervised by the tutor during the two hour workshop in the computer labs. Their technical skills are assessed via four computer based tests which carry 40% of the module score. The weekly two hour lecture / seminar is primarily used by the students to develop their research and presentation skills and, using the "Student as co-creator" approach to share their learning with each other. During each seminar the academic will provide a short fifteen minute contribution on one of six key topics covering the data identification through to gaining final analytical insights to provide an overall context to the module. For the rest of the seminar, the students will give short ten minute presentations, in pairs, on a range of specified topics which they research and also develop short tutorial materials for the rest of the cohort.

3.3 Emerging IT product Developments (6CC515)

In this final year undergraduate module a different approach is taken. Rather than using Base SAS which is essentially a single product, this module exposes the students to the totality of IBM Bluemix and Watson Analytics. In this environment, it is not feasible for the academic to have a comprehensive technical capability in all the products. Instead, the academic only needs to have a broad awareness of the capabilities of the various packages that might contribute to the students' analytical activities.

IBM have provided us with staff who visit to lead seminars and workshops to both introduce the products and also to give advice during the exploration of the capabilities and the development of the tools to gain the planned insights.

The students are also required to find a significant set of data that fires their enthusiasm. They are not given any specific data.

Given that IBM Bluemix contains approximately 100 different products, many of which are in a continuous state of development, this module demands an even more immersive involvement from the students.

4 Analysis of Results

There were 19 students on the IDA module and 13 students on the EITPD module with the following results profiles. The horizontal axis identifies the grade band that the students achieved.

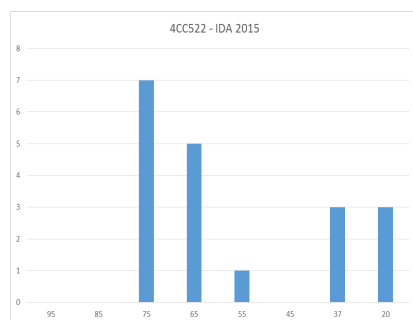


Fig. 1. First Year Results

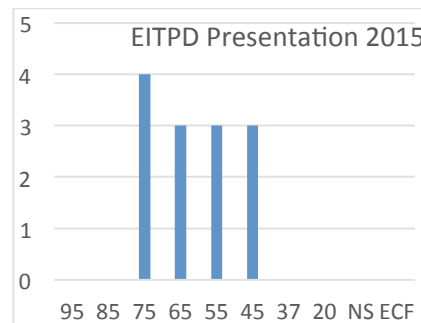


Fig. 2. Final Year Results

4.1 First Year Module – Introduction to Data Analysis

It should be noted that the six students on the right-hand side of the graph in Fig 1, displayed a similar level of disengagement with all their modules. It appeared that

there was a fundamental issue with their approach to University level education rather than disengagement with the SAS programming element of the module. The remaining students demonstrate considerably better levels of achievement that we were expecting.

4.2 Emerging IT Product Development Module

The main assessment for this module was a fifteen minute critical review presentation covering the totality of the exercise from identification of the data and the potential questions that might be answered, through the data cleansing and integration of the necessary product elements, to the insights gained. The structure and timing of the presentation was designed to replicate a post-project presentation to the business customer and CIO that would be normal in a business setting.

The notable result is that no students failed the task, although some came close. The ones scoring above 60% all developed extremely interesting insights and used a wide range of unexpected datasets from crime statistics linked to locations of CCTV cameras to an analysis of the Steam and Valve activity statistics. Their presentations have been re-engineered and posted on the departmental YouTube channel as exemplars of the types of insights that can be gained by using Watson Analytics, see https://www.youtube.com/playlist?list=PLWT0aRqpyk1oBwS8t5QVz-qVeX_ndURi0.

5 Conclusions

The “Academic as Learning to Learn Expert” and facilitated immersive learning has allowed students who specifically enrolled on the BSc IT program in order to avoid computer programming have all surprised themselves by developing the ability to teach themselves how to program in SAS and use Watson Analytics and to also communicate well.

Research is continuing to refine and develop this approach to further improve the levels of engagement and achievement.

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Workshop

Exploring the Future of Immersive Education

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Abstract. This extended abstract describes the #iLRN16_SFP workshop which opened the iLRN'16 conference held in Santa Barbara, California USA from the 27th June to the 1st July 2016. The main focus of the workshop was exploring future trends and expectations for research into immersive learning. The event was a collaboration between the Creative Science Foundation and the Immersive Learning Research Network.

Keywords: Virtual-Reality, Immersive Learning, Mixed Reality, Ideation, Innovation, Science-Fiction Prototyping, Creative-Science.

Introduction

The focus of the workshop was to explore how current research might be imaginatively extrapolated to explore the possible ways immersive-reality technology might change future education. In doing this, it took a very broad vision for the delivery of education stretching from formal education at (say) university through industrial training to informal settings.

2 Methods

The workshop adopted the *Science Fiction Prototyping* method which was proposed by the futurist, technologist and author Brian David Johnson, a Professor of Practice in the School for the Future of Innovation in Society at Arizona State University in Phoenix who also provided the keynote at this event. Essentially, the method involves writing short fictional stories that imaginatively extrapolate current practices forward in time, leaping over incremental developments, exploring the world of disruptive product, business and social innovations. Because *Science-Fiction Prototyping* adopts a rich story-based structure it is able to create high-fidelity analogues of the real world, enabling it to act as a type of prototype to test ideas. In more practical terms the workshop followed the '*Imagination Workshop*' ideation methodology devised by Hsuan-Yi WU of the National Taiwan University. This workshop adopted a genre of Science Fiction Prototyping called μ SFP where the participants wrote Twitter-size fictions to illustrate some future possibilities for immersive education research.

3 Workshop Structure

The workshop followed a fairly conventional structure as shown below:

- Welcome to iLRN
- Invited talk (Brian David Johnson, the creator of the SFP method)
- Introduction to SFP
- Imagination Workshop (brainstorming, selecting ideas & writing a μ SFP)
- Group presentations, voting and prize for best μ SFP

4 Competition

To mix some fun with serious research the conference attendees were invited to enter a Twitter-based competition to write an individual μ SFP that described how they foresaw immersive learning technologies and pedagogies changing the nature of future education. To enter they were asked to tweet their stories to **#iLRN16_SFP, the name of this workshop**. The top 3 μ SFPs (as voted by attendees) received a prize (an Amazon voucher) which was presented at the closing session of iLRN 2016.

5 Outcomes

The workshop outcomes were posted on:

http://www.creative-science.org/activities/ilrn16_sfp/

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Posters

Creating a Sense of Presence in 3dimensional Multi-user Virtual Environments for Education

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Abstract: This presentation discussed ongoing research being conducted at two different universities in the United States. Students enrolled in four different graduate courses are experiencing at least three synchronous meetings in a 3dimensional virtual learning environment (3dVLE) hosted at one of the institutions. Students engage in meaningful discussions related to the course topic, collaborate in group activities, and answer a series of surveys adapted from three instruments: the Presence Questionnaire, ITC-Sense of Presence Inventory, and the Community of Inquiry Questionnaire. Researchers aim to discover if the use of a 3dVLE helps to create a sense of presence, in addition to exploring students' perceptions about the use of 3dVLE's in online instruction.

Keywords: Distance learning · Interaction · Social presence · synchronous learning · Computer-mediated learning · Computer Mediated Communications · Community of Inquiry · 3dimensional multi-user environments.

1 Objective and Purpose

Graduate students attending online courses at two universities in the United States – one located in the north, the other one in the south-utilized a 3dimensional multi-user virtual environment (3d MUE) as a tool for communication, engagement and online collaboration. Researchers involved in the study aimed to understand if utilizing these type of tools could foster a sense of presence in online learning, which is fundamental when developing a community of inquiry [1]. In addition, the study presented students' perceptions and opinions regarding the use of 3d MUEs in online instruction.

2 Background Perspectives

Every day, more institutions are migrating their traditional courses to online delivery. Unfortunately, students indicate the lack of human interaction and lack of sense of presence, as one of the main factors to drop from online courses [2, 3, 4]. Instructors are using different mechanisms to develop a sense of presence, such as synchronous chats, discussion boards, and group assignments. Requiring students to interact with each other is an effective way to ensure that students are able to establish a social presence in distant learning. There are several tools being used for synchronous

communication such as GoToMeeting, WebEx, and AdobeConnect; however, researchers explored the use of 3dimensional virtual environments, as they can offer a more robust platform for collaboration, group engagement, and delivery of course materials. In addition 3d MUVes can offer a shared space, which, although virtual, can be perceived as a real one, at the moment of the interaction. Social presence can be defined as the level to which a person is perceived as real in mediated communication [5] and the “degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships” [6, p. 65]. Seminal research discussed the importance of creating a sense of presence online to enhance the learner-instructor relationship [7], and argued for the creation of rich social atmospheres which generate a climate of high level dialog, and critical thinking [8,9]. Research conducted simultaneously at two different universities in the United States aimed to define a) if the use of an interactive multi user 3Dimensional multi-user virtual environment could foster social and student presence in five courses delivered 100% online, and b) to investigate students’ opinions and perceptions of using these tools for online instruction. The courses were different from one another, and their topics ranged from teaching with visual and media literacy, introduction to distance education, instructional design, multimedia design, and managing technology in educational settings. This was an exploratory study, which utilized the Communities of Inquiry (COI) framework [1]. The researchers surveyed participants using demographic questions, and surveys adapted from three instruments: the Presence Questionnaire (PQ) [10] the ITC-Sense of Presence Inventory [11], and the community of inquiry questionnaire [12]. Students participated in at least three synchronous sessions as part of their coursework. Those sessions were conducted in a 3dimensional virtual environment developed in one of the universities participating in the study.

Students were required to discuss their experiences with the 3d MUVE in online asynchronous discussions located in the course learning management system, and those were analyzed using Gibbs’ [13] coding system.

3 Importance of the Research

The number of institutions of higher education that offer online courses has grown for the past ten years [14]. The challenge is now to move away from traditional methods of teaching to online methods of instruction, resulting on a shift in the perspectives of instructors and their students [15]. Many problems and concerns are being voiced in both the teaching and student community regarding online instruction. Students comment that some of the disadvantages of taking online courses are a feeling of isolation, the lack of engagement with instructors, and the lack of face-to-face interaction. Teachers are struggling to find new ways to engage their students. This research discussed the use of a 3dimensional multi-user virtual environment as a synchronous tool for engagement and collaboration, which allowed students to interact with each other and with the instructor in a safe and controlled virtual space. The poster presentation showcased preliminary research outcomes related to students’ opinions about using these tools for online instruction, and presented results to the surveys administered in the fall 2015-spring 2016 to five

different graduate online classes.

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Merging the virtual and the real: A collaborative cross-reality game

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Abstract. In this paper, we present a collaborative cross-reality game for two players, Lab2, which blends tangible board game and immersive virtual reality playing spaces in a gameplay that aims to promote and train collaborative behaviour. As collaborative learning has been stressed as an effective teaching method for many years, Lab2 could assist learners in exploring and further developing their collaborative skills in a playful manner. One player controls a physical game board showing a moveable maze of “pathway” tiles, while the second uses a spatially tracked HMD to find himself inside a virtual-reality version of the game-board’s maze. The goal of the game is to collect a set of tokens hidden inside the maze. Reaching these tokens requires the players to collaborate via their complementary roles. We will first outline the game design concept and then detail the user-testing based evaluation of our game prototype.

Keywords: Virtual reality, tangible interfaces, multiplayer, serious game, motion tracking

1 Introduction

Within the context of further promoting collaboration in educational and professional environments, the goal of this project was to develop a serious game for training collaborative communication skills which explores the potential of digital games for training these in a playful manner. A complementary aim was to employ intuitive, immersive game interfaces in order to aid players concentrate on their communication with each other rather than on the handling of the game controls.

The development of the game design concept was based on a set of design heuristics distilled from an extensive analysis of related literature and game examples with a particular focus on collaborative gameplay and intuitive interface design. The resulting concept was evaluated through qualitative user testing.

2 Game Design Concept

2.1 Game principle

The game principle of Lab2 was inspired by the “treasure hunt” style board game “The Amazing Labyrinth”[1], which presents a maze of pathway tiles which players can rearrange in order to reach and collect treasures spread over the maze.

2.2 Cross-reality interfaces

It was felt that the principle of a moving maze offered potential for cross-reality problem solving for two players: One player controlling the maze on a real-life game board as in the original game, and the other player experiencing the game from within the maze’s walls by means of a virtual reality HMD. These two interfaces could then be cross-linked in real-time via spatial tracking and projection mapping techniques.

2.3 Fully collaborative gameplay

The gameplay was designed to require a variety of collaborative interactions between the players for a successful resolution of the game’s scenario: The players take asymmetric roles which are both required to reach the in-game tokens, have to perform joint task and can only win or lose the game (“sink and swim”) together.

3 Qualitative user testing results

The evaluation’s key questions were whether the system could successfully promote collaboration in problem solving, and also whether the cross-reality setup offered any advantages over a more traditional game configuration. Pairs of players were briefed on the game scenario, and then asked to play the game, first using the cross-reality set, then with the desktop PC version of the game. Data was collected through observation of players and post-test surveys.

The results showed that despite encountering some technical issues, the game and interfaces were found to be both fun and exciting, and to generate a wide range of desired collaborative behaviours. Participants felt that more games using similar cross-reality interactions would be highly desirable.

4 Conclusion

Although this early prototype had a number of technical issues, the overall results support the game concept idea. We therefore foresee a rich future for collaborative and innovative cross-reality games.

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Conversation-based support for French extracurricular school activities in the context of smart territories through claim management and automated learning

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Abstract. My research aligns different approaches on the phenomenon of conversation in a theoretical framework that provides a model for measuring pupils' degree of immersion with their learning ecosystem, and declines it into a panel of methods improving such a measure. Research experiment gives an example of predictive decision support on defects within the learning environment. This technology is born out of 2013 reform policies on education in France meant to strengthen pupils' degree of enrolment into the overall education program through better piloting of their learning "rhythm" ("rythmes scolaires"). Methods implemented as deep learning routines and plugged into an issue tracking platform are combined with a game installation that trains the learning environment as it is represented into the 3D issue tracking software to become responsive to time budget risks associated with specific resources accessible in the learning ecosystem.

Keywords. smart city, data science, conversation, claim management, France

1. Introduction

Conversation based research mentioned in this article drives the conception of a software meant to augment and regulate actors' perceptions of their learning environment. A collaborative issue tracking software used for education purposes being installed in a French town is being equipped with an indicator that predicts how well the actual learning ecosystem responds to failures regarding learning resources reported in the claims, through decision support on claims' priority levels and risk analysis for 3D viewer, depending on the choice of claims' recipients. For experimental purposes, the means by which learning ecosystem may impact rhythms is first simulated through a collaborative orienteering game especially designed to control effects of the environment on transactional distance (Marquet, 2003) vis à vis the game resolution. Game design includes conversations which are utilized for their capacity with strengthening pupils' orienteering of each other (Tarde 2013, Moscovici 1998) in their search for gamechanging artefacts distributed on the playground. Afterwards, the means by which the learning ecosystem may hypervise actual slowdowns are illustrated as the priority context builder interprets priorities based on an estimation of the player time budget units at disposal before other players and former collaborators understand the solution to the game themselves (Sacks 1989, Gadamer 1989), from the data captured from diverse IoT equipment dedicated to the game. At that stage, conversation theories help situating cognitive processes (Suchman 1987) through better understanding of actors' orienteering efforts in their

environment. At last, the means by which the learning environment response augments actors perception of these slowdowns is shown with pondering urgency level according to choices with recipient of the claims (Grice 1970, Pask 1976) in the claim management software (in addition to predictions on choices among possible collaboration partners in the experimental game itself). Overall, implementation of environmental response is inspired by Turing's design of the imitation game as an experimental case scenario for determining adequate conversational effort and for diminishing the sense of instrumental conflict (Marquet, 2011) when such an effort is overtaken by nonhuman elements (e.g. a computer in Turing case). It is achieved through the construction of a constraint-based Network being optimized through cost function (Turing 1950, Grant 1991). In fine, the issue tracking system enriched with these "proof of concept" features is meant to act as a smarter mediation between human needs and environment understanding of these needs thanks to predictive risk analysis associated with the choice of claim recipients, and functioning as real time feedback. Built in machine learning methods inspired by conversation theories are meant to strengthen visibility of actors on their learning environment and to channel their efforts during the planification of learning activities (budgetisation, parents' follow up etc). They enable remarks from actors involved with planification & instruction to be matched with actual slowdowns in learners' activity through actors' optimized coselection and codefinition of their learning environment.

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Special Tracks Preface

The field of immersive digital learning environments has been an extremely successful topic of interest. One of the challenges of this growing research field is its interdisciplinary and broad nature. Immersive learning consists of a wide range of research interests and fields and enables collaboration between researchers and practitioners from different disciplines. Continuing on our successful experience at iLRN 2015, we have introduced special tracks as a forum for quality scientific research in focused areas. The mission of these focused tracks is to bring together specialists from diverse areas to enable collaboration and exchange of knowledge.

Thus, we invited specialists from different research fields to submit focused special tracks to this conference to highlight various areas of immersive learning. iLRN 2016 features four special tracks covering topics:

- The track “K-12 and School Tech” is chaired by Dennis Beck and Yvonne Earnshaw. This track discusses immersive learning research in the primary and secondary classroom.
- The track “The Future of Education” explores possible ways how immersive-reality technologies might change future education. The track is chaired by Vic Callaghan, Michael Gardner, and Jonathon Richter.
- In the track “Cognitive Serious Gaming” the track chairs Markos Mentzelopoulos, Daphne Economou, Vassiliki Bouki, Aristidis Protopsaltis, and Ioannis Doumanis explore how cognitive principles can be applied to improve the training effectiveness in serious games.
- In the track “Immersive and Engaging Educational Experiences” the track chairs Johanna Pirker, Foaad Khosmood, Kai Erenli, Britte H. Cheng, Maroof Fakhri, and Zoë J. Wood discuss how educational environments can be designed, and analyzed with a focus on immersion and engagement.

Twenty-two submissions were received and six were chosen as full papers to be published in the Springer proceedings for an overall acceptance rate of 28%. Thirteen were chosen for the online proceedings. Authors submitted contributions from the UK, Ireland, and in the United States – Arkansas, California, Illinois, Montana, and Ohio.

We would like to thank all chairs and reviewers of the special tracks for their commitment to make the tracks an integral part of the conference by selecting a broad variety of high-quality research presentations related to immersive learning. We thank every person who helped make the special tracks a successful part of the conference.

June 2016
 Johanna Pirker and Ken Hudson
 Special Track Co-Chairs

Special Track 1: K-12 and School Technology

Welcome to Gallery 5 – An immersive digital art experience

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Abstract. As school funding in the U.S. continues to drop or stagnate, arts education programs have suffered, particularly in poor districts. One approach to overcoming this problem has been for non-profit organizations to develop innovative curricula with technology components that allow students to learn about art without having to leave the classroom. In this presentation, we discuss one such project called Museum Mash-up: American Identity Through the Arts. In particular, we focus on the Gallery Five virtual museum space along with the mixed methods research outcomes regarding student experiences of learning art concepts at a distance with digital tools.

Keywords: Immersive, Virtual, Art history, Situated cognition, Cognitive apprenticeship

1 Objectives and Purposes

The history of American art is rich and varied. However, many schools have suffered budget cuts as well as increased pressure to prepare the children in their care for high stakes standardized exams, as well as employer and state demands for increased STEM education (Williams, 2014). Because these exams do not usually include art, this academic discipline often becomes an afterthought. This is short sighted, as recent research indicates that students tend to do better on these exams if they have had exposure to art, specifically an art museum (Bowen, Green & Kisida, 2014; Green, Kisida & Bowen, 2014).

To bridge this gap, some non-profit alternative educational institutions provide educational opportunities in art for public school students. One example is the Crystal Bridges Museum of American Art, in Bentonville, Arkansas, partnered with Virtual Arkansas. This group provides high-quality digital courses to public school students in Arkansas. This partnership has resulted in *Museum Mash-Up: American Identity*

through the Arts. In this course, students make connections among art, history, and identity, and they practice and apply the skill of curation to create two online exhibits: one about student individual identity and one about American identity.

Technically, the Museum Mash-Up course includes a carefully selected variety of American Art images, thoughtfully authored multimedia learning objects, and interesting and compelling assessments, hosted by Virtual Arkansas in an online Blackboard Learning Management System. Most uniquely, it included extensive use of *Gallery 5*, an immersive, 3D online experience in which students curated their own art collection.

The Museum Mash-Up course was piloted in spring 2015 with 38 students. A pilot study was done consisting of two parts. First, the course was evaluated using the *Quality Matters* (QM) rubric. Second, a mixed methods study of student and instructor perceptions and attitudes was conducted through the use of surveys, interviews, focus groups, and observations. We examined the qualitative data, considering themes that inductively emerged from data collected using interviews and a focus group. We also considered quantitative data collected as part of several student and instructor surveys, looking for trends in student and instructor opinion. Finally, we merged the findings to develop recommendations for improvements that should lead to learning design improvements. For this presentation, we focus on student and instructor perceptions and attitudes about the *Gallery 5* immersive environment and its impact on art learning among students.

2 Theoretical Framework or Perspectives

The course design employs a direct instruction model of computer-based instruction (Kulik & Kulik, 1991), while the signature pedagogy used in the *Gallery 5* environment was situated cognition, specifically the cognitive apprenticeship. This was meant to supplement the direct instruction taking place in the classroom by placing the learning in a rich context surrounded by what it is they are expected to know and do. Theoretically, this occurs when students learn from an expert where they observe, enact, and practice expert actions with help from the teacher (Brown, Collins & Duguid, 1989). In this case, we wanted students to understand art in historical and physical contexts, especially situated within the practice of museum curation.

In practice, students using the *Gallery 5* immersive space gather contextual information about specific artwork, artists, and historical periods. Each work of art has primary, secondary, and multimedia source materials that include essays and videos. Throughout the course, Crystal Bridges staff videos also unpack the curatorial and exhibition process as part of the virtual component of the cognitive apprenticeship. This informs the final project: a student-curated exhibition within an immersive three-dimensional rendering of the one of the museum's galleries. Using game engine *Unity3D*, this virtual gallery application was created by staff and students from the Tesseract Studio for Game Design and Immersive Environments at the University of Arkansas. This allowed students to create multiple gallery projects and share them

with fellow students and their teachers. After gathering project requirements, several essential features were established for the virtual gallery application. These include navigation, placement of artwork, and first-person experience. After gathering project requirements, several essential features were established for the virtual gallery application: navigation, placement of artwork, and first-person experience.

2.1 “Navigation” and technical virtual specifications.

Navigation refers to how the gallery space is presented to users; specifically, how do they see the space and maneuver through it? Also, how do they get an overall sense of how they might want to arrange their artworks? For this, we decided on a three-quarter overhead perspective, a common approach in real-time strategy games, along with the ability to orbit the view and zoom in and out.

We also built in the ability to toggle the roof and glass windows of the gallery off and on. A schematic mini-map at the left margin keeps the user oriented to the space and to allow the user to adjust their position by dragging the camera icon on the mini-map. A drop-down “tray” allows artwork thumbnails to be placed; users can select these by clicking on each, which closes the tray and presents the artwork as a moveable object in the 3D space. Users can then place the artwork on the gallery walls by dragging to a position and releasing the left mouse. At any point, artworks can be removed from the wall and returned to the tray, so that placement is always editable. We also provided tag functionality, which allows users to enter text describing the artwork, and to position the tag at any point around the piece. An eye-level guide can be enabled, which allows users to gauge where a piece lies relative to visitors’ average eye level.

Finally, we provided adjustable lighting, so that users can position lights within the gallery to highlight specific pieces and provide a sense of transition between pieces or thematic groups. So that users can test how their virtual gallery feels, we provided a first-person walk mode allowing free movement anywhere in the virtual gallery space. Users enter this mode by clicking on the gallery floor to transition from the overhead perspective to first-person view, automatically orientating them to the nearest painting on the wall. Users are then free to walk through gallery and may adjust the placement of the paintings while in this mode. While not efficient for the initial placement of the paintings, player testing showed that being able to adjust the arrangement in first person mode was something users wanted, as it gives an important virtual sense of being tactile and immediate.

A design imperative throughout has been simplicity of use. We know that our student population includes many avid gamers, but also many who are not. Our target audience also includes teachers and parents, and fewer of this group will have significant gaming experience. Nonetheless, it is crucial that all users rapidly become accustomed to the application, without frustration or confusion. The main goal is to allow students to communicate creatively through their placement of artwork, tags, use of lighting. Therefore, the application needs to be as natural and transparent as possible in supporting that function. Looking ahead, we anticipate significant

additions to the application will include sculpture, mixed media pieces, and avatars, the last of which should allow students and teachers to meet and collaborate in the virtual space. We also look forward to engaging the students in considering the relationship of their artwork placement to the environment and lighting conditions outside the gallery, which is framed by continuous glass panels on the north and south, and considering likely movement patterns given the floorplan of the gallery.

3 Methods

3.1 Qualitative data collection and analysis

The semi-structured interview and focus group were conducted and recorded online using the Blackboard Collaborate meeting tool. The focus group was attended by two students and the interview was attended by the instructor. Questions were synthesized from current distance education theory as well as from interview protocols used in other studies that looked at the nexus of technology and art education.

A pretest survey was also administered to students during the first few weeks of the course. The survey contained ten questions, four of which were open-ended text entry. 38 students completed the survey (100% response rate). A posttest survey was administered near the end of the course, which contained 35 questions, five of which were open-ended text entry. Nine students completed the survey, giving a 30% response rate. The low response rate was due to a misunderstanding about the date of the survey between the researcher and the teacher.

After transcribing the focus group and interview audio files, the transcript was reviewed by the researchers to ensure accuracy. The constant-comparative method was used to code the interviews focus group with a goal of categorical saturation, as described by Lincoln and Guba (1986), with an awareness of and correlation with pre and post test data. To do this, we developed an initial codebook, which included each code, a definition of the code, and guidelines for using the code. A confirmatory analysis was also conducted through three rounds of coding. The themes that emerged fit into the structure of the *Gallery 5* environment, namely, the technology, pedagogy, and instructor.

3.2 Qualitative Results

Technology. A major theme that emerged was that students' were mostly interested in the process and skills involved with building parts of the course. "The gallery stuff was really interesting...I like that stuff because it helped me see how you do it in the real world." Students centered on their ability to feel present in the *Gallery 5* environment saying that "...you could walk around in it...[it] felt real" The instructor said that *Gallery 5* was the capstone experience and brought everything that students were learning together in one activity. However, students were not entirely positive in their evaluation of *Gallery 5*. "It wasn't the best I had ever done (in terms of immersive environments)" said one student, "this was alright, I guess, I don't know. I wasn't expecting doing that sort of thing this year, but it also wasn't like a normal

game with quests and stuff.” This data helps to highlight strength of the *Gallery 5* environment – the ability to feel physically present in an online environment – while highlighting a potential weakness – the lack of scaffolding in the form of a quest or search made in order to complete a task. If no future game elements such as a win scenario, conflict, or rule set are added, it also goes to the idea that beforehand students should have clear explanation that this is a simulation not a game, in order to reduce the disconnect between their expectations and the reality of activities in the space. Further, the student obliquely refers to the graphical fidelity not being as high as what they experienced in other digital spaces like video games, which has been a problem with academically created games and simulations not in terms of effectiveness at impacting learning (De Giovanni, Roberts, & Norman, 2009), it has been noted by students to impact their engagement with lower graphical quality engines (Warren, Jones, Dolliver, & Stein, 2012) and should be a consideration.

Pedagogy. Another major theme that emerged from our qualitative data involved the pedagogical methods used in the Museum Mash-UP course. Because this course involved teaching both content knowledge and skills in the academic discipline of art and art history, it is helpful to consider the notion of signature pedagogies. Lee Shulman (2005) defined signature pedagogies as, “types of teaching that organize the fundamental ways in which future practitioners are educated in the professions.” Employed here, it helps frame a discussion of one type of instruction that appears to fit art and art history.

The signature pedagogy used was situated cognition, specifically the cognitive apprenticeship. This occurs when students learn from an expert where they observe, enact, and practice expert actions with help from the teacher (Brown, Collins & Duguid, 1989). The *Gallery 5* immersive environment was designed to provide a real-world context and situation to learning the process of curating an art collection. The instructor seemed to prefer this method when she talked about the hands on mentoring opportunities that were missing in most online courses:

I did a site visit to one of my schools and...they were working on projects...I saw instances where being there in the room with them could help students quite a bit. I had an opportunity to help a student show a student how to do something that he wouldn't have gotten just strictly online because I was there in the process...I've been teaching art for 12 years so those are the things that I realized going on the site that there are little opportunities that are missed because you're not right there with the students.

The instructor also saw this aspect of being with the students to help them just when they needed it as missing from the Museum Mash-UP course. However, this aspect of having the instructor “being there in the process” may fit with the students’ feeling of being present in and their sensation of being able to physically navigate the *Gallery 5* environment. This speaks to the potential need to develop a pedagogy of presence in the online course –a way of teaching that emphasizes real time opportunities for a teacher to interact with and mentor students within an online environment that allows

students to feel present with others while completing authentic art related tasks. Further, the teacher was not trained in the core elements of cognitive apprenticeship and the expectations and approaches a teacher should use relative to either the pedagogical method or how it was employed within Gallery 5. Training in these areas should improve learners' experiences in the future, a finding echoed by Warren, Dondlinger, Stein, & Barab, 2009 with the *Anytown* literacy game.

Instructor. The last major theme that emerged from the qualitative data focused on the instructor. The instructor of the Museum-Mash-UP course was well qualified in terms of her educational background, content level courses taught, and online instructional experience and preference. She possessed an entrepreneurial spirit that motivated her to volunteer to teach the course, and the same attitude enabled her to learn alongside her students. Additionally, she is already thinking of the next time she will teach the course, revealing a long-term approach to success and iterative changes.

The instructor has also discussed innovative ways to improve the course, such as the use of a document camera so that she can demonstrate art techniques in a live, online meeting. She also discussed changes to the final project, video learning objects, and a way for students to share their work with others:

I would envision it to be ... the final exhibit to be done all virtually where there are art work descriptions and music and everything is all together in one spot virtually in Gallery Five so that they're not doing different things... they're not using a bunch of tools but instead they're only using one.

If you could build a tool where the students could make a video of their Gallery Five exhibits so that they can download it and keep it, that would be ideal I would think. They can actually be talking to somebody through the tour they could be the tour guides. That would be awesome. Then there'll be something students could share with an external audience.

3.3 Quantitative Methods and Data Analysis

The ITC Sense Of Presence Inventory (ITC-SOPI; Lessiter, Freeman, Keogh & Davidoff, 2001) was administered during the *Gallery 5* immersive art experience and immediately after that experience to measure students' sense of presence. Presence has been used as a global experiential quality metric to evaluate, develop, and optimize immersive environments. It is generally defined as a user's subjective sensation of "being there" in a scene depicted by a medium (Barfield, Zeltzer, Sheridan, & Slater, 1995). It has also been defined as "a perceptual illusion of non-mediation" (Lombard & Ditton, 1997), a definition that is consistent with the former one as it implies that a user incorrectly perceives a mediated scene to be unmediated. Further, Slater, Usoh and Steed (1994) described presence as "the (suspension of dis-) belief "of being located in a world other than the physical one.

All items on the ITC-SOPI had a 5-point Likert scale. Four common factors are present. Spatial Presence, for example, “I had a sense of being in the scenes displayed,” “I felt I was visiting the places in the displayed environment,” “I felt that the characters and/or objects could almost touch me.” Engagement, for example, “I felt involved (in the displayed environment),” “I enjoyed myself,” “My experience was intense.” Naturalness, for example, “The content seemed believable to me,” “I had a strong sense that the characters and objects were solid,” “The displayed environment seemed natural.” Negative effects, for example, “I felt dizzy,” “I felt disorientated,” “I felt nauseous.”

SPSS was then used to obtain descriptive statistics to describe the basic features of the data in the study. Also, frequencies and central tendency measures were used to describe most variables.

3.4 Quantitative Results

Factor analyses and frequencies. The dimensionality of the 37 items on the ITC SOPI inventory was analyzed using maximum likelihood factor analysis. Three criteria were used to determine the number of factors to rotate: the a priori hypothesis based on the literature that the measure had four factors, the scree plot test, and the interpretability of the factor solution. The scree plot indicated that our initial hypothesis of four factors was correct. Based on the plot and this hypothesis, four factors were rotated using a Varimax rotation procedure. The rotated solution yielded four interpretable factors, spatial presence, engagement, naturalness, and negative effects. The spatial presence factor accounted for 31% of the item variance, the engagement factor accounted for 18% of the item variance, the naturalness factor accounted for 14% of the item variance, and the negative effects factor accounted for 10% of the item variance.

Results indicated that 40% of students felt spatially present in the *Gallery 5* environment, 44% felt engaged, 55% felt that the environment seemed natural, and 24% experienced negative effects from the environment.

4 Scholarly Significance and Discussion

The Museum Mash-Up course is the result of a partnership between Crystal Bridges Museum of American Art, Virtual Arkansas, and the Educational Development Center, provides a rich art history experience for students in 9th through 12th grades. It includes a carefully selected variety of American Art images, thoughtfully authored multimedia learning objects, and interesting and compelling assessments.

With that said, this mixed methods pilot study revealed the following concerns that, if addressed, should result in an improvement of student learning:

4.1 Provide helpful tutorials on how to use the *Gallery 5* Immersive Environment

Students were not prepared to use Gallery 5, and this led to a greater learning curve for students than expected. Video and PDF tutorials should be provided on how to do each task within the *Gallery 5* environment and these tutorials should be linked within each assignment that uses them.

4.2 Add an orientation experience for the *Gallery 5* Immersive environment.

Provide an orientation period in the *Gallery 5* environment where students complete similar, but not exact activities to those required in assignments. This will provide needed scaffolding for students to slowly grow in their confidence and expertise with the environment.

4.3 Expand the use of the *Gallery 5* Immersive environment.

Despite the high enrollment of uninterested students in the course overall (39%), this portion of the course still maintained 44% level of student engagement, 55% who felt that the environment seemed natural, and 40% who felt spatially present in the *Gallery 5* environment. The high level of student attraction to this learning activity should be capitalized on. An expansion of the use of the environment to include its use during 50-75% of the course would help engage more students. Use of *Gallery 5* in a stepwise fashion to scaffold students in both the technical and artistic usages of the environment would help them to learn and use the environment in bite-sized chunks rather than all at once.

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Table 1. t-test results

Question		Pretest average	SD	N	Posttest average	SD	<i>t</i>	df	<i>p</i>
AHI	9	3.41	1.02	8	3.50	.54	.24	45	.81
AAI	9	3.44	1.10	8	3.88	.84	1.12	45	.27
MI	9	3.69	1.13	8	3.50	1.60	.41	45	.69
MF	9	2.18	1.01	8	2.38	1.06	.50	45	.62
AAK	8	2.47	1.01	8	3.50	.535	2.79	44	.008**
VAC	9	3.13	1.20	8	3.38	1.51	.51	45	.61

** $p < .01$ level of significance

Best Practices for Developing Online Learning Aids: Towards Systems Engineering

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Abstract. With the rise of Internet and the relative ease of delivering and accessing course material online, we are enjoying a proliferation of online digital learning aids and shared collections of assignments that have proven useful in our AI classes. In this paper, we discuss the efficacy and challenges of online learning from learner's perspective that we have gained through feedback from our AI classes (semi case study) and the available results of case studies about online learning experiences. Later in this paper, we indicate how we have used systems engineering (SE) methods integrated with the insights gained from observations and the case study in our development to improve its effectiveness.

Keywords: online learning, systems engineering, artificial intelligence, e-learning from learners' perspective.

1 Introduction

Many of the studies in online learning remain rather anecdotal, coming from the point of view of the instructors and designers of the courses [11] [12]. While comprehensive perspectives are required for understanding the potential value of online learning, few studies have detailed the learner's perspectives of online learning [9]. Knowing about the learner's opinion can help the online learning aids designers to improve the performance of these systems. The Teaching Artificial Intelligence (AI) as a Laboratory Science (TAILS)¹ project [1] [2] is an online learning artificial lab for teaching introductory AI concepts. This project is developed based upon the SE approaches to provide learning material in a more effective way. TAILS develops new and comprehensive paradigm concepts by implementing an experiment-based approach modeled after the lab sciences. Moreover, this project interweaves AI and software engineering course material and uses a top-down approach as its main learning method.

2 Definition of Online Digital Learning Aids

Several terminologies are used for online learning, which makes it difficult to develop

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a generic definition. Terms commonly used for online learning include elearning, internet learning, disturbed learning, network learning, tele-learning, virtual learning, computer assisted learning, web-based learning, and distance learning. All of these terms imply that the learner is at a distance from the instructor, uses some of technology (usually a computer) to access the learning material and interact, and some form of support is provided to learners [3]. The structure of many online learning labs is based upon autodidacticism or self- education. Self-education is the act of learning a subject in which one has had a little or no formal education. There is no instructor in these self-education learning labs. For this purpose, we define the online learning as a system in which a learner uses a computer to access the learning material, there is no direct interaction between the learner and the instructor, and the system is available 24/7. As there is no instructor in these learning aids, they should mostly focus on the learner and learning process, provide adequate support to the learners, and their materials must be well-designed so the learners can understand the objectives of the courses clearly.

The online learning systems encompass learning by utilizing a broad array of practices, tools, simulations, tutorials, and other artifacts that effectively use internet and smart computers. Online learning provides websites, pictures, videos, simulations, and interactive learning artifacts that help the students to have of a dynamic view of what they are learning. The available artifacts enables students to access the learning materials from anywhere in the world at any time by just having an internet connection. In other words, in the internet-focused world there are no boundaries for learning.

Online digital learning aids are virtual labs presented in the form of websites. They can approach learning from a top-down method, bottom-up approach, or anything in between. For instance, learning can be in the form of tutorials with descriptions and several lessons or examples, simulation of algorithms or applications, collection of exercises, or combination of these components. In addition to the variety of forms that learning can take, each can be represented in different levels of difficulty to match different levels of challenge.

3 First Development

The core idea in TAILS' initial development was to provide AI and software engineering learning material for students. The overall goal of the first development was to reveal the manipulation of AI concepts in real life applications and technologies such as path finding. The learning material was presented online on the TAILS website as simple activities simulating real-world AI applications. The structure of the activities were specifically designed to show the changing results step by step while the students were playing. The initial development also contained several practical and paper-and-pencil exercises available in the lab for students to challenge their knowledge.

Although our observations revealed great interest in students who experimented with the TAILS lab, we decided to investigate the inefficiencies of our work. We observed

that playing the games and solving problems are interactive but incomplete. Students might find the learning through games confusing if they cannot understand the logic behind them. We also investigated the results of similar case studies and realized that they were indicating reports of weaknesses and inefficiencies in online learning systems. For instance, participants in Hara and Kling's (1999) qualitative case study of a web-based education reported lack of support and response [9]. Many participants in the survey in 2003 by Song and Singleton reported difficulty understanding instructional goals, bad instructional design, and technical problems causing distraction [10]. Based on our findings, we recognized that the TAILS required some additional supportive learning material for the learners, such as documents describing the algorithms and rules of the games, tutorials for exercises, pseudo-codes of the algorithms, and UML diagrams to at-least display how the codes are working. In addition to the quality and efficiency of learning methods provided by TAILS, keeping the applications working properly over time (maintainability), robustness, modularity of the system, and reparability were the other challenges that we believed were solvable by applying SE methods to the TAILS.

4 Necessity of Systems Engineering

In the beginning of the technology era, or the epoch of great innovations and artifacts [4], the implicit mandate of the engineer was to design for first use. As technology grew stronger and we entered the epoch of complex systems and later the epoch of engineering systems, the focus changed. The goal of engineers in designing and developing systems was no longer simply working. The focus has been changed to be on quality, maintainability, robustness, reparability, modularity, and other ilities.

In addition to the mentioned weaknesses, the technical challenges of developing TAILS such as the ability of running on multiple platforms over an extended period of time (accessibility and operability), emergence of human factors as both users and developers (usability), reparability, and modularity, necessitated us to think more holistically not only about the overall purpose of our system but also about its interactions, impacts, and externals. This is called systems thinking. Applying systems engineering approaches on TAILS development initially necessitated us to investigate its goal, requirements and organize the working teams based on our requirements. We needed software engineers to implement the algorithms, content experts to come up with new ideas and alternatives, data analyzers, storytellers to document the process, graphic designers to think of the interfaces to be more user friendly, web developers to build up a website, and systems engineers to coordinate teams and apply SE methods to the development process. Thinking holistically, the purpose of TAILS changed to development of a comprehensive, robust, engaging, and interactive online learning aid. In fact, we needed systems engineering tools and methods not only to design the development process, investigate the risks, and find alternative solutions, but also after completion to maintain the system.

5 Comparison of Online Digital Learning Aids

Applied systems engineering methods in developing TAILS when coupled with the

advantages of other available online aids can engage and motivate students toward learning activities. For this purpose, we compared SIGCSE's Nifty Assignments project at Stanford University [5], EAAI's Model AI Assignment project at Gettysburg College [6], and Poole and Mackworth's AIspace project at University of British Columbia [7] in terms of their successes or failures in resolving the mentioned weaknesses found in our observations and the case studies.

Figure 1 discusses the strengths, available innovations, and also weaknesses of these systems separately. SE approaches can reinforce the strengths of these systems, such as o_ering a metadata table and reduce their existing shortcomings to make them highly helpful and easy to use. This helps students to focus more on the learning material without being distracted by technical issues.

6 TAILS and SE Methods

The comparisons in Figure 1 reflect that developing a helpful online learning aid requires thinking deeply and investigating it not only from a software perspective, but also from a complete system view. Failure to investigate from different perspectives can result in failures in the initial design or during maintenance.

Clearly, there is a large set of interrelated decisions to make when we build online learning systems: What kind of delivery model shall we use or what mixture of these models? Will we support learners and trainers anywhere, anytime, at any pace; are there exceptions to this? What kind of learning scenarios do we need? Which actors will interact at delivery time, what are their roles, what resources do they need? What kind of interactivity or collaboration should be included? Will we use multimedia or plurimedia materials? What materials can be reused and are there new ones to build? How are we to manage distributed resources on the networks? How can we support interoperability and scalability of the system? What kind of standards will be used? How do we take in account the technological diversity between groups of users within the target population? How can we promote reusability, sustainability and affordability of the web-based learning systems we are building? Basically, these decisions are mostly about the type of the delivery model and the actors, type of support for the learners and the system, resources, and materials [8]. We used SE methods and systems thinking to answer these questions and solve the challenges of re-developing the TAILS.

The TAILS project has two major components: a set of lab experiments to promote student retention of concepts and retention of majors, and insight into student learning through the labs. We anticipate that the proposed lab experiments will engage two more learning types in the computer engineering coursework: the kinetic learner, who needs to perform tasks to learn, and the model driven learner, who needs the big picture to assimilate course material. In other words, TAILS offers several learning methods on its website, each of which is interesting for a specific group of students. The website is user-friendly and offers several AI learning materials in different modules. These modules have online activities for students to help them visualize how AI ideas are applied to real world problems. Documentations, test suites, UML

diagrams, source code, video tutorials, and classroom scaffolding such as PowerPoint files are available for each module. The exercises will allow students to experiment with working applications, modify algorithms, understand the effect of changes to parameters, and extend existing solutions. Supplying diverse learning material additional to the games almost eliminated the difficulties and confusions of the first development. Moreover, in regard to SE approaches, we increased independency of the modules to facilitate reparability, maintainability, and robustness in order to alleviate technical problems. We believe that diversity of the resources and existing solutions can improve the feedback and support for the learners and positive experiences with these tasks will increase student confidence as well as interest in pursuing further research.

7 Best Practices with TAILS

The pedagogical scaffolding required for the module, a map of the web pages for the online delivery of the content, and documentation of the software applications that implement the AI algorithms, which are the target of the project, highly accompany the modules. Best practices for enhancing the user experience include, but are not limited to, providing an inventory of the files needed to run each application, known dependencies, and clear instructions for compiling the code and running the application. Video tutorials are especially helpful. To encourage engagement, students are able to play any games used to demonstrate an algorithm, with computer players provided for the case of multiplayer games. Assumptions of player familiarity with any game is avoided and rules for each game accompany the module. The description of each exercise in the module includes the scaffolding required to complete the assignment, as well as pseudo-code and programming language details appropriate for each exercise. The independent design of the modules in the structure of the website provides more technical support for the website and facilitate long time availability and accessibility to the website.

8 Conclusions

As the use of technology grows in education, science and engineering are interweaving themselves into a knot. This requires the teachers, engineers, scientists, and innovators to convene and re-think the new challenges and needs from different perspectives. Technologies such as computers and internet can help the schools and teachers expand the frontiers of knowledge, but they can add new challenges. We believe that SE methods can help the designers and teachers in defining correct requirements of developing the online learning systems and making right decisions about the new challenges.

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Learning aid's name	Presenting media	Learning tools /Tutorials	Assignments/ Experiments	Strengths and weaknesses
SIGCSE's Nifty Assignments project at Stanford University	A website that provides topics of the existing projects as links in the home page and a brief description about the project.	Some brief tutorials are provided from the designers of some of experiments in the website. Some only contain information about the projects, such as picture, application, starting code, or brief summary.	Several experiments from CS categories like AI and DS represented in different types, such as: codes, analyses, or questions. Each assignment might have a handout, sample data file, starting code file, model grading criteria, and a runnable demo application.	+ Metadata information table + Covers several fields of CS - A little information about the existing code or app - Lack of guidance and tutorial - No unique coding language or structure (technical issue) - Not enough info about the algorithm used - Lack of available solutions (support/feedback issue) - Lack of user-friendliness (design)
EAAI's Model AI Assignment project at Gettysburg College	A website with links to several assignments listed in tables. Tables refer to different symposiums and a brief description is also available in the tables for the assignments.	The projects cover a wide range of AI experiments. The experiments might provide different tutorials on the link or downloadable pdfs such as handouts. The codes and runnable apps for exercises are available as downloadable files.	There are some examples or tutorials for the assignments and they are available rather in the webpage or as a pdf file. Other requirements of the assignments like data, codes, and simulated applications are provided in different links in the exercises. Most of the experiments are programming assignments.	+ Metadata information table + Supportive tutorials for exercises + Examples and test suits available - A few complete source codes. - Lack of guidance in the web (technical issue) - No unique coding language - Lack of info about the algorithms - A few runnable demo application - Leakage of available solutions (feedback/support issue) - Lack of user-friendliness (design) - No unique and comprehensive structure for exercises (technical issue)
Poole and Mackworth's AIspace project at University of British Columbia	A well-designed website that provides learning material in several modules, such as: exercises, tools, and downloads.	Learning tutorials in this website are almost visual in form of runnable Java applications. Instructions to use the applications are available in videos or documents. Learning materials are represented in runnable apps, video tutorials, and exercises with solutions.	All of the assignments and experiments are under the Exercises tab. There are several exercises available for every module. Each exercise has background readings, pictures, playing with the apps, and questions as well as solutions for the exercise. There are some open source applets available in a link to another website.	+ A well-structured website (technical support) + Updated versions of Java apps (technical support) + Unique app programming method (all runnable in Java) + Available learning tutorials + Available solutions (feedback) - Lack of maintainability (technical issue) - Lack of available codes - No info about the algorithms - No info about the applications - Errors in open-source applets (technical issue) - No programming assignments - No online running apps (downloadable) (technical issue)

Fig. 1. Comparison of Nifty Assignments, EAAI Model AI Assignments, and Poole and Machworth's AIspace

Special Track 2: The Future of Education

An Online Immersive Reality Innovation-Lab

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Abstract. This paper introduces the concept of online ‘*Innovations-Labs*’ (i-Labs) as location-independent collaborative ideation spaces. We highlight the challenges and opportunities that disruptive innovations present to companies and society, and discuss how *Science Fiction Prototyping* and *Diegetic Innovation Templating* can provide a means to explore that space by acting as ideation process and a language for capturing and communicating innovations. A core hypothesis of this paper is that there are significant gains to be accrued from integrating *Virtual Reality*, *Science Fiction Prototyping*, *Diegetic Innovation Templating* and *Innovation Labs* to form an online immersive reality innovation-lab which both offers better affordances and access to people wishing to undertake innovation related activities. We present details of our initial implementation of an online innovation-lab (*Our HEX*) which takes the form of a virtual-reality space-station. We then conclude the paper by describing future directions of our work, principally, a venture which uses ‘*Our HEX*’ space-station platform, plus a supporting textbook published by Tsinghua University Press, to teach ‘*English, Computing and Creativity*’ to Chinese students. Finally the paper concludes with a summary and reflections on our work to-date.

Keywords: Virtual-Reality, Innovation-Labs, Ideation, Innovation, Science-Fiction Prototyping, Diegetic Innovation Templating, Creative-Science, EFL.

1 Introduction

It is generally agreed that innovation is an essential component for economic growth and productivity. A recent report by PriceWaterhouseCoopers, the largest professional services firm in the world, found that “*Five years ago, globalisation would have been the most powerful lever for growth and every business would have been talking about China. But now, the growth lever that has the greatest impact is innovation. Ninety three percent of executives tell us that organic growth through innovation will drive the greater proportion of their revenue growth*”[1]. Thus it’s hardly surprising to find that governments around the world place a huge importance on supporting innovation activities although how they do that varies widely, depending on various political and financial factors. While innovation sometimes appears to be rooted in the individual (eg Steve Jobs) from a government perspective it is a product of a *National*

Innovation System (NIS) that includes all economic, political and other social institutions affecting innovation (eg education, financial structures, regulatory policies, labour markets; culture etc). For example, China operates a NIS derived from their 15-year national plan (2006-2020), the '*National Outline*', which contains a section that focuses explicitly on creating nation-wide structures favourable to innovation [2]. In contrast the USA has not adopted a centralized approach rather, being a country that grew out of the notion of free enterprise and thinking, innovation was more easily established as it was part of the underlying 'DNA' of American culture. That is not to say that government policy does not play a role in fuelling American innovation, just a lesser one than in most other countries. It is difficult to measure a countries innovation capacity but one metric is the number of patents that are registered annually. Those statistics place the EU, USA, Japan and China in leading positions, aligning well with their economic performance. Because of the importance of innovation to companies and national economies, there is a huge incentive for companies to find tools that can aid the process of innovation. Once such tool is *Science Fiction Prototyping*, an ideation and communication tool that was first proposed by Brian David Johnson while he was working for Intel Labs in Portland. The basic principle of the method is that the stakeholders of the innovation create futuristic fictions as a means of unleashing their imagination plus communicating and testing the ideas [3]. Another tool is *Diegetic Innovation Templating* which uses existing fiction as an inspiration for new innovations (eg the flip-phone being inspired by the Star-Trek communicator) [4]. Innovation works better with a group of people where they can spark ideas off each other and the limited knowledge of an individual can be supplemented by others. One popular group-based approach is the *Innovation-Lab* (i-Lab) which offers a specially designed environment that is conducive to creative thinking [5]. For example, i-Labs provide participants with a relaxed comfortable setting where they can contribute ideas anonymously during ideation sessions. Generally, i-Labs require the participants to be physically present in the same location. However, the advent of virtual-reality has opened up the possibility of an i-Lab being located online in a virtual space which allows participants to be located anywhere in the world, and to utilise tools that would not exist in the physical world. Thus, this is the aim of the work in this paper, to explore the potential arising from combining i-Labs, virtual-reality and science-fiction prototyping, diegetic innovation templating to create a novel online innovation facility which will be described in the following sections.

2 Related Work

2.1 Innovation Labs

An innovation-lab (i-Lab) has been described as an "*inspirational facility designed to transport users from their everyday environment into an extraordinary space encouraging creative thinking and problem solving*" [5]. The i-Lab concept was based on a model created by the UK Royal Mail's '*Futures and Innovation Group*' in 1997 for the purpose of helping their management teams brainstorm future possibilities. In

doing this it became apparent that the interactions within the groups, together with the conversational and session management tools played a significant role in the effectiveness of the sessions, leading to the idea for providing specialist environments to support these activities.

In transferring the i-Lab concept from the original Royal Mail environment to the wider world there have been three notable projects. The first was the '*Learning the Habit of Innovation: Harnessing Technology for Strategic Planning*' (LHI) which was a collaboration between the UK Royal Mail and the universities of East Anglia, Cambridge, Essex, Bedfordshire plus Anglia Ruskin University. It was operated out of the University of East Anglia from 2001-2004 and funded by the Higher Education Funding Council for England [6]. The project sought to transfer the i-Lab model created by the UK Royal Mail into higher education and involved formalising a template that would form a minimum set of conditions to recreate an innovation environment. In brief they deduced that an i-Lab required three interlinking components namely the *environment*, the *technology* and the *facilitation mechanisms* to make it suitable for ideation and innovation activities. Furthermore, they determined that an iLab session comprised some mix of the following activities (most electronically supported):

- Icebreaker and reviver activities
- Discussion & getting other people's perspectives
- Brainstorming & voting
- Headlines, cut & paste collages and PowerPoint presentations
- Wall activities (collaborative writing, doodling etc)
- Scenario building
- Role play

They emphasised that creative thinking was not necessarily a rational, linear process and that revisiting and refining ideas could be a productive way to progress. At the core of the process was brainstorming, a technique for unleashing a flood of thoughts driven by members sparking ideas off each other, or carefully injected external stimulus. Having generated sufficient ideas a group would go on to categorise, rationalise and vote on the suggestions. Implementing the ideas is more challenging and occurs beyond the i-Lab session.

The two other notable ventures were EU Leonardo da Vinci collaborations between educational institutions from Poland, Greece, Romania and Turkey, coordinated by the University of Essex in the UK around two projects, namely '*The European i-Lab Competences Development Programme*' (2006–2008) and '*The Innovation Laboratories for the Quality Assurance of Vocational Education and Training*' (2012-2014) [7]. These projects led to the establishment of three innovation laboratories in Poland, Turkey and Romania and the production of a standard guide for i-Labs, namely the '*Innovation laboratory – Good Practice Guide*' [8] all of which aimed at the promotion of i-Lab use throughout Europe which, today, has resulted in over 100 globally-located i-Labs (from social to technical) created by organisations as diverse as the Standard Bank, Walmart, John Lewis, the UK National Health Service, Ryan Air and government (eg New York's 'Public Policy Lab' or the 'Social Innovation

Lab for Kent’) [15]. In respect of this paper, one of the most significant i-Lab developments has been the introduction of web-based software which provides a much more efficient (and faster) ideation process together with providing an anonymity component [9]. Moreover, this computerisation has enabled i-Labs to move into Cyberspace, allowing participants to be freed from the need for physical co-location, a feature we build on in our online version of an i-Lab (*Our HEX*).

In our work, we use brainstorming as part of a product-innovation process called *Science Fiction Prototyping* that will be explained in the following section. In this we adopt a procedure called an *Imagination Workshop* which was first proposed by Wu in 2013 and is similar to the brain-storming process used in an i-Lab except it uses science fiction and fantasy ideas to extrapolate forward current technologies, business and social practices by ten-plus years [10]. These concepts will be explained in the following section.

3 Creative Science

Creative Science refers to creative methods for supporting science, engineering, business and socio-political innovation through various imaginative activities. For the purposes of this paper those mostly concern *Science Fiction Prototyping* (SFP) and *Diegetic Innovation Templating* (DiT).

3.1 Science Fiction Prototyping

As was mentioned earlier, *Science Fiction Prototyping* was proposed by Brian David Johnson, Intel’s then Futurist, as a response to a particularly difficult innovation challenge Intel faced in designing new generations of integrated circuits. Their challenge was that it takes between 7-10 years to take an integrated circuit from concept through to production and, during that period, there can be as many as 6 generations of potential applications for it. For example, new models of mobile phone can be released as frequently as every 18 months. Thus, chip designers needed to anticipate applications 7 years’ ahead of specifying a chip (and possibly longer as the applications may live on for another 15 or more years) which, in a rapidly changing world, presents a formidable challenge! Of course an even bigger worry is the risk of disruptive technologies coming along. Thus, there was a compelling case for Intel to find a creative-thinking process that might come to their aid. Their solution was *Science-Fiction Prototyping*. Essentially, the method involves writing short fictional stories that imaginatively extrapolated current practices forward in time, leaping over incremental developments, exploring the world of disruptive product, business and social innovations. Because *Science-Fiction Prototyping* adopts a rich story-based structure it was able to create high-fidelity analogues of the real world, enabling it to act as a type of prototype to test the idea. Moreover, being a story it was accessible to anyone (aka the old adage ‘*everyone likes a story*’) making it a perfect vehicle for conversations between all the stakeholders of the innovation, including society at

large (the customers of innovations). The outcomes of *Science-Fiction Prototypes* are used to create new kinds of products, businesses or socio-political structures etc.

3.2 Science Fiction Prototypes Style

The most common size for a *Science Fiction Prototype* is 6-12 pages (referred to as a *mini-SFP*) which is of a similar size to a conference paper [10]. However, 6-12 pages can take many days to write so for innovation sessions, that need to take place in less than a day, an even shorter form of *Science-Fiction Prototype* was developed; the *Micro-SFP* (or μ SFP) [11] which will be described in the following section.

3.3 Science Fiction Prototyping Workshops.

Typically, science fiction prototyping based innovation sessions take the form of an *Imagination Workshop* [14]. It involves gathering together a group of participants, specifying a goal (eg a new business or product etc), providing a context (eg business, home etc), setting a timeline (eg usually 10+ years into the future) and offering support for brainstorming about possible futures. A World Café approach is adapted to stimulate brainstorming and discussion with participants being placed in small groups (eg 5-7 members). Most other aspects are similar to an i-Lab.

3.4 μ SFP- A Shorthand Innovation Language

There is no agreed specification for micro-fiction but, given the close relationship of *Science Fiction Prototyping* to technology perhaps it is not surprising to discover a popular size for a μ SFP is one that fits mobile phone text (160 characters) or Twitter messages (140 characters) which, in English language, equates roughly to 25-30, words. Since μ SFPs are short, they have the advantage of being quick to write, enabling users to capture and create many ideas in a short time period, in a similar timescale to brainstorming. Thus, μ SFPs are seen as being complementary to brainstorming, providing a means to wrap a brainstormed idea in a more story-like framework which provides added meaning. From another perspective μ SFPs are an interim step between a raw idea and a full *Science Fiction Prototype*. By way of an illustration of the principle of μ SFPs, consider the following example:

Zoe, you've been my life-long friend on SentiBook; today the news feed reports most social network friends don't exist, are you real? (22 words, 133 characters)

This μ SFP extrapolates forward in time the current trend of companies adopting ever-more more automated customer call handling systems but explores the consequences of such technology reaching out more widely, for example into email and social messaging systems. It raises the question about whether we will know, or even care, if the parties we are communicating with are real or artificial. In this particular example the μ SFP observes that our lives are becoming increasingly virtualised through, for

example, friendships on social networks with people we may never have met physically. As AI advances, machines will be better able to mimic real people, raising all kinds of new opportunities and conundrums.

Following the creation of a μ SFP the next step would be to expand it into a *mini-SFP* (a 6-12 page version with a rationale and comments), followed by the usual product development cycle involving pre-production prototypes etc.

3.5 Diegetic Innovation Templating

Diegetic Innovation Templating (DiT) is a process of extracting creative ideas (eg innovations) from fictions created for the purpose of entertainment, rather than for technology, social or business innovation. Thus they are typically science fiction or fantasy movies or TV series such as, for example, Star-Trek that taps into the creative abilities of great authors and filmmakers as source of creative ideas. The term ‘*diegetic*’ is borrowed from film studies and refers to things which are embedded into a fiction, playing an integral role in the story, such as the use of a gadget by one of the characters, and seen through their eyes. The artistic nature of such productions makes them particularly useful for non-technical applications or for situations where writing bespoke fictions is not a good option. For example it has been used by one of China’s leading fashion design houses (Sunfed) where it leverages the advantage from popular fiction being embedded into socio-cultural contexts (ie the firms marketplace) aiding branding and marketing efforts [12].

3.6 Out of the Box and into ‘Our HEX’

By way of a summary of this section, we introduced *Science Fiction Prototyping* and *Diegetic Innovation Templating* as tools to support the early ideation phase of the innovation process by providing a means to engage people's imagination in thinking ‘*out of the box*’ about future possibilities. *Science Fiction Prototyping* also allows the ideas to be tested within a plausible narrative and provides a way of opening dialogues, independently of specialist domain knowledge, with all the key stakeholders. In the next section we will describe ‘*Our Hex*’ a virtual spacestation which provides an online facility to host i-Lab activities based around the *Creative Science* concepts we have presented above.

4 The Virtual Spacestation (on online Innovation-Laboratory)

4.1 A Spacestation Based i-Lab

Since *Science-Fiction Prototyping* concerns thinking about high-tech futures, the idea to base the online i-Lab on a simulation of a spacestation was born. The first version was funded by the *Creative Science Foundation* as a way to explore the concept of ‘*free will*’ raised in Brian Johnson’s original *21st Century Robot* science fiction

prototype [13]. Our current online innovation lab is a modification of that early virtual-reality spacestation and consists of a large central arrival area (Social Deck) leading to an, essentially, unlimited number individual rooms, each outfitted to resemble an i-Lab.

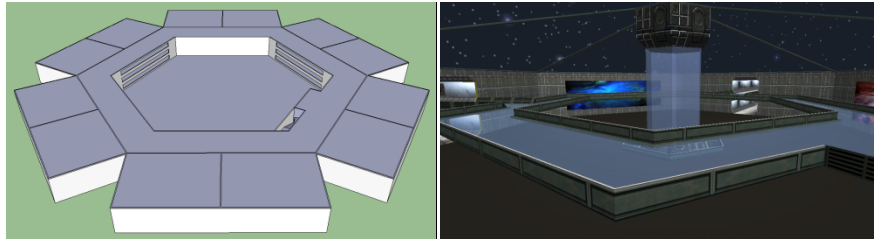


Fig.3. ‘Our’ ‘HEX’ Spacestation (Layout & Prototype Interior).

The spacestation structure was inspired by the *Hexagon Restaurant* (affectionately referred to as “*Our HEX*”) at Essex University (now defunct) which is shown with 6 pairs of i-Labs (Fig 1) but, in practice, since i-Labs are simply software instances, there is no fixed number as they can be created on-the-fly, as required. In keeping with the list of functionalities listed earlier, each simulated i-Lab includes a communal electronic white-board, a set of anonymised editing stations (so ideas and comments can be written to the white-board without identifying the writer) and facilitator tools for managing and archiving the sessions.

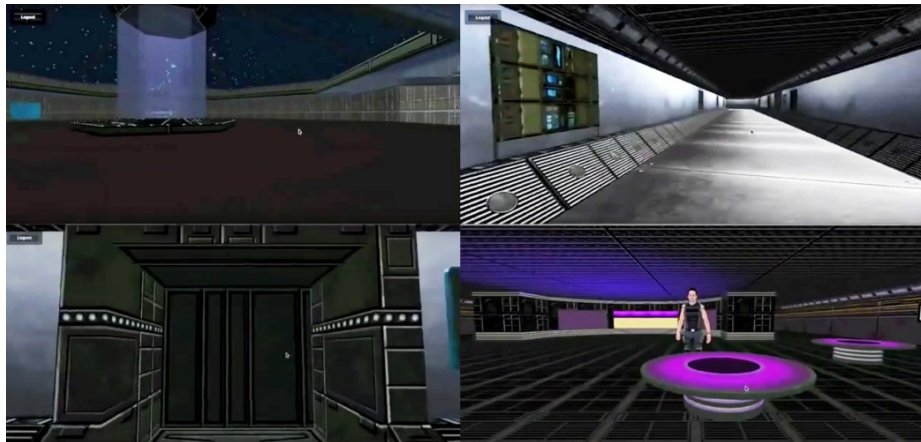


Fig. 2 – The Unity 3D Prototype iLab space station (clockwise from the top left there is the Social-Deck, one of the radial connecting corridors, an i-Lab entrance and a view of an i-Lab)

With reference to figure 2, each user who accesses the virtual world (ie logs in) first appears in the central arrivals area (the Social Deck). From that location they are free to walk around the environment; interacting with any displays they encounter (eg display boards showing outputs from earlier science fiction prototyping, diegetic innovation templating sessions, or interactive display boards where they can participate in competitions to evaluate innovation outputs, or just read notices of other

events). The central area has corridors leading to each of the different i-Labs. In each i-Lab, users are able to participate in Imagination Workshop sessions (described earlier). Teachers and facilitators are able to observe, assist and rate student work.

The prototype of ‘*Our HEX*’ was implemented using Unity-3D, an online gaming engine. Being an MMO cloud based virtual world, users are able to log into the environment via a link from the website of the Creative Science Foundation (CSf). The spacestation’s i-Lab server resources are provided by a cloud based system. The execution-engine currently supports a Java runtime environment structured in a modularised client / server arrangement to facilitate future expansion. While a working prototype of the spacestation has been built (a video walkthrough is available at <http://www.youtube.com/watch?v=-i6ki5YHGZc>) there are a number of aspects that require completion before the system can be publically deployed, most notably creating a full gamut of i-Lab facilitation tools plus completing a formal evaluation with students. In addition the platform’s user-guide needs to be integrated with the Tsinghua University Press textbook. Thus, ‘*Our HEX*’ is a ‘work-in-progress’ task with functionality being added continually in response to user needs. To provide an insight to our immediate work-plans, the following section describes our next steps.

5 Deployment Plans

Currently ‘*Our HEX*’ is being operated with a closed group of students at Shijiazhuang University, China, who follow a *Computer English* course [17] based on a carefully crafted Tsinghua University Press textbook [18].

By way of some background, in China it’s mandatory for universities to teach “*Public English*” to all their students as this is seen as a necessary skill for them to thrive in a global business environment. For computer science students this requirement is translated into the provision of a specialized English module called ‘*Computer English*’ that is usually delivered to students in their 3rd or 4th year [19]. By combining English Language with Computer Engineering, the course is made relevant to the student’s studies [20] [21].

Beyond learning English, another vital skill for a workforce with aspirations to compete in global markets is an ability to innovate, which *Science-Fiction Prototyping* supports. Thus the proposition to integrate learning English Language, Computer Science and Innovation via an engaging new course was born, leading to a pilot trial being conducted by Zhang at Shijiazhuang University during the period 2014-2016 [16]. Following the success of this trial (student motivation and performance were demonstrated to sharply increase, with one student even publishing his SFP in an international workshop [22]) the team worked with Tsinghua University Press to produce a textbook that has been made available across China [18]. In support of this venture, we are planning to use the ‘*Our HEX*’ spacestation platform as a means to widen access to innovation-lab facilities across China and the rest of the world. As part of this vision, in the longer-term, we plan to address other languages such as Spanish.

Thus, “Our HEX” functions as an online school to teach ‘*English as a Foreign Language*’ (EFL) based around Creative Science, which brings the additional bonus of training students in creative thinking and innovation. In terms of the potential for this venture, the market for teaching English is estimated to be worth some \$5 billion or more. In China alone there are an estimated 250 million English learners, increasing by 20 million per year, with a requirement for 1 million English teachers, which has led to the emergence of a plethora of enterprises seeking to satisfy these needs. Examples include *Ivy League English*, founded in 2009 by graduates of the Massachusetts Institute of Technology, which provides an app that connects students with USA-based business coaches for real-time roleplay activities (www.ile-china.com/), the 2013 Kickstarter funded start-up, *Influent*, that created a video game designed to introduce foreign vocabulary to learners by them exploring an interactive 3D environment filled with hundreds of selectable objects (www.playinfluent.com) through to full blown MOOCs learning platforms such as the Shanghai based *Hujiang* which has grown to over 90 million registered users since starting in 2001 (www.hujiang.com/). Hence, this venture joins a fairly crowded marketplace but differentiates itself by offering a novel combination of science, creative-thinking and language learning, especially tailored for university based Computer Engineering students through a supporting Tsinghua University Press textbook.

From the earlier sections it can be understood that creative science exercises English language by requiring students to read and write short stories plus undertake group work via brainstorming and presentations (and, as a by-product, getting other useful skills such as creative thinking and product innovation). Because, this involves group-work there is a space issue since, ideally, each group would have their own dedicated space (room). Clearly, in most situations that is impractical. For example, in the case of Shijiazhuang University's ‘*Computer English*’ course, their 160 students would require some 23 rooms (assuming maximum group sizes of 7 students). Thus, ‘*Our HEX*’ overcomes these space limitations as well as broadening participation to students, independently of their geographical location. In addition, given the virtual nature of the space, it is simple to outfit it with simulations i-Lab tools (ie an electronic white-board, anonymised editing stations and computerised facilitator tools) making it a virtual innovation-lab that can be replicated with little cost.

While our current focus is on creating an online “*English as a Foreign Language*” school we have been considering other longer-term possibilities for ‘*Our HEX*’. In terms of language training it would be possible to enrich the activities by including online role-play [23] [24]. Beyond language training, clearly one major application is as an online Innovation-Lab which would aim to satisfy the growing commercial demand for innovation services and we are working with a Taiwanese start-up, LivingPattern Technology Inc to explore these possibilities [25]. Other possibilities include collaborating with the Creative Science Foundation to host an online version of their vacation ‘*Entrepreneurship Schools*’ (<http://www.creative-science.org>) or working with FortiTo Ltd to create online ‘*Maker Schools*’ (www.fortito.mx).

5.1 Deployment Platforms

A key issue is the cost of accessing this service. As a consequence we developed the system to work with a range of technologies to better fit the user's resources. These range from commonplace technologies such as mobile phones, pads, laptops and desktops, to more sophisticated devices such as virtual and augmented reality glasses (see figure 3).

Being a virtual-reality environment, '*Our HEX*' has the potential to simultaneously offer a number of different user experiences, depending upon how an individual chooses to interface and interact with the world. For example, whether the world is viewed from a first or third-person perspective can significantly alter the relative experiences of individual users, especially when working with others in team-based exercises. Furthermore, technologies such as VR headsets, (e.g. the *Oculus Rift*, or *HTC Vive*) could be used to generate a more immersive experience in the minds of users, allowing them to move around '*Our HEX*', with the impression of actually being transported inside the artificial world. Mixed reality interfaces, such as the Metavision's *Meta-2* or Microsoft's *HoloLens* system, could also potentially be used to superimpose fragments of the spacestation onto the real world, effectively turning a physical room or other location into an extension of the '*Our HEX*' environment. Such an arrangement could facilitate interaction between groups of people where several are sharing the same physical space but wish to interact with other remote users present elsewhere in '*Our HEX*'.

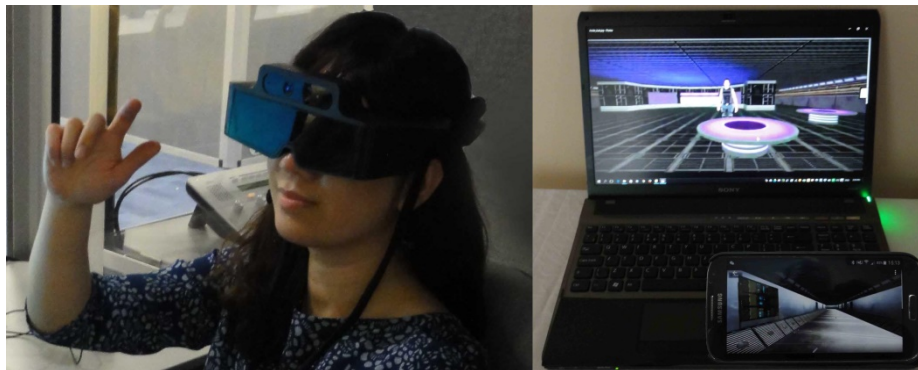


Fig. 3 – Some platforms for “*Our HEX*” (picture courtesy of Dan Chen)

As mentioned earlier, '*Our HEX*' was implemented using *Unity 3D*, a professional tool used for the creation of computer games. The decision was made to use a game engine as an implementation platform in order to take advantage of some of the available graphics, physics, networking and other technologies developed by advancements in the computer games industry. Another reason was to give users some familiarity via a common interface, with many of the controls being identical to those used in PC games, (e.g. WSAD movement controls). By making the user as comfortable and immersed as possible in the '*Our HEX*' environment, their user

experience should be enhanced and hopefully create a more productive innovation or education session. Other computer games technologies that may be beneficial to a learning/innovation environment are also being explored for potential integration with the ‘*Our HEX*’ system. For example, live streaming services, such as *Twitch*, could be invaluable for a teaching experience, as users could both visually see a live representation of their teacher and provide feedback or ask questions via the text chat feature. From a business perspective, live streaming services could have potential benefits such as revenue generation from advertising and subscriptions or tips from users. Recordings of past broadcasts can also be played back on-demand by users.

6 Summary

This paper has described how we developed an online creative space which integrated *virtual reality*, *science fiction prototyping*, *diegetic innovation templating* and *innovation-lab* concepts to create a novel shared ideation space. We argued that the synergy derived from this linkage introduced significant new opportunities for those seeking to undertake innovation activities. For instance virtual reality both provides a more engaging and functional space, together with widening participation. We also argued that the inclusion of creative science tools provides a particularly good approach for exploring disruptive innovations as it levers people’s imagination through the use of futuristic science fiction to offer more radical perspectives on the future. We also explained that a story based narrative provides an effective way to facilitate communication between professionals and lay-members of society, who frequently lack a shared vocabulary to converse (articulated by the mantra “*everyone likes a story*”). Finally we described how, in support of the book we have published with Tsinghua University Press in China, we are exploring the application of the ‘*Our HEX*’ spacestation platform as an aid to students learning a combination of English language and innovation. Clearly this work is at an early stage and we will look forward to reporting on further progress in later conferences.

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Virtual Observation Lenses for Assessing Online Collaborative Learning Environment

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Abstract. The purpose of this paper is to introduce a new approach for assessing learning outcomes from collaborative work in 3D virtual environments. It represents a novel computational framework that improves recording and observing collaborative activities between students to evaluate learning outcomes. The framework includes a virtual observation model that maps observing learners in classrooms with observing and assessing the students in 3D spaces. This can be accomplished by applying a mechanism that combines natural agents and software agents to support collecting learning evidences from virtual activities and simulate the educators' observation(s). Such a novel framework will solve issues that could develop from evaluating students' performance, interaction, skill and knowledge in collaborative virtual learning environments.

Keywords: E-learning; 3D Virtual Worlds; Assessment; Virtual Observation; Collaborative Learning; Learning Evidence; Software Agents; Natural Agents.

1 Introduction

The power of networks and computers has invented technologies that support learning and connect geographically dispersed learners to enhance learning experiences. Several educational technologies have been widely applied that connect scholars and educators to provide different types of activities and to access learning sessions remotely without requiring physical attendance. By using online environments, organisations could easily educate learners and support collaborative learning without offering physical place or hiring educators.

A great technology that enables virtual collaborative learning is the immersive environment, the 3D virtual worlds (3D VWs). The 3D spaces are increasing in popularity because of many features that distinguish them from other online systems. They connect students in real-time and enhance interactivity, exploration, and engagement between them. Moreover, they facilitate investigation of ideas, situations and places that cannot be reached physically; delivering learning processes; providing

realism of interaction, discussions and activities of even the most complicated topics in simpler conditions with less cost.

Collaborative learning can help students to achieve learning through working with their peers, who support them to enhance their information and skills, resulting in constructing new knowledge and experiences. Learners usually obtain new knowledge while participating in learning sessions, so evaluating learners in a group should not be applied just after the last learning session, but it should also be applied during the learning process. Wells [1] also stated that educators should evaluate the whole learning process when performing collaborative learning activities rather than look at the final artefact as evidence of learning.

However, numerous issues can arise when assessing learning outcomes for a group of students in the 3D environments. Firstly, observing users' behaviour dynamically and collecting evidence of learning are complex tasks in VEs. Secondly, various skills, including communication and negotiation skills, can be gained from collaborative activities, but it is difficult to automatically detect evidence of them in these spaces. Thirdly, labelling and recognizing the evidence of many users in real-time is difficult because several students are contributing at the same time, which makes tracking the evidence much more complex. Therefore, finding an event detection method that can dynamically recognise users' behaviour, collect learning evidence data, and analyse events to measure the learning outcomes, is necessary. Gardner and Elliott [2] indicated that 'learning within technology creates a pedagogical shift that requires teachers to think about measuring outcomes in non-traditional ways'.

The purpose of this paper is to introduce a new approach for assessing learning outcomes from collaborative work in 3D virtual environments. It represents a novel computational framework that improves recording and observing collaborative activities between students to evaluate learning outcomes. The framework includes a virtual observation model that maps observing learners in classrooms with observing and assessing the students in 3D spaces. This can be accomplished by applying a mechanism that combines natural agents and software agents to support collecting learning evidences from virtual activities and simulate the educators' observation(s). Such a novel framework will solve issues that could develop from evaluating students' performance, interaction, skill and knowledge in collaborative virtual learning environments.

2 Related Work

2.1 Identifying Learning Evidence in Virtual Environments

Identifying learning evidence is simple in the multiple choice online test format, but it becomes more problematic in 3D VEs or educational games, because of the large number of observational variables and the complex relationship between these variables and students' performance [3]. Although technological improvements assist in recording data, even for difficult situations, understanding and analysing the composite data that results involves more complex processes.

Certain approaches have been used to assess modelling learners' skills and knowledge in simulation learning spaces. The approaches can be categorised into two groups: 1) knowledge engineering/ cognitive task analysis approach and 2) machine learning/data mining approach. The knowledge engineering approach formulates logical rules to assess and group particular students' behaviours. The rules are also applied to differentiate the level of students' skills such as the study by [4]. In the machine learning/data mining approach, learners' behaviours are recognised by analysing data and extracting learners' performance from the log files that are auto-generated while students are participating. For example, learning evidence has been collected through analysing users' log data by applying cluster analysis algorithms to determine the key feature of students' performance in educational game environments [5].

However, the log files save all the players' responses to the given educational problems which creates enormous amounts of data that provide a serious obstacle for researchers when collecting learning evidence from immersive environments [6]. This makes it very difficult to capture individual students' learning, knowledge, and skills and challenging to identify the actions and performance that represent learning. Moreover, collecting data in simulation or virtual environments without consideration of how the data will be assessed or scored is an ineffective method for creating assessments. Hence, designing the learning environment from the beginning to enable assessment and collecting learning evidence is more preferable [7].

Additional issue with identifying learning evidence is that technologies cannot capture all of the acquired skills. Several skills can be gained from collaborative activities, but it is complicated to automatically detect evidence of them [8]. For example, the quality of the interaction skills between students including teamwork, collaboration, negotiation, and communication are hard to measure with regular assessments. The study [9] proposed techniques that permits assessing learning outcomes (skills, knowledge, and competencies) by using elements such as smart objects and avatars in 3D spaces. However, these techniques lack in measuring the quality of learning in collaborative environments.

Analysing various users' behaviour/data, identifying the meaningful actions, and combining those actions into learning evidence to determine the learning outcomes are very complex processes in such environments. Consequently, discovering techniques that could dynamically recognise learning evidence and analyse events to measure the quality and quantity of learning outcomes is advantageous. Developing such mechanisms will help to identify and gather proof of learning during collaborative activities in immersive worlds and correlate the evidence with learning objectives, to assess the overall outcomes of the learning processes.

According to Thompson and Markauskaite [10], 'educators need to move beyond traditional forms of assessment and search for evidence of learning in the learner interactions with each other and the virtual environment, and artefacts created.' Hence, we have considered another assessment method such as classroom observation which greatly assists educators to evaluate students by collecting evidence about their

learning. We have mapped the physical observation to the 3D spaces to provide more insights of what evidence could be collected from students' performance. Section (2.2) gives more explanation of the observation method in learning.

2.2 Observation

2.1.3. 'Teacher observation occurs continually as a natural part of the learning and teaching process and can be used to gather a broad range of information about the students' demonstrations of learning outcomes' [11]. Observation takes place in several settings and with a variety of methods. It can help teachers gather information about the individuals' and groups' behaviours and skills. To distinguish the observation levels in classrooms, Gray [12] introduced conceptual frameworks that follow educational standards to define the basic frames for observing. Because observing classrooms is very complex, he suggests that each teacher should select a specific frame or 'lens' to gain more insight into a specific classroom characteristic. Such 'lenses' are summarised in Table 1.

Table 3. The Observable Signs Pertaining to the Eight-Question Areas [12]

1. The learning climate	<ul style="list-style-type: none"> • Degree to which students can express their feelings and opinions • Frequency with which student responses are used and extended • Amount of interaction and sharing among learners
2. Classroom management	<ul style="list-style-type: none"> • Use of preestablished classroom rules • Use of instructional routines • System of incentives and consequences
3. Lesson clarity	<ul style="list-style-type: none"> • Frequency of examples, illustrations, and demonstrations • Percentage of students who can follow directions given • Use of review and summary
4. Instructional variety	<ul style="list-style-type: none"> • Use of attention-gaining devices • Changes in voice inflection, body movement, and eye contact • Use of a mix of learning modalities (visual, oral)
5. Teacher's task orientation and content presentation	<ul style="list-style-type: none"> • Orderliness of transitions • Teacher's preorganization of administrative tasks • Cycles of review, testing, and feedback
6. Students' engagement in the learning process	<ul style="list-style-type: none"> • Use of exercises and activities to elicit student responses • Monitoring and checking during seatwork • Use of remedial or programmed materials for lower-performing
7. Student success	<ul style="list-style-type: none"> • Number of correct or partially correct answers • Number of right answers acknowledged or reinforced • Number of delayed corrections vs. immediate corrections
8. Students' higher thought processes and performance outcomes	<ul style="list-style-type: none"> • Use of teaming, pairing, or other cooperative activities that encourage student problem solving • Display of student products and projects • Opportunities for independent practice and application

Adopting these 'lenses' when observing students can determine what could be evaluated and monitored when assessing students. They can help to observe students learning and to recognise the type of evidence should be collected when measuring

the learning outcomes. Furthermore, creating a virtual observation hierarchy model to determine the granularity levels of observing learning activity in collaborative virtual environments can assist designers and developers to identify the learning evidence that can be captured and help to apply it in the virtual environment. Suskie stated that ‘the more evidence you collect and consider, the greater confidence you will have in your conclusions about students learning’[13].

3 Proposed Observation Technique in 3D VWs

We propose the Virtual Observation Portal (ObservePortal), which is a 3D virtual environment that can track users' behaviour and capture real-time evidence from collaborative activities. The environment employs real classroom observation lenses and applies each lens to the virtual world. The observation level can be stated in the learning design by the teacher to identify which lens should be activated to evaluate the learners. It determines the levels of granularity for observing learning activity in virtual environments to capture the learning evidence, beginning with general observation to in-depth observation (more details in section 5.4).

To capture the learning events, the platform utilises some techniques from agent systems to track users' actions and predict the learners' acquired skills and knowledge. It has two different types of agents: software agents and natural agents. The software agents track learners and collect different users' clicks and actions, while the natural agents perform peer evaluations of each other to evaluate the quality of performance. These agents are employed to record both implicit and explicit data that will be analysed to determine the learning evidence and students' performance. All agents will work together in real-time to collect the learners' evidence (more details in section 5.3).

3.1 The Learning Environment

The virtual world (ObservePortal) is the environment in which the students will perform the activities. To implement the research prototype, the InterReality Portal will be used, a project developed by a member of the Immersive Learning Lab, Anasol Pena-Rios, at the University of Essex (Figure 1) [14]. It is built upon the Unity¹ platform, a flexible development platform for assembling 2D and 3D collaborative games and environments. The environment was developed using the C# programming language. We chose to apply the prototype within this environment because it supports collaborative programming activities and assists in setting up learning tasks that help students understand the concepts and functionality of embedded systems in smart homes.

¹ <https://unity3d.com/unity>



Fig. 4. Graphical User Interface (GUI) – InterReality Portal [14]

4 Conceptual Framework

Based upon the literature, observing and measuring online collaborative learning outcomes, both dynamically and on the fly, within 3D virtual worlds is scarce. As a result, we have proposed a Mixed Intelligent Virtual Observation (MIVO) conceptual framework that mixes learning models and computational models for observing and evaluating collaborative learning in 3D VWs. The framework consists of five models: user, learning, observation lenses, mixed agents and presentation (Figure 2). Each model will be discussed in the following section.

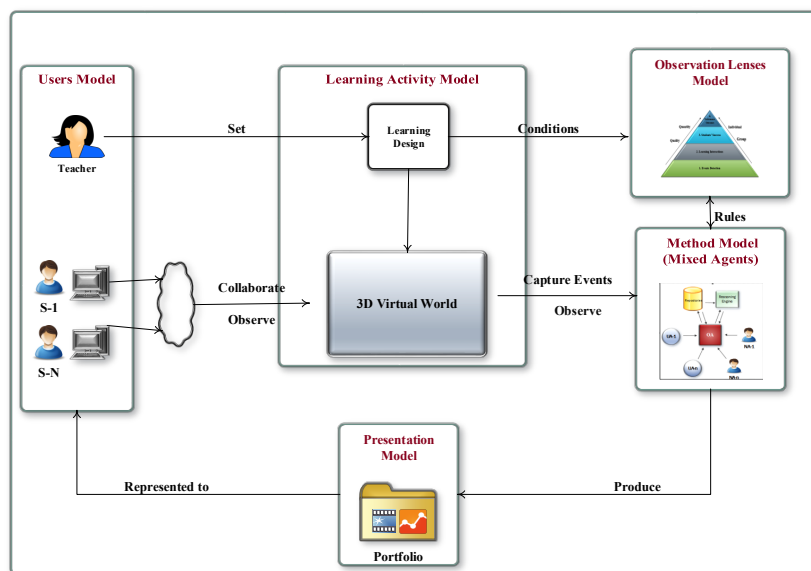


Fig. 5. Mixed Intelligent Virtual Observation (MIVO) Conceptual Framework for Collaborative Learning Environment

4.1 Users Model

This model identifies who the users are and their roles within the learning activity. Users will be either learners or teachers, and the specific user interface will be displayed based upon the user's identity and role. For example, instructors have a customisable interface that allows them to design learning activities. Moreover, a teacher can view learners' portfolios to evaluate their performances and review their work. From the learners' viewpoint, the user interface will enable them to interact with the environment and with other students' avatars. All participants will then work together on the simulation learning activities in the 3D environment. They can participate in the activities, evaluate others, obtain learning feedback from the system and view their portfolios.

4.2 Learning Activity Model

This model consists of two parts: the learning design and the environment that contains the collaborative learning practices. The learning design is defined as the learning scenarios that can be shared in the system and that can be planned and adjusted by the teachers. Moreover, the teachers can specify the observation criteria for evaluating the learning outcomes. Also, this model includes the virtual environment that students will participate in.

4.3 Mixed Agents Model (MixAgent)

This model identifies the method of gathering different types of evidence to illustrate individuals' and groups' learning outcomes. We expand the concept of software agents to include natural agents (users). The software agents will be needed to automatically track users' behaviour and collect data from real-time events as users interact with each other and with objects in the virtual world. Two types of software agents are used: user agents and ontology agent. In addition, the natural agents will be combined with them to enhance the capture of evidence. All agents, software and natural agents, will collaborate and work towards one central goal together, to produce evidence that evaluates the quality and quantity of students learning and performance (see Figure 3). In the following section, the agents' capabilities including their particular assessment abilities will be discussed.

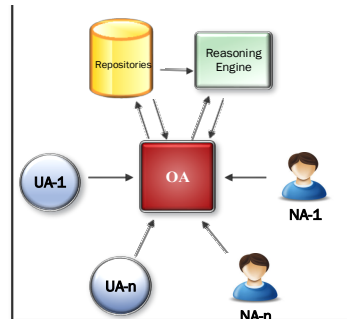


Fig. 6. Mixed Agents Model (MixAgent)

- **User Agents (UA).** These agents will be created once a student is authorised in the environment. There will be an agent for each learner. This agent can trace the user's actions in real time, translate any behaviour into data and send them to the ontology agent. They will monitor users' log data, behaviour and history.
- **Natural Agents (NA).** Peer evaluation could assist in capturing implicit learning evidence that is hard to capture with technology [8], and it would be useful to secure it from people directly to distinguish students' performance. To this end, learners will be considered natural agents. These agents can produce learning evidence by regularly assessing the quality of each other's communication, negotiation, teamwork, and active learning skills. While students are working together, there will be sliding scales scored from 1 to 5 will allow natural agents to act and rate other learners regularly. When the natural agents produce evidence and trigger the system, messages will be sent to the ontology agent. The ontology agent will receive the data and store them in the ontology repository. Employing natural agents will permit capturing the quality of learning outcomes that are too complicated to be identified by technology.
- **Ontology Agent (OA).** This agent is based on a semantic web and ontology approach that models different elements in the VW. Ontologies typically consist of object classes, the relationship between these objects and the properties that the objects have [15]. With ontologies, we can set up all the relationships between objects so that devices can understand the meaning of concepts. They can offer a standardised vocabulary to describe a knowledge domain by developing connected semantics and sets of vocabularies that can be reasoned. Thus, we have proposed this agent which has the ability to receive data from other agents and send them to the repositories. It will act as a communication agent and a bridge between all agents in the learning environment, so the collected data from other agents can be analysed based on logical rules that could assist in retrieving learning evidence. This agent will infer the relationship between the collected data and what it means in term of learning evidence through using a reasoning engine. Moreover, the logical rules will permit reasoning the repositories and parsing more meaning from the data gathered by each agent.

4.4 Observation Lenses Model (OLens Model)

This model determines how we can analyse the data that is captured by the agents. To observe the students in the classrooms, educators should consider numerous criteria, aspects and frames to gain more insight into the students' learning and improve their education. However, not all learning outcomes and skills mentioned can be easily observed and identified in virtual environments. Depending on the observation framework [12], we adopt particular 'lenses' to our model and applied them to the 3D VW to evaluate what could be monitored in these environments. The virtual observation model defines the levels of granularity for observing students and recording evidence of collaborative learning, commencing with high-level to low-level observation (see Figure 4). The observation layers are: events detection, learning interactions, students' success and performance outcomes.

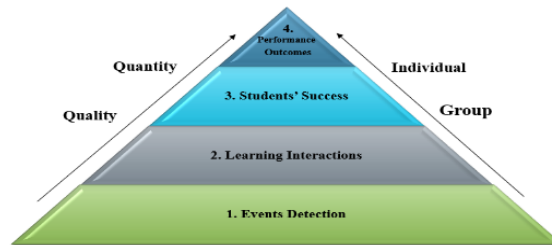


Fig. 4. Observation Lenses Model (OLens Model)

Describing the model lenses and their pedagogical meaning, beginning with the lower level of the hierarchy is Events Detection lens. This simulates an instructor when he/she watches a collaborative activity from high altitude, but without looking deeply into what is happening. In the VW, the automated observer monitors the activity by recognising that a sequence of events is occurring and capturing these events without judging. The second level is Learning Interactions lens, which considers a deeper view of the social and environmental interactions. In our case, the social interactions are between peers, and the environmental interactions are between students and the VW. Evaluating the quality and quantity of collaborations and interactions infers whether the learners have valuable interactions and if they are active learners in their groups. It determines the amount of sharing and interaction among students. The third level is the Students' Success lens. It represents teachers when they are observing the students' success by counting the number of correct answers, the number of right answers reinforced or acknowledged, and the number of delayed corrections. The fourth level is Performance Outcomes, which simulates the observer tracking the students in-depth to identify the skills and knowledge that they have acquired from the learning activities.

These frames help to measure the individual's and the group's performance, and the quality and quantity of each learning outcome. The following sections provide examples of how one can map some of the pedagogical lenses to collect evidence or to create logical rules that can be applied to the VWs.

- **Events Detection Lens.** This level focuses on observing the activity from a high level and collecting different events that demonstrate interactions between students and their surroundings. Examples of the events that can be observed and collected from students and group activities include the following:

Avatar Actions:

Avatar Log: <AvatarID, AvatarName, LogInTime, LogOutTime, Date, GroupNo>

Chat Log: <AvatarID, DialogueTime, DialogueText>

Touched Object: <AvatarID, ObjectID, ObjectName, TouchedType, Time>

Rating: <AvatarID, RatedAvatar, RateScore, Time>

Group Actions:

Group Log: <GroupID, GroupMembers, StartTime, EndTime, Date>

Group Dialogue: < GroupID, GroupDialogueText >

GroupRating: <GroupID, GRateScore >

- **Learning Interactions Lens.** In this level, we are extending the teachers' judgements of group interactions in a physical setting to understand the interactions between the group and individuals in the virtual environment. It is possible to infer the quantity and the quality of the learners' interactions by creating rules based upon the teachers' viewpoints. Table 2 gives examples of the rules that can be created in this lens.

Table 4. Examples of the observation rules

	Quantity	Quality
Individual	The number of a learner's contributions in using the virtual objects during a period compared with other learners.	The rating scores for a student from other members in a period. 5 = Excellent; 4 = Good; 3 = Average; 2 = Fair; 1 = Poor
Group	The number of the group's contributions in the activities compared with other groups.	The average rating scores for all members in one group.

4.5 Presentation Model

The final model in the framework illustrates how evidence of the learning outcomes will be presented to teachers and learners. From the evidence gathered by agents and applied observation rules, the evaluation model will demonstrate how the performance of individuals and the groups was rated. The observation methods will allow analysing the learning outcomes from the activities and will correlate them to the learners' portfolios. These portfolios can demonstrate students' performances through any type of method, for example, it can include a feedback dashboard displaying when performance was either high or low, to allow teachers to evaluate the group as a whole and as individuals. Another example is that the performance could

be reviewed by video snaps that map between time stamps of evidence and video recording to enhance the learning affordances of the immersive environment through visualising and reviewing the learning outcomes.

5 Conclusion and Future Work

In this paper we have introduced and described the Mixed Intelligent Virtual Observation (MIVO) conceptual framework for the collaborative learning environment. It consists of several models: user, learning activity, mixed agents, Observation Lenses (OLens), and presentation. The **MixAgent** and the OLens models play important roles to observe and recognise events that are occurring during the learning activity to evaluate the students learning.

This is a work-in-progress paper and there is much research still needed to be completed. Currently, we are commencing with the technical experimental phases to investigate the appropriate mechanism, based upon the complexity of observing and assessing learning in 3D VWs. The aforementioned collaborative environment, InterReality Portal, is used which allows students, worldwide, to participate in learning activities. In the future, the mixed-agents approach, namely, the combination of the natural agents (users) and software agents will be implemented to provide better results for collecting evidence and evaluating students. Hence, this phase will demonstrate how software agents can be combined with natural agents to improve the collection of learning evidence.

The next phase of the experimental phase will explore how to observe students' activities in the virtual world by applying methods from physical educational settings. The mixed agents approach helps observe and recognise events that are occurring during the learning activity and record them without evaluating the students. To analyse and translate these events, we will examine the frames of the OLens Model to create virtual observing rules that can infer learning outcomes in such environments.

The final experimental phase amalgamates all previous phases and explores the observation system implementation within the design of the collaborative learning activities, constructing learners' portfolios based on the evidence-gathering mechanisms, and analysing this data based upon the observation layers in the model in real-time.

Beside the experimental phases, the evaluation of our work is an essential component which is considered for the future progress. The research framework and models will be evaluated through user-based and expert-based evaluations. We are looking forward to report the results for the experimental and evaluation phases in future events and conferences.

Acknowledgment.

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The 21st Century Interpreter: Exploring the use of smart-glasses for technology-augmented interpreting

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Abstract. In this ‘work in progress’ paper we set out the case for how smart-glasses can be used to augment and improve live Simultaneous Interpreting (SI). We do this through reviewing the relevant literature and identifying the current challenges faced by professional interpreters, such as cognitive load, memory constraints and session dynamics. Finally, we describe our experimental framework and the prototype smart-glasses based system we are building which will act as a testbed for research into the use of augmented-reality smart-glasses as an aid to interpreting. The main contributions of this paper are the review of the state of the art in interpreting technology plus the smart-glass experimental framework which act as an aid to Simultaneous Interpreting (SI). Later papers will report of other phases of our work.

Keywords: Simultaneous Interpreting, Translation, Languages, Augmented Reality, Smart Glasses, Meta, glossary-building, term extraction, multi-media learning, multitasking

1 Introduction

Interpreting is to orally translate the spoken words in language ‘A’ into language ‘B’. Modern interpreting gained its professional status as early as the establishment of League of Nations, the forerunner to the United Nation [1], where interpreters were required to render oral languages between French and English, the two working languages of the organization.

Interpreters work in two different modes: consecutive and simultaneous. A consecutive interpreter listens to the source spoken language and renders it into the target language when the speaker stops for interpreters to deliver the messages to the listeners. A simultaneous interpreter renders the spoken language into the target language to the listeners in real-time while the speaker is delivering a speech. In this paper, we will only discuss simultaneous interpreting, as the smart-glasses will be applied to simultaneous interpreting only. Nowadays, simultaneous interpreters work in many different settings. International organizations, such as the United Nations and the European Commission, employ their own in-house interpreters, managed by a specific department (United Nationals DGACM n.d.), which oversees management of

interpreting services for their on-going programme of international conferences and meetings.

Interpreting services are considered an ancillary service of the Meeting Incentives Conferences Exhibitions (MICE) industry [3]. Along with the development of MICE industry around the world [4], in order to engage multi-national participants in conferences and meetings, there is a growing need of professional interpreters. As such, there are already a large number of freelance interpreters, especially in the mega cities, providing interpreting services to international conferences, seminars and multi-language meetings.

The growing trend and demand are reflected by the university education system. In China alone, more than 100 universities have master level interpreters' education programmes. In the UK, the U.S and the European countries more and more universities provide master level interpreters' education. In order to provide a near-native working environment, universities invest large amount of funding in building interpreters' lab with a conference setting with a large conference table and delegate positions. The conference participants listen to the interpretation at the delegate positions through headsets.

2 Simultaneous interpreters' technical working environment

2.1 Inside the simultaneous interpreter's booth

The physical working environments of simultaneous interpreters are fixed and mobile booths. Simultaneous interpreters usually work in pairs in a booth (Fig.1). Each booth is set up with two user consoles (Fig. 2), which are each provided with a microphone and a headset. Interpreters listen to the source language through the headset and deliver the interpretation via the microphone at the same time. The interpreters take turns to interpret at every 20 – 30 minutes. The listeners outside booth listen to the interpretation from the wireless receivers or at the delegate positions. All the audio feeds are connected to a mixing console which is controlled by an audio-visual technician on site.

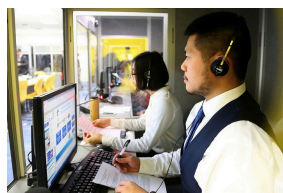


Fig. 1. Interpreters working in pair in a booth **Fig. 2.** Interpreter's console
(the Interpreting Lab in the University of Essex)

In order to maintain the quality of an interpreters' working environment, ISO - standards [5] have been established for both mobile booths and fixed booths. The European Commission [6] has also published a technical specification for booths in conference rooms. The standards and specifications require a booth technician onsite to guarantee the two-way communication in and outside the booth. Three core metrics aim to reduce unnecessary cognitive load on the interpreters' thereby improving their performance:

- The input sound quality (to provide clearer speech)
- The quietness of the booth (so interpreters can concentrate), and
- A good view of the conference/meeting proceedings.

Interpreters also bring their own technological devices such as a laptop, tablet computer and/or smart phone to booth. Such personal devices are used to (1) display session materials (i.e. agenda, presentation files) plus a self-prepared glossary and (2) facilitate searches on the Internet.

2.2 Alternative conference interpreting equipment

In recent years, alternative equipment has been used in conference venues, mainly to reduce the cost of equipment. For example, the Tourguide system with one-way communication channel is sometimes used for small scale conferences/meetings. With this system, booths, interpreters' consoles and the mixing console are not required. Audiences listen to the interpretation through wireless receivers. To have good audio reception, interpreters need to sit near the loud-speakers or near the human speakers. Though it saves the cost of equipment hiring, such a working environment can greatly affect the interpreters' performance due to uncontrollable audio input.

A recent innovation was the introduction of a mobile phone application which, together with Bluetooth, is used to transmit interpretation services to individual listeners, replacing the wired equipment [7]. Audio input and output for both interpreters and audiences are controlled by the application. The application claims to ease the job of *conference equipment manager*, not that of the interpreters, however.

2.3 Multimedia learning context at conferences/meetings

Conferences and meetings often have a theme or correlated themes. Invited speakers talk around the theme with the aid of presentation files, often in one of the two formats PowerPoints or pdf. The introduction of the theme, the speakers and the speakers' topics are presented on the conference/meeting agenda. The purposes of conferences and meetings are to disseminate information and exchange ideas. The process of dissemination and interaction is actually a learning process for the participants. Therefore, interpreters work not just across different subject knowledge, topics and cultures but also in different learning contexts. Recent years have seen large advances in the provision of technological support for conferences and meetings.

Compared with 20 years ago, conference speakers no longer use transparent plastic slides but instead use computer based presentation files, large rich multimedia displays (i.e. screen panels), fancy lighting, and more reliable and clearer sound systems help to enhance the multimedia learning experience of the conference/meeting participants.

Along with the development of software and applications, it becomes much easier and faster to design and create graphical information. Presenters add audio and video clips, complex diagrams, and figures to their presentations for better demonstration and explanation and to compress complex ideas within their presentations. The multimedia display of information and the more complex content in a presentation constitute a “*multimedia cognitive load*” for interpreters [8]. The implication is that while comprehending the presenter’s messages in real-time as well as delivering it in the another language, interpreters will have to make use of much or all of the limited capacity of their working memory to comprehend, process and express the message in another language. There will be very little capacity left for interpreters to follow up the presenter-designed learning process for audiences.

To facilitate comprehension of a particular presentation, interpreters study the text and diagrams on slides to form understanding of the speaker’s presentation and main ideas prior to the conference/meeting. In order to accurately render the speech and maintain a good flow of delivery, good views of the presentation file and the conference proceedings are essential for interpreters in the booth at the conference/meeting.

3 The role of the glossary for simultaneous interpreters

While preparing for an interpreting task, an interpreter usually compiles a bilingual glossary, which is formatted as two parallel columns, with one column presenting language-A and the other the equivalent word or phrase in language-B. The glossary usually contains unfamiliar words, technical terms and proper names extracted from *the speakers’ presentation files, conference/meeting agenda and relevant readings* during the preparation phase. Professional interpreters, including the interpreters from the Association Internationale des Interprètes de Conférence (International Association of Conference Interpreters AIIC), consider glossaries to be of paramount importance.

AIIC is a global association of conference interpreters with over 3,000 professional members from across the world. The organization was established more than 60 years ago. Their web magazine regularly publishes articles about hot issues in the interpreting world, glossaries being one of the popular topics. The association has given guidance on glossary building in their *Practical Guide for Professional Conference Interpreters* [9]. This guide suggests the process of glossary building is a learning process which helps the interpreter to understand and remember terminologies and concepts.

A recent article in AIIC [10] presented the results of “*A survey of glossary practice of conference interpreters*”. The results confirmed the importance of the learning process during glossary building, describing the process as one to “*learn about issues and concepts*”. In the survey, professionals agreed that most of the glossary comes from presentations, the agenda and information linked to the agenda [10]. Moreover, the survey indicated that instantaneously retrieving the glossary from (1) the interpreter’s memory or (2) a glossary list, are the only ways to use the prepared terms in the process of real-time rendition and delivery. This survey, not only emphasized the significance of the glossary list, the presentations, the agenda and interpreter’s memory, but also illustrated a dynamic relationship and links between them.

3.1 Technologies for extracting terms and build up glossary

The ways to search for accurate translations of terminologies and proper names have changed from using traditional dictionaries to online dictionaries, and/or massive cloud services and databases [11, 12]. Xu and Sharoff [13] reviewed methods using comparable corpora to extract terminologies from conference documents and web content. They claim when the accuracy of the generated term lists is high, the use of automatic term lists could improve the preparation efficiency of interpreters.

More applications are also available to interpreters. Costa et-al [14] reviewed the available software for interpreter’s terminology management to be used prior to an interpreting task. They also described “unit conversion” applications for mobile phones which are helpful when converting between currencies and measuring units.

3.2 Are technologies assisting interpreters in the right way?

This is a serious question raised by researchers and practicing interpreters [12, 15]. Technologies can be helpful, but with conditions and constraints. Various issues raised include how much time interpreters might spend on finding the resources and trainings required to learn and adapt to the new technologies, the familiarity required to use the new technologies, and the cognitive capacity available when working for using these technologies. For example, when an interpreter works in the booth, with a laptop to read the slides, a tablet showing terminologies, and a mobile phone at hand ready for looking up new terms, the interpreter will have to shift attention and increase processing capacity when using different media to search for information.

4 Challenges to Interpreters

4.1 Cognitive challenges

Cognitive challenges are also widely acknowledged and discussed theoretically by researchers and practicing interpreters. The last two decades has seen considerable discussions concerning the cognitive challenges faced by interpreters, firstly from a linguistic perspective [16–19], and secondly from a psychological perspective [20–22].

This research has shown that modern presenting methods and rich-media contexts bring additional cognitive challenges, the extent of which are dependent on the content in the presentation files and on the nature of the technological environments.

Brook Macnamara [23] from Princeton University reviewed all the cognitive aptitudes required of an interpreter, and identified the cognitive functions required for interpreting. She used five complex diagrams to illustrate the required skills, abilities, intelligence, and memory from “operational, perspicacity, processing, and second language learning” perspectives (see Macnamara’s paper for details), which in turn evidently reflects the cognitive challenges often experienced in interpreting.

4.2 Multitasking, attentional control and memory

Simultaneity of cognitive tasks (listening, processing and speaking) is known as multi-tasking, which is a foundational skill of Simultaneous Interpreting (SI). Attentional control allows interpreters to appropriately allocate attentional resources: (1) to attend to the useful stimuli to “logically reason, analyse and store information in memory”, (2) to activate a functional working memory for processing information and form renditions in the target language [23]. With the additions of presentation files, the use of glossary list and other conference/meeting materials, the interpreters also need to allocate attentions to visual aids so as to assist comprehension and rendition. Technological advances in the personal devices are intended to support the interpreters with better management and easy alignment of additional visual information. However, the diversified applications and formats of the conference materials require the interpreter to allocate cognitive capacity and shift attentional resources for managing and processing different visual materials. For example, in a case when an interpreter needs to find a term in the glossary (prepared from the presentation materials), the interpreter’s attention shifts to finding the term in the long list of glossary.

As suggested by Macnamara [23], in the process of simultaneous interpreting, attention is allocated to different tasks simultaneously. Familiarity of tasks reduce cognitive load. The extreme development of familiarity is automation (as cited in [23]). In the previous case of ‘term searching’ in the glossary, an automated search for terms in the glossary illustrates one form of automation. Later in this paper we will present a system (hypothesis) which explores both opportunities for reducing cognitive load through use of automation and a better designed Human Computer Interaction (HCI).

4.3 Challenges caused by the location of booth

We will illustrate the challenges facing interpreters by studying one of the settings of our training facilities in the University of Essex. LTB6 (Lecture Theatre for teaching) in the University of Essex was built with fixed booths. This facility is used to host mock conferences to train interpreters. The venue comprises a large lecture room with

a capacity for 300 people. The booths are fixed on one side of the upper floor (see Fig. 5).

When the interpreters go into the booths to setup the workstation, they turn on a laptop which displays a glossary list together with the speakers' presentation. In this particular context, the interpreters need to constantly check the main auditorium screen to follow the presenter's speech. As the screen concerned is about 30 meters' to one side of the booth (Fig. 3 and Fig. 5), the interpreters have difficulty reading text on the screen. To have a view of the conference proceeding, the interpreters need switch their gaze from the main auditorium to their personal laptop from time to time. Another difficulty is that the interpreter is not always able to realize immediately when the presenter changes slides, especially when the display on the projector is unclear (Fig. 4). In cases where speaker's jump slides, there is a risk of negative psychological effects on interpreters who feel they have lost track of the presentation.

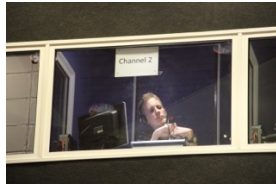


Fig 3. Interpreter looks at the projector from booth **Fig 4.** Projector's view from booth



Fig 5. Booth position in LTB6

The pre-prepared glossary list can have thirty (or more) pairs of specialized terms in two languages. When the presenter mentions a term which was included in the prepared list but which the interpreter cannot remember the exact translation of, she/he needs to refer to the glossary list. Finding the term from the glossary list means re-focusing their attention away from the speaker and the list (adding to their cognitive load), until the term is located. In a case when multiple unremembered terms appear within one sentence, the interpreter needs to find all of them from the glossary list, occupying a great amount of the interpreter's cognitive capability and risking delays in interpreting.

Thus, from this setting we argue that cognitive loading (or overloading!) of an interpreter is a major factor in determining how well an interpreter performs. In particular, for any technology to be adopted by interpreters it needs to lower, rather than increase their cognitive load. The two most important aspects of cognitive loading for interpreters is 1) their working memory, and 2) their speed of reasoning. The first of these can be supported by creating computer supported glossaries of terms,

with fast search methods to access them (essential extending working memory) and the second of these can be improved by good human-computer interaction design making information and control simple and intuitive (essentially simplifying any reasoning activities). By way of a theoretical basis, for the first we are building on the concept of working memory, for the second we build on the notion of elementary mental discriminations, or the Stroud number. Exploring how technology, and in particular smart-glasses, could positively augment an interpreter's capability is the aim of our research. Our approach to this is described in the following section

5 Interpreting in booth with augmented reality glasses



Fig 6. Chantel (interpreter) in a booth

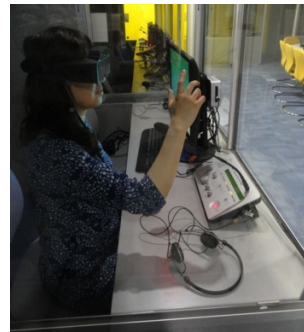


Fig 7. Chantel (interpreter) wearing meta-1 glasses

As was explained in the previous section, we have set out to explore how smart glasses may be used to reduce the cognitive load on interpreters, in order to improve their performance. Thus, a project was initiated in the University of Essex to undertake research on potential solutions to the challenges described in the previous section for 21st century interpreters using augmented reality smart-glasses. At this stage we are hypothesising that smart-glasses can overcome the problems we have described, so our mission is to characterize the challenge (one of the purposes of this paper), create some theoretical models for the pedagogy and computer architecture (another aim of this paper) and then finally test the hypothesis by experimenting with a real system (an aim of a future paper). Our hypothesis is not simply a binary question (does it hold or not) but rather an exploration of the variables at work especially regarding HCI parameters such as size, position, colour and mode of control of the interpreting session data. Thus our experimental architecture seeks to accommodate as much customisation as possible, allowing the interpreters to change as much of the appearance and operation of the system as is practical. Explaining this in another way, we are arguing that by placing a pre-prepared glossary, together with other session information in the interpreter's field of view (Fig. 8) using augmented reality glasses (with appropriately designed Human Computer Interaction), interpreters will be able to reduce their cognitive effort and concentrate more on rendering information and messages from different sources.

At this stage we are prototyping the system, starting with an electronic mock-up of the user interface which is shown in the diagram below:

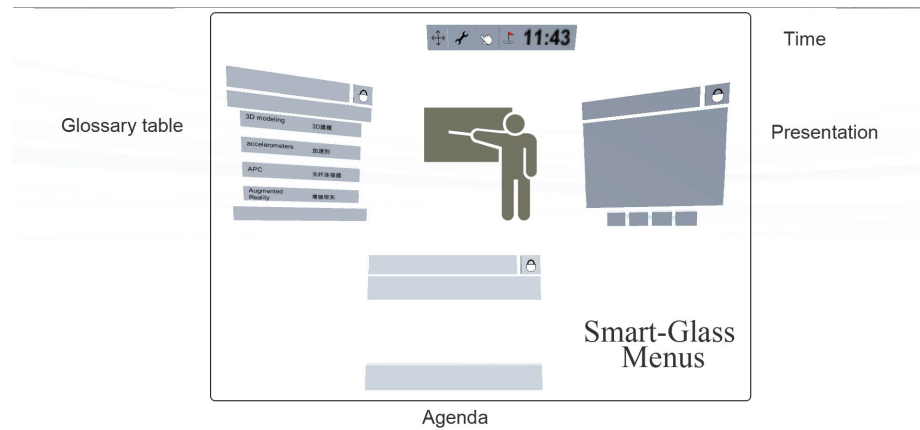


Fig 8. AR-Language Interpreting smart-glasses screen

We envisage the smart-glasses will be worn by the interpreters during live sessions allowing them to simultaneously view the real event and virtual screens containing supplementary materials positioned to one side of their field of view. The virtual screens are relatively large (a metre or so at a distance of a few meters) and contain information such as the glossary of terms, the agenda, the presenters' slides, the time and an auxiliary window that could, for example, be used by the supporting (second) interpreter who could provide additional and unplanned information. We also envisage that the second interpreter would wear a set of smart-glasses which they could use to manipulate information at key moments; to assist the main interpreter (eg undertake an online search for unknown vocabulary arising from a Q&A with the audience). This is very much an experimental system, and so one of its purposes is to allow the interpreter to customize the environment as much as possible so new research data can be gathered from how the system is personalized or used in live interpreting sessions. Thus there are many hidden functionalities concerned with personalizing the environment.

This framework forms a model for interpreting that we call SmARTI (Smart Augmented Reality Technology for Interpreters). The Meta glasses we are using were designed for individuals to wear, but have proved to be little heavy for prolonged use. Thus, one of the ideal specs for of smart-glasses for interpreters would be lightness; other features being no wires (not tethered), fashionable appearance, excellent sound, long battery life (at least a half day) etc. The current state-of-the-art in wearable AR glasses has some way to go before they would meet an ideal specification for interpreters since they are tethered, a little on the heavy side for prolonged use, and the geeky appearance might not be appealing to all interpreters! To popularize the use of this technology, interpreters will require further hardware improvements which this work will also aim to throw light on.

6 Summary & Reflections

This paper introduced the booth environment for simultaneous interpreters. It argued that insufficient assistance is given to the interpreters in booths to reduce the cognitive load caused by the increasing use of technology and the ever-increasing complexity of contexts at conferences and meetings. In particular, we identified that extending working memory and easing reasoning tasks were key areas where technology might be used to improve an interpreter's performance. We also proposed that wearable smart-glasses might provide a useful simultaneous interpreting environment and, have described some preliminary studies we are undertaking using Meta-1 augmented-reality glasses. This is a work-in-progress project and at this stage we have framed the problem space through a literature review, identified the research issues to be explored, proposed a solution (with hypothesis), created an operational model (SmARTI – Smart Augmented Reality Technology for Interpreters) and built a simple prototype all of which we have reported on in this paper. Our longer-term aim is that we hope to be able to create what is, in effect, a virtual (and wearable) interpreting booth that is designed in such a way as to reduce the cognitive load on interpreters, thereby improving their mobility and performance. Our aim is to refine this design through ongoing work, further exploring the issues and reporting on those at later conferences.

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Special Track 3: Cognitive Serious Gaming (CSG)

New Directions in Cognitive Educational Game Design

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Abstract. What makes an educational game good? This paper describes three research directions that could provide insight in the underlying principles of effective educational games. These aspects are 1) The importance of distinguishing between types of to-be-learned knowledge, 2) the need to understand the relationship between game mechanics and learning goals, and 3) using research on intelligent tutoring systems to create more personalized learning experiences. Central in these directions is the concept of cognition and how it impacts the educational effectiveness of an educational game. This paper will give a short introduction on cognition and discuss why the research directions require further research.

Keywords: Educational Games · Cognition · Learning · Intelligent Tutoring Systems · Instructional Design

1 Introduction

The dream of educating so-called digital natives through engaging videogames was met with much skepticism at the turn of the century. A decade later, this skepticism has been replaced by a cautious optimism that educational games can have beneficial learning effects [1, 2, 3]. Instead of focusing on questions such as: “can educational games be a potential tool for educational purposes?” and “can educational games be better learning tools than traditional tools?” we now focus on the question: “what makes an effective educational game *good*?” This has led to new topics, such as how the design of educational games should be discussed [4], and which methodological aspects of educational game research are still lacking [5, 6].

This paper will focus on three research directions that still lack thorough research, but are strong contenders for understanding the underlying principles of effective educational games. These three directions are as follows.

1. The knowledge that a user acquires from playing an educational game (domain-specific knowledge) and the prior knowledge required to be able to play said game (game-specific knowledge) need to be considered separately in the design of educational games.

2. The relationship between different types of game mechanics and different types of learning goals needs to be formalized and better understood.
3. The applicability of Intelligent Tutoring Systems (ITS) literature on its overlapping educational game design aspects (e.g. adaptability) needs to be investigated.

These three directions have one fundamental overlap: they are based on how people learn and how their cognitive processes accommodate learning. We discuss this from a user-centered design perspective; the majority of the instructional and design choices should be based on how specific people acquire new information and skills.

We believe that underlying principles of effective educational game design can be distinguished in three categories, each interacting with the other two. These categories are 1) the user, 2) the learning content, and 3) the game [7]. This paper will look at ideas which focus mainly on the interaction between the learning content and the user, something of which we believe requires more research.

This paper will first describe the role of cognition in learning, which can be found in Chapter 2. In Chapter 3 to 5, we will discuss each of the research directions in more detail. Finally, we will discuss and conclude our work in Chapter 6.

2 The Role of Cognition in Learning

The cognitive processes that provide us with the ability to store, structure, and retrieve new information are fundamental to learning. They allow us to remember a theoretically infinite amount of knowledge, ranging from exact facts (e.g. giraffes have a long neck) to the context in which these facts are learned (a combination of smell, sound, emotions, etc.) [8]. Of particular importance in this process is 1) identifying different types of knowledge, 2) understanding how knowledge acquisition occurs for these types, and 3) formalizing how the knowledge acquisition process can be facilitated.

2.1 Types of knowledge

Knowledge is taken in, stored, and recalled in different ways. Some knowledge can be recalled explicitly (e.g. facts about a giraffe's physique), while other knowledge can only be recalled implicitly (e.g. how to ride a giraffe). This distinction can be mapped to the difference in storage systems, i.e. between declarative memory and non-declarative memory [9].

Declarative memory can be further subdivided into primary, or working, memory, semantic memory, and episodic memory [10]. Semantic memory is used to store facts, relations between those facts, and the resulting meaning of those facts. Episodic memory is used to store past experiences, including autobiographical aspects such as the time, place, feeling, and sounds associated with those experiences.

Non-declarative memory is used to store implicit knowledge about visual and auditory information, as well as implicit knowledge about doing (motor skills) and reasoning (cognitive skills). The latter pair, which describes one's skills and habits, is referred to as procedural memory [11].

Finally, there is strategic knowledge: knowing when to apply a specific skill to solve a specific problem. This type of knowledge is a combination of semantic knowledge, episodic knowledge, and procedural knowledge, and it is acquired from previous experiences in which specific skills have been applied to specific problems.

2.2 Knowledge acquisition

When confronted with new information, we initially try to interpret this information within existing knowledge schemas [12]. By doing so, we give more relevance to what is to be learned, i.e. we embed it in what we already know [13]. Another benefit of this process is that it supports recall at a later moment; the more connections we can make to existing knowledge, the easier it is to remember the information [14]. Properly learning a skill or procedure may even require prior task-related semantic knowledge, as that may be needed to understand the steps taken in the procedure itself [15].

Initially, recalling and executing a procedure, or skill, requires conscious processing, which may impose a severe cognitive load on the learner [16]. However, the more one uses the skill, the more 'ingrained' the skill becomes, decreasing the cognitive load required to recall the steps of which it consists.

This process is very visible when learning how to drive a car; at first, you have to understand all the different skills involved: steering, switching gears, balancing gas and breaks, etc. Managing all these skills the first time you are driving will demand all of your focus, making it difficult to be fully aware of what is happening around you, let alone chat with your instructor. However, the more experienced you get at driving, the less cognitively demanding the aforementioned skills become (i.e. you become *fluent* in those skills). In turn, this allows you to focus on the traffic around you, anticipate possibly dangerous situations, and perhaps chat with your instructor.

This *fluency* allows the learner to acquire strategic knowledge. The reason fluency often supersedes strategic knowledge is in the fact that the learner's cognitive abilities are less taxed when fluency has been achieved, allowing the learner to think more about *when* and *why* a specific skill may solve a specific problem. The lack of strategic knowledge is what best defines the difference between experts and novices, as experts are able to recognize a problem's patterns, while novices still have difficulty grasping the problem as a whole [17].

2.3 Facilitating knowledge acquisition

The way in which a student is instructed and assessed influences the way his or her knowledge is structured and the effectiveness with which information is being learned. The work in [18] provides a set of five guidelines which reflect a contemporary view on effective instructional design for educational games:

- *“Stimulate semantic knowledge.*
Relate material to the learner’s experiences and existing semantic knowledge structures to facilitate learning and recall of the information.
- *Manage the learner’s cognitive load.*
Organize material into small chunks, and build up gradually from simple to complex concepts.
- *Immerse the learner in problem-centered activities.*
Provide opportunities for learners to work immediately on meaningful, realistic tasks.
- *Emphasize interactive experiences.*
Develop problem-centered activities that require manipulation of objects to encourage active construction/processing of training material to help build lasting memories and deepen understanding.
- *Engage the learner.*
Devise learning scenarios that maintain the performance of learners in a “narrow zone” between too easy and too difficult.” [18]

As can be seen from their descriptions, many of these educational principles are related to how we acquire, process, store, and retrieve knowledge of different types. These aspects therefore need to play an important part in designing educational games with learning goals in the cognitive domain.

3 Distinguishing learning and play

In order to be able to learn from a specific tool or medium, the learner should already know how to use it. For example, when one is expected to learn for an exam by reading the prescribed book for a course, one has to be able to extract the knowledge from the medium (i.e. written text). Not knowing how to read, lacking proficiency in the written language, or simply having difficulties understanding the writing style are all aspects that can interfere with the learning process.

In educational games, the medium is an interactive environment in which the learner is supposed to interact with the environment to acquire knowledge and learn skills. The same problem from the example above applies in this situation, albeit in a different way: not knowing how to navigate in a 3D environment, not knowing how to progress through the learning environment, and not being able to distinguish relevant knowledge from irrelevant knowledge may all impact the effectiveness of the educational game.

This is also found in previous research, showing that users with prior general gameplay experience learned more from an intervention than their less experienced peers [19, 20]. Furthermore, from observing and interviewing the non-experienced users, it became clear that they had difficulty focusing on the domain-specific knowledge, as they were too busy figuring out how to interact with the game.

From the cognitive principles described in Section 2.3, we can see game play as an extraneous cognitive load caused by the fact that the tool itself requires cognitive effort to use [21]. Thus it is crucial as a designer to take this into account and consider both the game play and the domain knowledge as separate learning goals. Of course, the basics of the game play would have to be taught prior to introducing the domain knowledge or else the user would not know how to play at all. Designers are tasked with not only with creating engaging experiences as part of the game play, but also have to keep an eye on the balance between the user's game play expertise and domain knowledge expertise. This can be seen as an extension to the guideline "*Manage the learner's cognitive load*", as described in [18].

4 The relationship between learning goals and game mechanics

The idea of having the game mechanics and the learning goals be seamlessly integrated into an educational game is far from new. Empirical research shows that this approach is effective in terms of motivation and learning effectiveness (e.g. [22, 23]). However, less is known about how the choice in game mechanics in and of itself can influence learning.

4.1 SURGE: learning Newton's second rule of motion

An interesting example of the impact of game mechanics on learning was found in [24], in which students learned more about Newton's second law of motion by controlling a space ship through a 2D environment. The user could change velocity in four directions: up, down, left, and right. For example, a ship moving to the right could be slowed down by applying power in the opposite direction. While the game was engaging, and positive learning results were found, the most interesting result was that the students had learned the principles *implicitly*. They could not explain their reasoning for the answers they gave on the physics test, even when they gave the correct answer. The authors argued that this was due to the fact that the game did not promote (cognitive) formalization of the concepts used in the game.

Important to note here is the fact that the game play was real-time, and mostly reaction-based; the user had to react to obstacles that appeared on the screen in a timely fashion as the user progressed through the level. While this does require the user to become familiar with the controls, and in extension the way the second law of motion works, there was no need for the user to reason about how the controls worked.

4.2 Fuzzy Chronicles: the follow-up to SURGE

In [25], the authors of the previous game created a follow-up game that would teach all of Newton's laws of motion. Here the goal of the paper was different: determining the influence of self-explanation questions and explanatory feedback. However, the game used a different set of mechanics than in the previous game: instead of real-time navigation, the user has to select a set of a-priori actions that are executed sequentially after the user decides to 'start the level'. The aim of the game is to ensure that the set of actions direct the ship from a start point to an end point.

This setup requires the user to play the game differently than SURGE, as the problem had to be reasoned about beforehand as opposed to reacting in real-time to changing situations. The students had a more explicit understanding of the laws of motion than in researchers' previous work on SURGE.

4.3 What does it mean?

Both games help us to identify that the style of game play, i.e. the mechanics, will influence the learning process. From a cognitive perspective, Fuzzy Chronicles allowed the user to process and deal with specific problems without the extraneous load of navigating a space ship in real-time to avoid collisions. Related follow-up questions to these papers are: does real-time input lead to better results with regards to behavioral learning? Do strategic puzzle-like mechanics lead to better results with regards to promoting knowledge structuring?

The only way to answer these questions is by understanding the cognitive process of information and skill acquisition and understanding how different mechanics relate to instructional and cognitive theories.

5 Applying ITS literature to educational game design

The design goal for educational games is to provide an optimal learning environment; a goal shared by the design of Intelligent Tutoring Systems (ITS). Still, there are differences. The field of intelligent tutoring systems has progressed much in for example implicit and online assessment [28] and has even worked on including game-like aspects such as narrative [31, 32]. On the other side, educational game design research has not had the same progression with regards to assessment and feedback [30], and has not incorporated many other results from ITS-studies. It is therefore useful to consider these results and possibly apply them to educational game design.

The following sections will explain what an ITS is, how it is able to provide such adaptive support, and it will conclude with the state of educational game design with regards to user modeling and adaptability.

5.1 What is an Intelligent Tutoring System?

Whereas educational games aim to engage and motivate users, ITSs aim to provide optimal support throughout the learning experience by closely simulating a personalized tutor. An example of well-developed ITS' are the *Cognitive tutors* which have been used to teach mathematics to students in the United States for over two decades now [26].

The level of detail with which these tutors can monitor the student's learning process allows them to select the right kind of feedback and the most relevant questions to increase the effectiveness of a learning session [27]. The main reason that ITSs are able to provide such a fine-grained learning experience is their usage of principles of cognitive theory, aided by methods of artificial intelligence to learn from the input of the learner [28].

This process requires a more formal representation of knowledge and the cognitive processes involved in acquiring that knowledge. Cognitive architectures such as ACT-R allow this formalization and help to describe a student's level of understanding in the computational terms, leading to models of student competency [29].

5.2 How do ITS' formalize knowledge and use it?

Cognitive architectures such as ACT-R allow tutoring systems to decompose otherwise complex tasks into 'procedures'. These procedures consist of a chain of 'production rules', which are simple if-then clauses. When a math problem (e.g. $8+3$) requires the addition procedure, the if-then clauses range from "if the left and right arguments are positive, add them together" to "if the sum of both arguments' ones exceed ten, remember to add one to the tens". These production rules consist of a combination of procedural knowledge and declarative knowledge. Each of these production rules has a certain probability of recall, which is determined by how often the rule is used. Less use means a smaller chance of recall [26].

A tutoring system not only keeps track of the production rules a user needs to know, but also the user's probability of recall for each rule. The system does this by modeling the cognitive process of memory decay and rehearsal effects, which give a rough estimate of the probability of recall. Aside from production rules and their recall probabilities, the procedures which consist of these rules are also tracked and evaluated [26].

The combined power of both the proficiency of the user on the procedures and the user's knowledge of the production rules allows the ITS to ask questions which train the user's 'weakest' procedures and thus stimulate recall of almost forgotten production rules.

5.3 The state of user modeling in educational game design

The fine-grained tracking of a student's knowledge seems to have only gained traction over the past six years [33, 34, and 35]. In those years, the results of research on evidence-centered design (ECD) show promise of a good approach to formulate and assess a student's competencies with regards to the learning goals of a game [36, 37]. ECD consist of three important steps: providing a competency model (what has to be assessed?), an evidence model (what kind of behavior has to be elicited for effective assessment?), and a task model (how can we elicit that behavior?).

ECD has the possibility of bypassing one of the barriers preventing the use of ITS literature in educational game design: the strictness of cognitive architectures. While the formal approach to knowledge found in architectures such as ACT-R allows an ITS to keep track of the student's progress, to a high level of detail, it also requires the to-be-learned skills to be formulated in production rules (as such is the language of ACT-R). The more flexible approach provided by ECD allows the designer to formalize the knowledge less strictly.

5.4 Using user models in educational game design

Educational game design shows promising results in assessing the user and using this knowledge for adaptive game play (e.g. scaffolding instructional content) is the next logical step [37]. ITS research could be used as basis for this step; providing tailor-made feedback and challenges are two key features of such systems [38]. A lot of developments, such as finding the right methods for statistically inferring the right feedback or questions, have already taken place in the field of ITS [39, 40]. As a first step the field of educational game design could look at the following problems already discussed in ITS literature:

1. Look into the use of artificial intelligence, not only for determining proficiency probabilities (as is done in [37]), but also for determining the right feedback and challenges [e.g. 40, 41].
2. Look into measures of adaptivity and the ongoing discussions in the field of ITS on how an educational game should adapt to its user [42].

6 Discussion and Conclusions

In this paper we have identified and described three research directions that will help the scientific community to build more effective educational games (and included relevant and recent articles looking into these directions). This is in line with previous work in which we formalized three dimensions of effective educational games [7]; the research directions represent important aspects that are required to bridge the gap between 'the users and their learning process' and the gap between 'the game mechanics and the learning process'.

The first direction emphasizes the need to differentiate between ‘learning how to play the game’ and ‘achieving the intended learning goals’. Not taking this into account may lead to lower learner performance and motivation throughout and after playing the game. One way to solve this is by adding tutorials or scaffolded feedback regarding the gameplay for less experienced users, but this may be off-putting to more experienced users.

The second direction emphasizes the need to understand the relationship between game mechanics and learning goals. It may be that different types of mechanics lead to a lower or higher performance for certain types of learning goals. This is very clear with regards to the relationship between ‘time to input actions’ and stimulating higher-order cognitive functions; if a user has to play a very reactive game, for instance a shooter, it may be difficult for users to reflect on their actions in a cognitive manner.

The third direction emphasizes the need for educational game design to further incorporate aspects and methods of intelligent tutor systems. In particular, it is becoming increasingly important to determine and apply a singular method to 1) identify do-main-related competencies and how they can be inferred from user actions, 2) make sure that the game consists of activities that elicit the intended user actions, 3) create appropriate user models that help to track the user’s progress through these activities, and 4) use these models to adapt both the learning content and the feedback to specific users.

These three research directions require a better formalization of the mechanics that are present in a game, the process through which different users acquire domain-related knowledge & gameplay-specific knowledge, and the optimal relationship between these two. This formalization should also help us to better describe the content of educational games; usually it is very difficult to get a good understanding of the in-game activities of an educational game and their educational quality just from their sometimes superficial descriptions.

Furthermore, for the field to mature, we need to include a certain level of adaptability in educational games to ensure that the game is a better ‘fit’. By adapting the game play content and in-game feedback to the a-priori knowledge and interests of the user, as well as the learning styles of the game’s target audience (e.g. children or adults), we will be able to create more effective and motivational learning tools.

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Cognitive Principles for Education-Based Learning in Young Children

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Abstract. The use of media devices is increasing with 41% of children between 24-36 months of age engaged in more than two hours of screen time per day. The number of games has also increased recently but little has been done to assess their educational validity. Given the substantial increase in media use by young children, a set of best practices is needed. We present principles that will be useful for designing and developing educational games for young children. To provide an example, we build the principles around a national problem; improving early-childhood language acquisition in low socioeconomic status children. Language development is often an indicator of pre-literacy skills that relates to long-term academic success. We argue that educational games could help facilitate language development and academic readiness skills in children before they enter formal school. Here we provide five principles as a framework to develop learning in young children.

Keywords: Game-based learning, learning, child development, children's media

1 Introduction

Children's access to media and technology has drastically increased with 75% of children under the age of eight with access to a touch screen or mobile device at home [1,2; see Figure 1]. Since 2011, the number of children who have used a device has nearly doubled from 38% to 72% and the average daily use has tripled from 5 to 15 minutes [2]. Given the significant increase in such a short time frame, several professional and health organizations such as the American Academy of Pediatrics, National Association for the Education of Young Children and the Fred Rogers Center for Early Learning and Children's Media have expressed concern over the amount of time children spend with media [3]. Part of the concern is driven by the dearth of research to assess the validity, efficacy or even usability of technology for children. But, the prevalence of electronic media will continue to expand and these digital devices are becoming an integral part of communities, cultural practices and even life at home.

As a result, the number of available apps is also drastically growing. In January 2011, just under 400,000 apps were available from the Apple App Store; as of July 2015,

that number was 1.5 million [4,5]. Indeed, the app landscape is quickly changing with a projected 24% annual gross revenue increase in 2016 and anticipated downloads for 2016 just under 150 billion [6]. The array of electronic devices and rise in use affords an opportunity to use these tools to impact educational outcomes and facilitate learning and development. Compared to other app categories, educational games are the most frequent type used by children aged 2-4 years [1]. However, a recent analysis revealed that only 29% of apps mention a particular curriculum in their description, with Common Core and Montessori being the most common [7]. In fact, researchers have identified only a few apps designed with an understanding of how children actually learn and very few have implemented research-based approaches for development and deployment [8].

We propose a set of guiding principles taken from child development and learning sciences to guide appropriate development of education based games and in particular, apps that help children learn language. Our motivation for creating a set of principles for language learning apps is based on our work that focuses on inequalities in language development [9,10]. In particular, children from low socioeconomic households are significantly behind in language development, an important predictor of academic success, by their second year in life. Before we discuss the guiding principles for effective language learning apps, we provide a rationale on the importance for language learning apps.

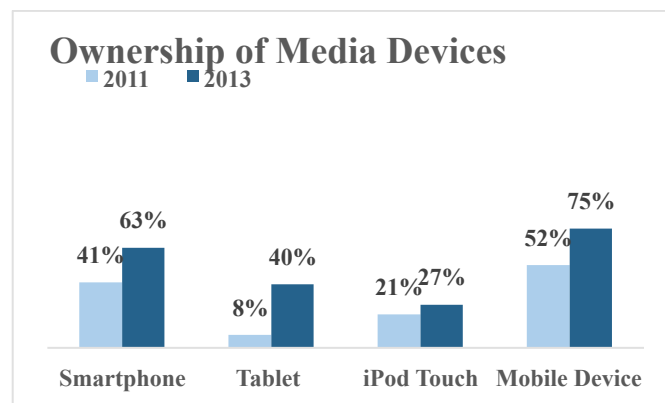


Fig. 1. Children's access to media platforms from 2011 to 2013. Among children from 0 to 8 years of age, the percentage of homes that own each kind of platform. Data displayed as percentages from Common Sense Media: Zero to Eight – Children's Media Use in America 2013 [1].

2 Rationale for Language Learning Apps

In this paper we identify and summarize best practices for the design of language-focused children's apps to enhance and increase learning opportunities. Children from

low socioeconomic status households have reduced opportunities for educational, occupational, and economic attainment [9,10]. Educational inequalities affecting children of low-income households begin long before children enroll in preschool [11,12]. The language gap in children from low-socioeconomic (SES) homes is evident in a number of measures including language processing, language comprehension and language production [13]. By age 2, there are already considerable differences in language abilities between advantaged and disadvantaged children [14]. These differences are often explained, in part, by differences in the early language environment [13], [15]. Families of low-SES are limited in the qualities and quantity of learning opportunities they can provide their children. In particular, differential learning opportunities have lasting effects on language development, a significant predictor of academic success [13]. We are interested in increasing the language skills necessary for academic success. One solution to bridge the language learning gap in children from homes of lower socioeconomic strata is to develop an interactive game to facilitate language development.

The remainder of the paper highlights key principles for key stakeholders, including designers and developers, when building educational games for young children. For each principle, we describe the relevant child research motivating each principle. We argue that these principles are crucial to providing a valid and effective education-based app. We then select current educational-based apps designed for children under the age of 5 that highlights each of these principles.

3 Principle 1: Integration of Development

Educational games should be developmentally appropriate and consider the cognitive, social, emotional, physical and linguistic needs of the child. In particular, apps should augment developmentally appropriate activities such as play [3]. Play is so critical to developmental outcomes that the United Nations High Commission for Human Rights has recognized it as a right for every child. The concept of play allows children to explore their environment, which facilitates use of their imagination and creativity [16] and ultimately contributes to cognitive development such as problem solving and decision-making [17], emotional development [18,19,20], language skills [21], physical activity, and future academic readiness skills such as problem-solving and readiness to learn [21,22,23,24,25]. Technology should be used to support learning during semi-structured play sessions to increase access to content [3].

Play is just one important component of development, but it also one of the easiest aspects to implement in apps. For example, in *Bugsy Preschool* (Peapod Labs LLC, 2014), the initial environment shows the main character, Bugsy, in what is presumably Bugsy's room. The room is a semi-structured play area that allows the user to explore various aspects of the room before heading off to a more structured learning experience. In the learning environment, the child is asked questions about shapes or numbers and is awarded an object after five correct responses. The object is transported to Bugsy's room and once the child touches the object, the function of the object (e.g. train) comes to life (Fig. 2). By creating an environment that children can

explore, the app affords the opportunity and potential for creativity and imaginative play. This kind of balance of structured and semi-structured environments takes advantage of the demonstrated developmental philosophies for positive outcomes.

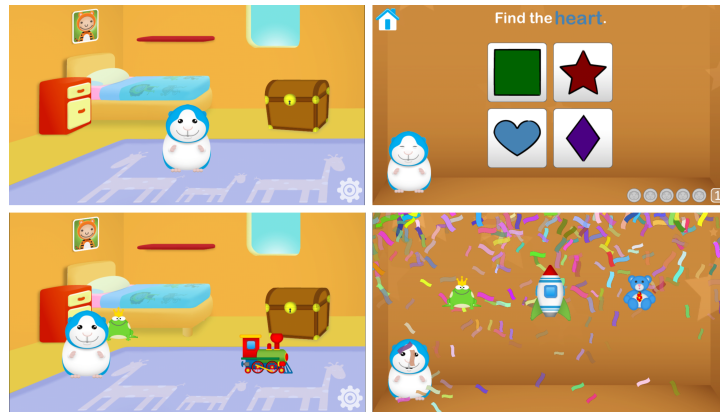


Fig. 2. Clockwise from the top left: Bugsy sits in his room waiting to explore; Bugsy participates in a learning trial; Bugsy selects a prize; Bugsy gets to explore the prize in his room.

4 Principle 2: Science of Learning

Educational games should closely align with learning theories in psychological science. Given that general learning is the most popular subject for educational apps, with 47% of apps for children designated in the general category [7], it seems appropriate that learning would be systematically tracked. But, only 2% of apps even mention that research was conducted to assess the learning outcome [7]. Thus, for many of the general learning apps, the learning process and even learning outcome is unclear.

Educational games are prime candidates for using social and statistical learning theories, two well-known frameworks that have been linked to current child development research in providing explanations for effective outcomes. Social learning implies some aspect of interacting with another social agent; the infant plays an active role in structuring their own environment and seeking out information or feedback from others. In this regard, the ecology (i.e. the environment) is important as it provides stimulation and opportunities for learning. The child's own behavior serves an important role in maintaining and facilitating social interactions and allows the child to learn based on the feedback received. What is most important in these interactions is that the child receives an appropriate contingent response.

To understand the importance of contingent responses to behavior, psychologists have manipulated the time and form of contingent social feedback to child vocalizations [26]. Researchers instructed the mothers in two conditions, contingent and noncontingent, on the type, form and time of response. In the contingent condition, mothers were instructed to respond after each time their child vocalized by providing a nonvocal response, such as a lean in, smile and touch. This nonvocal response was to control for the possibility that vocal stimulation could enhance the level of imitation and the authors were interested in how nonvocal feedback might influence learning. In the yoked condition, mothers used a response pattern from one of the participants in the contingent condition. Thus, the child received the same number of social interaction, but it wasn't contingent on their vocalization. Children who receive contingent responses after they vocalize were more likely to produce developmentally advanced vocalizations compared to children who do not receive contingent responses [26]. This result is even more striking when the contingent response is vocal and structurally different from their native language. Children who receive contingent vocal responses, irrespective of their native language, to their own vocalizations produce vocalizations that are similar to the responses they received compared to children who did not receive contingent vocal feedback [27]. The key factor in the learning scenario is that contingent feedback to the child's behavior is crucial for learning. These studies demonstrate that the form (i.e. vocal, nonvocal) and timing (i.e. contingent, noncontingent) are important to facilitate learning and development.

Indeed, initial research on media use found that children learn better from a live social partner than from a video presentation, known as the video deficit [28,29,30]. For example, children were able to imitate more after viewing a live presentation than a televised presentation [31]. Similarly, children are able to perform better on tasks when observing events through a window than on a television [32]. In studies of live interaction, the infant experiences contingent feedback from the individual whereas in televised presentations, many of the social cues are removed [30]. In one study, toddlers were exposed to novel verbs in live social interactions, contingent social video training, or yoked video training [33]. They found that children learned verbs during contingent social interactions, both during live and video training. Additional studies have demonstrated that children can learn from video if the format has the opportunity to engage in contingent interactions [34]. These studies also highlight the importance of contingent social interactions in promoting learning.

The findings from television provide suggest principles that should be used in apps for effective learning. In particular, the child should play an active role in the app and receive appropriate contingent feedback based to their behavior. For example, using voice recognition technology, the app could engage in conversational turn taking to elicit vocalizations from the child. Instead of the child being passive, the app could serve as motivational tool to encourage active engagement as defined by the production of a behavior. Once the targeted behavior is produced, the app could provide contingent feedback. For example, in *Peekaboo Barn* (Night & Day Studios, Inc., 2014), the scenes are straightforward and quite simple (Fig. 3). The red barn can open by a swipe or tap from the child to reveal a farm animal. When the barn opens to reveal, for example, a cow, the child could be asked, "What animal do you see?" to

which the child could respond with “Cow” and a prompt, contingent response by the app could say “Yes, that’s a cow.” To encourage further conversational turn-taking, a hallmark behavior for language learning, additional questions asking about the sounds, where the animal lives and what the animal eats could be embedded in the app. The key underlying process is to engage children in meaningful social interactions that provide prompt, contingent informative responses.

The second theory, statistical learning assumes learners are faced with challenging and often, ambiguous environments with multiple sources of information. For example, if you are suddenly transported to a new environment and someone walks up to you and says “dax,” then you, as a learner, need to determine the correct referent. You might be thinking to yourself, “What is a dax?” This is the classic *word-to-world mapping* [35]. Perhaps you try to pick up social cues from the individual based on their attention, facial expression or gestures. But, another approach, statistical cross-situational learning, argues that individuals need to experience various learning instances across several contexts to determine the referent. In order to determine the meaning of dax, you need multiple contexts and instances of dax to know what the referent is in the environment. Statistical learning allows individuals to detect the regularities in their environment. The theory argues that learners, both children and adults, can extract regularities from repeated presentations of complex stimuli across various contexts. This has been demonstrated for word learning [36], word segmentation [37], syntax learning [38], tone sequences [39] and visual sequences [40].

One advantage to the statistical learning framework is that information presented to the learner doesn’t necessarily need to occur with a *one-to-one* mapping. So, instead of showing the cow on the *Peekaboo Barn* and stating “This is the cow. See the cow?” the game could embed a story about the cow with additional information. The learner will eventually understand, after enough repetitions that the big four-legged animal with black and white is most likely a cow because every time the word cow is mentioned in a story, a picture of this animal appears or is present. Games should be designed so that across various contexts, similar information is presented. In the example of the cow, over time, as long as a picture of a cow is presented in various contexts with the word “cow” then the child will start to learn about cow.

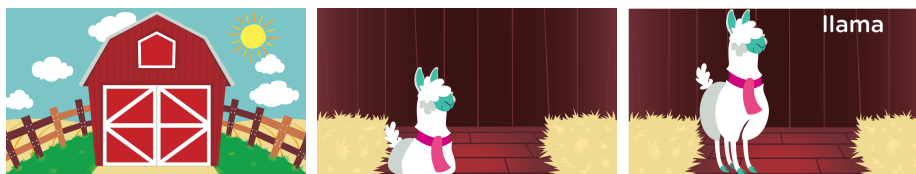


Fig. 3. From left: the child touches the barn to open; the barn opens to show an animal (e.g. llama); llama is displayed on the screen.

5 Principle 3: Embedded in Parent-Child Interactions

Games should provide a platform that enhances and facilitates parent-child interactions. This sentiment has been echoed by the AAP, NAEYC and Fred Rogers Center as crucial elements to optimize learning. Much research has examined the relation between parent-child interactions and language development. A key finding is that the quality of interactions significantly relates to many facets of language development such as word learning [41]. One of the main concerns about the increase in media use is the consequence for face-to-face interactions. Most parents (58%) report that media doesn't have an effect on their family time, but 28% report that media contributes to spending less time together [1]. Given the function and significant increase of media use, it is foreseeable that parent-child interactions could potentially decrease [1]. However, we argue that well developed games could potentially serve as a mechanism to increase the quality and quantity of parent-child interactions.

A large body of research has identified early language experience as a key environmental factor in language development and in particular, the social interaction in which children are embedded is the most significant predictor of expressive language. Parent-child interactions that create a shared 'communicative foundation' (i.e. symbol-infused joint engagement, routines and rituals, and fluent and connected conversations) foster optimal language development. Children can better learn the meaning of words in parent-supported activities in which parents introduce words rather than just overhearing them [42], [8].

Given the importance of parent-child interactions in development, special consideration should be given to maintaining and facilitating social interactions. First, apps could require input from the parents at crucial points in the game. For example, a prompt could require a verbalization from the parent to the child. In the *Hat Monkey* (Fox and Sheep GmbH, 2016) game, a screen appears, "Monkey is Coming! Can you open the door?" accompanied by cheerful music (Fig. 4). The parent could ask the child and click the appropriate button to proceed to the next scene where the child could independently (or with the parent) figure out how to open the door for monkey. In this interaction, the parent is playing an active role in engaging with their child around a specific event (i.e. opening the door for monkey). From a language perspective, the child is learning about the concept of a monkey and also basic functions of a house: opening the door. Second, apps could provide feedback to the parent about their child's engagement. Continuing with the *Hat Monkey* example, one of the prompts asks children, "Can you give Monkey a high five?" If the child completes the action, a feedback loop could be sent by text or email to the caregiver about the completed actions of the child such as, "Sofie knows how to high five the Monkey! Ask Sofie to give you a high five." Aside from the feedback, the game also encourages parents to initiate similar activity with the hopes of increasing the quantity of parent-child interactions. Finally, a third way that apps could foster parent-child interactions is by suggesting other opportunities related to their child's interest. Another scene in *Hat Monkey* asks the child, "Let's dance! Can you copy these steps with Monkey?" The app could provide feedback to the parent about the length of time

the child spent dancing with the monkey and suggests other dancing related events available in the community. For example, in Chicago, perhaps the feedback would suggest a local dance class or an event such as the Chicago SummerDance event. The goal of embedding game-based learning in parent-child interactions is to supplement, not replace, the key element of language development.

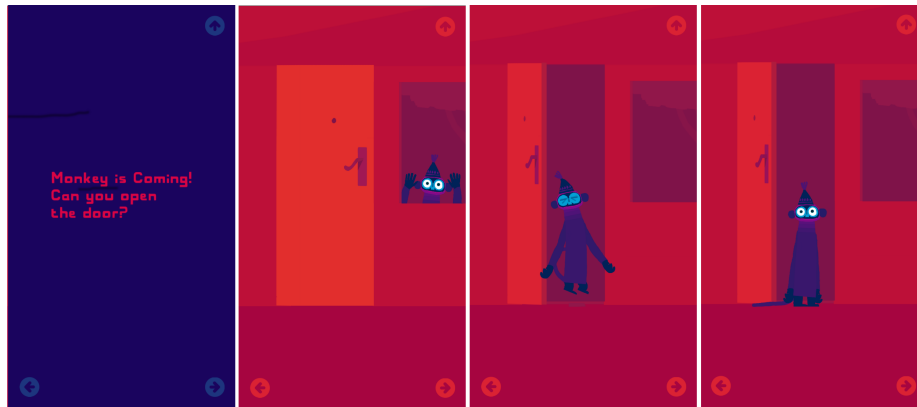


Fig. 4. From left: a text displays the next activity; Monkey approaches and knocks on the door; Monkey comes through the door once the child opens it; Monkey is now ready to engage.

6 Principle 5: Utilizes Interventions

Games have the potential to serve as effective interventions. Clinicians recognize the benefits of incorporating technology in intervention strategies, as it is cost-effective allowing parents to implement them in the home environment. Several apps have been developed for individuals with disabilities to teach various skills, augment communication, serve as an alternative form to communication and assist with language skills such as receptive and expressive vocabulary [43]. Guides on evaluating the usefulness and efficacy for apps designated for intervention have recently emerged [5], [43] and support the use of electronic devices to teach individuals. In one study, children with developmental delays were able to learn early language skills necessary for pre-literacy development. Even more encouraging is that their learning was generalized across contexts and even after the intervention; their skills were maintained [44]. For example, in 3-year-old children from low-income households, vocabulary increased by 14% in a 2-week period after interacting with a vocabulary app [45].

7 Conclusions

We see language-learning games bridging the academic gap between different socioeconomic strata. As electronic devices are becoming increasingly accessible, both in price and usability, apps directly targeting these special populations can be

developed. In order for apps to be successful in their intervention (i.e. increasing language development), a highly focused research effort should be implemented. The guiding principles we propose in this paper can serve as a framework to both researchers and developers to create effective and meaningful experiences to facilitate language development, ultimately impacting academic readiness skills and success. Additional research and development is needed to ensure the validity of this framework (Fig. 5).

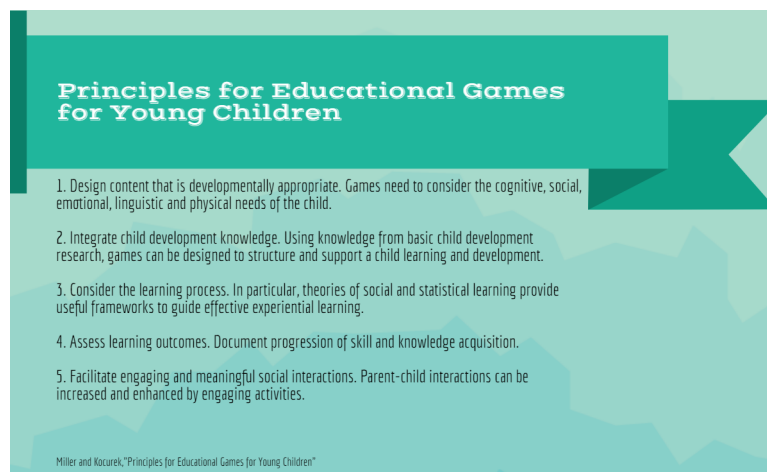


Fig. 5. Summary of key principles for game-based learning for young children.

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Serious Games in 2025: Towards Intelligent Learning in Virtual Worlds

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Abstract. This paper outlines the current state of learning, the problems arising and research needed by developers and educators using Virtual Worlds as an intelligent learning environment. Artificially intelligent avatars are required for virtual on-line problem and case based learning. However, the use of AI requires extra supportive frameworks, models and both staff and student goals. Natural simulations and avatar interactions are all part of the learning environment but realism, student paced learning, adaptive goals, natural language interaction, feedback and assessment are active goals for the next decade of virtual education research.

Keywords: Serious Games, AI, Game Based Learning, Virtual Worlds

1 Introduction

Technology has enabled online learning to reach new heights of student numbers and courses offered by Universities around the world. Once considered the poor relation of tertiary education, online learning, Virtual Learning Environments (VLEs) and online supporting tools have come of age and are increasingly used as knowledge repositories and discussional tools. Online learning is now neither a solitary exercise nor a knowledge base, it requires engagement from both the tutor (lecturer, teacher, educator) and the student. Research in online learning and virtual environments is a global enterprise; Australia, China, Canada, the USA and Europe are leading the work through papers on VLEs, VWs, games based learning, goal driven education and avatar interaction. Further, back in 2013, Gartner predicted that mobile virtual worlds will be increasingly used by young users, teens and tweens [1] and the current growth of educational virtual worlds and technologies demonstrates that need.

This position paper considers the field of learning in Virtual Worlds (VWs) and the necessary research and goals to enable learning environments to be student self-paced, semi-directed and goal driven using intelligent avatars as both information repositories as well as goal supportive processes.

The paper starts with the problems and lessons learnt over the last decade of using VLEs and VWs to enable non tutor led learning. The various elements that must be considered are outlined in section 2. The goals for the next decade are presented in

section 3 and necessitate the cooperation of both AI and Natural Language specialists, Education experts and virtual environment researchers.

2 Online Learning

Many students have applied to do online courses through edX [2] or through universities worldwide such as the Open University in the UK [3] or through Harvard [4]. These courses have proliferated over the last decade and vary enormously in the levels of student support, interaction and assessment.

Many online VLEs are linear reading and assessment submission whereas some scientific environments use online laboratories or simulations such as Crystal Island [5] or Virtual Singapura [6]. Historical re-enactments or visualisations [7] are common in Virtual Worlds and there are more Arts based online environments, for language learning [8], history or archaeology but there has been an increase in medical and biological learning environments in recent years [9]. The choices for online education are varied, but research focus and development is also disparate.

2.1 Information Overload and Memory

One major lesson that all tutors are aware of, is that of Information Overload [10]. We are in an information rich age and many commentators suggest that the amount of information a modern student has to wade through online is exponentially increasing, most of it unnecessary or irrelevant noise. However, [10] stated that many students either drop a course, participate less or late and when they get overwhelmed with work or goals, become stressed, confused, anxious or depressed. Therefore as educators, we must be wary of Information Overload (IO) when designing course content and assessment but also be aware that students do need to encompass a reasonable amount of information to be able to assess, collate and compare facts or data. This fine balance is one that tutors must constantly assess but student cohorts are notoriously different from year to year and, indeed, from student to student so the fine-tuning of information requirements is a tutor heavy task each time a module is taught. Little is known about IO in online learning but learner readiness, the quality and quantity of information and the visual interface are considered to be relevant factors.

Capacity of memory is an area of psychological as well as educative research that covers many topics such as number of facets a person can remember at any one time, the movement of information from short term memory to long term memory and shallow and deep processing. All learning requires practice and experience and the Confucian adage or I hear and I forget. I see and I remember. I do and I understand has vital relevance here. To move from short term to long term memory, or from shallow surface to deep learning, requires repetition, and loose experiential goals. In our current Internet age it is easy to consider that all information is a click away, but we need to have some deep learning to be able to progress from basic arithmetic to studying the movement of stars, deciding on a dose of insulin or encoding an online avatar.

Nash and Shaffer [11] discussed mapping relationships through Epistemic Network Analysis and indicated that less facts but more skills will aid in a student's preparedness for online learning. Essentially, they suggested that learning should be considered as a Reflective Practitioner partnership where a mentor guides a novice through their learning, taking into account skills and knowledge at each stage.

2.2 Types of Learning

Tutors use different models of learning from primary through tertiary education and students themselves have individual preferences for learning. Some students are good at understanding diagrams or images and others at reading information. Research indicates that students learn well from animations or videos [6] and current academic training in the UK encourages the use of more images than text in one's teaching because of the human ability to remember images better. However, this may be useful for some sciences but is not useful for subjects that are text based such as learning languages or theoretical sciences.

A mix of learning styles is recommended by many educationalists, from reading texts to performing practical laboratory or classroom exercises, coupled with videos or discussion classes.

With regards to educational theory, collaborative learning or construction, problem based learning, game based learning, role playing, questing and virtual fieldworks are all being used [12]. Recent work, [13], has considered situatedness and meaningful contexts and the way groups work together. Olympiou et al. [14] have considered the student's mental model and whether visible or invisible objects can help abstract concepts for understanding.

Other concerns authored by recent researchers include coding schemes for collaborative decision making and the motivation of students [6], student attention and assistance needed and the believability of the environment [15].

Jacobson et al [16] suggested designing for a Virtual Pedagogy, aligned with university or school syllabi. They suggested that levels of technical assistance could be guided by a Student Lab book, essentially as a road map through a course. The notion of Productive Failure is encouraged as a way of learning better, that is, the student learns more by repeating experiments to attain a goal with expected failures of design, data or results as an in-built design objective by the tutor. Thus, states and transitions are required for both the Student Lab book and the virtual experimental framework.

2.3 Types of environment and tools

Currently tutors use Virtual Learning Environments such as Moodle [17] and Blackboard [18] or Virtual Worlds such as Secondlife [19] or open source variants such as OpenSim [20]. Game based simulations can be written in either of the latter environments but some tutors prefer to use game engines from Minecraft

[21] or similar. However, many tutors use smartboards, videos or audio for supporting and enhancing learning from textbooks or whiteboard. Essentially a mix of learning environments from story telling or reading a book to writing an essay, through discussions and video lessons to physical or virtual practical sessions are all part of the rich choices a tutor has.

Jacobson et al. [16] added the necessity of designing for aesthetics in a virtual environment. The more aesthetically pleasing, or fun, a working environment is, the more a student will engage. For example, designing an algorithm to move a robot around a screen can be fun, but designing an algorithm for moving Dr Whos Tardis through space in a simulated 3D environment can be exciting as well as competitive.

To develop a useful VLE or VW a large cohort of experts are needed, from the tutors who know the content to the developer, computer scientist, skilled at programming the environment and the artist who creates the avatars or objects. Any processing framework such as for avatar discussion, intelligence or direction requires a corresponding framework for goals and transitions. By going further into the learning process, such as the aforementioned memory and cognitive issues requires the assistance of educational psychologists. Making the whole environment creative, adaptive and interesting would also require game based learning researchers. Immersion in an online environment is possible through 3d projection CAVEs or through headsets and body sensors. The development of headsets such as Google Cardboard or Oculus Rift and newer eye tracking devices all enrich the user experience. Cheaper drone technologies may allow real time feedback from external environments such as archaeological digs or flood planes. A future in which distributed robots feed tactile information from an external site, coupled with overviews from drones is no longer science fiction. This decade will see online educational environments undergoing seismic changes.

Consequently there are many researchers needed to develop a virtual educational environment and each will use either games engines, frameworks, screen captures, activity recognition, natural language processing, interaction models, databases etc. alongside the general issues of network load, efficiency and robustness.

2.4 Levels of interaction

Students should have access either to a laboratory based VirtualWorld (or VLE) where their learning or experiments are embedded. A CD may be applicable if the students are geographically distributed but there are obvious technical requirements associated with either approach.

Once a student has done some learning on their own, they can be linked to other students through discussion fora or through the virtual environment. Chat rooms, discussion areas etc are all applicable here. Tutors can monitor and lead topics but it is important to constrain discussion to relevant issues and not allow interference from external topics. The goal of this level is to prepare the student for self-directed or goal-directed learning in the virtual environment.

Once these basic levels have been passed to the tutors required level, the students can then be given entry to the self paced virtual world or simulation. By this stage, therefore, some prior knowledge through the previous levels has been gathered (and perhaps tested for). The virtual environment will allow a mix of learning strategies that tutors may switch between, depending on the required tasks. The use of headsets, tactile input and 3D projections as well as soundscapes will enable the student to have a more enriched, and therefore memorable, experience.

2.5 Roles and Guidance

Current research has shown that before going into online or virtual learning, a student must have attained a core knowledge or skill set [14] [22] before beginning more group based or self paced working. Thus, the tutor is extremely important and necessary to lead the student towards the appropriate level. A tutor must be an active presence in teaching even when learning is mainly online.

Chen et al's work on Information Overload [10] indicates that a primary role of a tutor is to recognize that each student will learn at their own speed and can cope with different amounts of information. Voogt et al's work [13] suggests that collaboration, grouping and partnerships must all be guided and practical or technical concerns such as policies, timing, belief systems or the broadband capabilities must all have a monitoring agent. Olympiou et al [14] also considered the students mental model through prior knowledge and abstraction of objects. This necessitates the tutor acting as an oracle for designing functional tasks through estimating high or low levels of prior knowledge. Bogdanovych et al. [23] previously indicated that virtual agents (if used) should have a human agent to guide and formalize the environment, the functionality and the interaction.

The above work suggests that tutors have to become experts in educational as well as dialogical frameworks, computer skills for encoding functionality into an avatar or developing a simulation as well as developing pre-tests and post-tests.

2.6 Lessons Learnt

Worldwide, there are many active researchers and educationalists building virtual worlds or environments to cater for rising student numbers and the changing needs of the 21st Century student. There are many facets to building working environments, especially developing virtual worlds wherein students can act out scenarios through avatars, or going further, immerse themselves through headsets and sensors. Learning goals and layers of syllabus aligned knowledge must be encoded to enable a useful learning experience for students rather than a repetitive or one time play experience. Thus frameworks for learning, essentially encoding learning theories into programmed environments, goal driven processes and adding variation for experiential learning is a blue sky research goal. Further, adding the experience of the tutor, with changeable levels of guidance and tutor interaction, as shown by [6] [16] [22], is necessary for student engagement and development.

A concern rarely mentioned by researchers is that of assessment. Grading is often done by production of a set of searched for objects, a quiz or a short class test on information gleaned from objects or avatars. Thus, research on better ways of assessing in-world or online work is required.

As a supportive tool in the classroom, enabling students to learn or play at their own pace, virtual worlds or learning environments have proved their place. They are invariably not tutor friendly to adapt or maintain and require a considerable skill set to develop and use on a frequent basis with differing environments or goals for students to attain.

3 Virtual Learning Goals for 2025

Section 2 outlined only a small sample of current research and issues in Virtual Learning Environments and educational Virtual World development. However, even with such a short sample it is obvious that many researchers worldwide should form partnerships to develop the next generation of online educational support tools:

- Natural Language Processing is needed to make avatars realistic and to adapt their responses depending on the students level of knowledge or skills.
- Game Engine designs should be adapted for learning theories, ensuring that there are scaffolded learning mechanisms embedded with an engine.
- Good scripts and narratives are just as important as the objects embedded in the virtual environment. All have to be naturalistic.
- Scripts, objects, information and student goals should all be adaptive to lend credibility and a sense of realism to the environment.
- Goals should be changeable depending on the level of prior knowledge of the student and their skill set.
- Skills and knowledge have to be tested for and analysed in a non game intrusive way. Similarly, student assessment must be hardened to be more than quizzes or multiple choice tests.
- The virtual worlds need a better interface for tutor (and student development) and to adapt the case studies, objects or narratives.
- Easier mechanisms for creating objects, avatars or storylines should be developed through game engines.
- There should be a mix of learning required of the students; problem solving, book learning, laboratory experiments, discussion rooms and groupwork.
- Student support from tutors should be semi-structured with the student allowed to learn at their own pace but with reasonable (and adaptive) goals to push them towards recognisable achievements.
- The use of powerful Artificial Intelligence is needed to create intelligent adaptive virtual interactions with online avatars directing or demonstrating to the student. Making the avatar as realistic with the NLP noted above will increase student engagement and will also allow tutors to anonymously take over the roles of avatars for monitoring and assessing students.
- Allowing student development of VW objects, areas or avatars will also

increase their engagement with a scenario.

- Reflection of their experiences should be enabled via student file storage to form a history of their school or university development.
- Tutors need to be able to share their worlds through safe environments such as educational clouds or networks.

Technologies are advancing faster than tutors can embed them into educational scenarios or environments. However, this technological race gives educationalists a rich variety of tools to use and create experiences that students will enjoy, remember and learn from.

4 Conclusions

As student numbers grow and educational technologies reach into the outback, the desert and the mountain, educational tools will be required to have far easier interfaces for designing appropriate scenarios, games and exercises for students of all ages. An easy interface for the tutor to edit, adapt or maintain is essential. The offered environment must have a built in and large variety of exercises, scenarios and assessments as well as changeable, adaptive and entertaining avatars with randomised movement of information objects. This requires the fields of AI and Natural Language Processing to meet with game designers, educationalists and Virtual World programmers and designers. Only then can a Virtual World be perceived as a more than supportive tool in the teaching arsenal.

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Special Track 4: Immersive and Engaging Educational Experiences

Note-Taking in Virtual Reality Using Visual Hyperlinks and Annotations

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Abstract. Immersive virtual reality shows great promise for teaching and learning, but the question of how best to apply the powerful practice of note-taking has been explored very little. In non-VR settings, research has shown significant differences in learning outcomes depending on the usage of different styles of note-taking. Active "long-hand" notes sometimes work better than "verbatim" or typed notes, suggesting that in VR, recording and playback alone as a form of note-taking is unlikely to be optimal. We imagine a new form of active note-taking in VR that uses long-hand but also leverages recordings and original source learning materials. The approach is to use a virtual scrapbook that contains visual snapshots that function as hyperlinks along with hand-written notes. We hypothesize that this will be superior to either form of traditional note-taking for learning complex and abstract concepts. We discuss our work-in-progress towards building a note-taking system that will help test this hypothesis.

Keywords: virtual reality, note-taking, learning

1 Introduction

Note-taking is a powerful tool to enhance comprehension and recall in learning activities. Immersive virtual reality shows great promise as a platform for engaging learning experiences that convey complex concepts and involve large corpuses of knowledge. The important question of how to take notes in virtual reality has not yet been explored in great detail. In this paper we lay out a set of design considerations for VR note-taking tools, and propose a promising approach that we are actively exploring. Section 2 provides background on the role of note-taking in learning. Section 3 poses the theoretical problem of note-taking in virtual reality, and Section 4 presents our approach of using a scrapbook of snapshot-based hyperlinks and annotations. In Section 5 we conclude with a discussion of future research directions, highlighting both challenges and opportunities.

2 Background: The Role of Note-Taking in Learning

Note-taking is a powerful tool for enhancing the effectiveness of learning activities, which goes back at least to ancient Greece, where the early form of the notebook was known as a hypomnema. Two functions performed by note-taking are (1) capturing the information that a learner is exposed to (external storage), which allows the information to be reviewed later, and (2) facilitating deep understanding through paraphrase, summarization, and so on (encoding) [6]. Due to the limitations in working memory [1], it has been observed that note-taking imposes a tradeoff between production and comprehension { the more time and attention that is devoted to the writing of notes, the less there is to devote to understanding the content [6]. When more time is devoted to production, notes tend to be "verbatim," and this style of notes is known as non-generative since it does not require or reflect that the learner has understood the material, whereas when more time is devoted to comprehension, notes can be generative, capturing the output of a process of idea synthesis [5].

Formal studies of the impact of note-taking disagree on its learning value. As highlighted by Lin and Bigenho [3], variations may be explained by differences in cognitive load associated with the particular systems and content in question. This is supported by their study showing that introducing distractions changes which of several note-taking methods yields the best learning outcomes [2]. A recent study that pitted an HMD-based VR learning system against a slide-show based learning system on a 2D display found the latter to be more effective, noting that note-taking was only possible in the non-VR system [4]. Taken together, a valid hypothesis remains that, with careful attention to the cognitive load imposed both by the environment and system affordances, it is possible to design learning systems (e.g. in VR) with support for note-taking that yield better learning outcomes than their counterparts without note-taking.

3 Theoretical Considerations

In virtual reality, experiences can be recorded and played back in a straight forward way. That is, a certain form of "verbatim notes" can be made available without any attentional effort. This frees up more attentional resources to devote to comprehension, but as noted above, generative note-taking is helpful in maximizing comprehension. As such, it seems clear that a form of active note-taking that also leverages the availability of audio/video recordings of VR learning experiences would be a promising possibility to explore.

We propose an approach leveraging "hyperlinking" as a rapid form of active note-taking. This means using a system affordance to choose a location in the learning content to refer back to later. Since this process is active- deciding and declaring that a moment is significant- we argue that a benefit associated with generative note-taking will be attained. Subsequently, when hyperlinks are reviewed, the content is accessible in its full original detail, allowing the learner to reap the benefits associated with verbatim note-taking.

3.1 Capture System: Snapshots as Visual Hyperlinks

Different kinds of snapshots can be captured, and all of them can be used as hyperlinks. 2D snapshots are a familiar, lowest-common-denominator way of capturing visual information. Because the environment is captured in 3D, though, 3D notes are also a possibility. These can be a static snapshot of a scene that can be revisited later, and this can be accompanied by one or many camera positions that the learner finds useful or enlightening. Traditional notes can be tied to entire scenes or to specific camera positions. When the 3D content is animated, the possibility of temporal hyperlinks arises. Snapshots may have multiple representations: 2D images small (thumbnails) and large can be embedded in 2D notes, or 3D snapshots (small and large) can be used but it is less obvious how. Animations can be represented as a series of keyframes that may be presented in parallel in space. One consideration is that it may be of significant value to design notes to be easily viewable on mobile devices and allow the review process to be more portable. 2D snapshots and hand-written notes do have this property, and this is a major reason to consider them as a central building block for a VR note-taking system.

3.2 Synthesis through Annotation

Within this framework, we ask the question: what do active, synthesized and generative notes look like in VR? We assume that the learning experience itself is made up of visual and auditory experience. To begin, traditional handwritten note-taking is a possibility, assuming it can be captured and displayed at sufficient resolution, as shown in e.g. [7]). Synthesized notes can contain multiple hyperlinks, and the corresponding snapshots can be annotated with sketches and handwriting. Hyperlinks that are not embedded in notebooks may also be useful- similar to post-it notes used to mark important pages or chapters in a textbook.

3.3 Review System

We have proposed that notes may consist of visual hyperlinks embedded within hand-written virtual notebooks. Using such notebooks, the review process would consist of decoding the meaning from the "traditional" notes directly, and following hyperlinks to view the original content again. It should include viewing new external sources of information from the Internet, as this is a natural way to get different perspectives on concepts. This has several implications: one of these is that the note-taking system itself needs to support usage during the process of review. Just as with paper notebooks - more notes can be added to the notebook as it is being reviewed. In this case, however, the methods recordings taken during use, the layering of different "real-times" can quickly get out of hand (replay the lecture, then replay yourself taking notes on the lecture, then replay yourself taking notes on the replay of the yourself taking notes on the lecture). For this reason it is critical that the review system provide a simple set of abstractions that supports multiple sessions of exposure and editing while keeping the complexity of linking to verbatim notes under control. of interaction and representation need to be carefully considered.

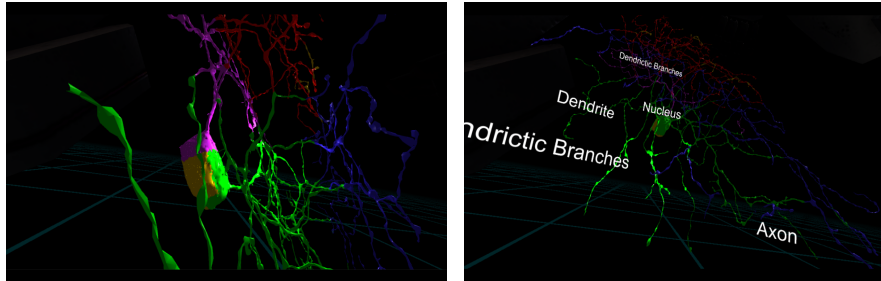


Fig. 1. The BrainVR environment allows learners to explore 3D neurons. Labels for neuron parts can be displayed.

4 Works-in-Progress: Note-Taking Using Visual Hyperlinks and Annotations

As alluded to above, we are exploring note-taking techniques based on virtual 2D “photos” that a user captures explicitly and intentionally. These photos assist learning in at least three ways: (1) their contents can help the user see and remember the insight gained, (2) they act as hyperlinks to return to the original position and environment configuration, (3) they can be incorporated into synthesized notes with sketches, collages, etc. We have implemented this idea in two variants - one that saves object perspectives, and another that saves spatial locations.

Our first implementation, shown in Figures 1 and 2 is a perspective hyperlink panel. The learner holds a complex object (example: neuron) in her hand which she is attempting to learn about. She can view it from any perspective by moving her hand and head, and can also rescale it using the controllers. She wishes to save and share insightful perspectives { these are defined by an orientation, camera position, and level of zoom for the object. A button on the controller allows her to take a snapshot of the perspective. The perspective is then added as a graphical thumbnail to a panel. Touching the corresponding thumbnail rotates the object to match the original perspective (regardless of the current orientation of the handheld controller). This application was built with the Oculus DK2 and Sixense STEM system. Our initial trials showed this to be a very effective and intuitive way of sharing perspectives of objects. As such, it is a solid building block for the note-taking system we envision.

In our second implementation is a spatial scrapbook, shown in Figure 3, the user explores a giant model of a human heart by moving around in 3D space. The size of the heart is such that arteries appear roughly large enough for an automobile to pass through. In this use case, the learner wishes to save locations and perspectives within a complex landscape. The user navigates the landscape by using the handheld controller to fly in any direction, with a velocity vector defined by a hand motion. He can take photos, sketch on the photos and arrange them on a canvas or book that travels in front of him like a portable drafting table. The photos can then be used as spatial hyperlinks to return back to the location where they were taken in the original 3D environment. This application runs on the HTC Vive. Our initial trials show this to

be an effective way of organizing information gathered through exploring a large, complex landscape with details in different locations and at different scales. One shortcoming is that abrupt transitions between locations are jolting and make it difficult for users to infer spatial relationships between locations. We are exploring solutions involving eased linear motions, and visual guides to indicate the path between locations.

Moving forward towards testing our hypothesis that this new form of note-taking is superior to note-taking in traditional settings, we are exploring methods for integrating 2D textbook materials into the 3D environment. This way, challenging 3D concepts can be presented with the advantages of motion-tracked virtual reality, while concepts that are well expressed in writing and 2D diagrams can be presented as such.

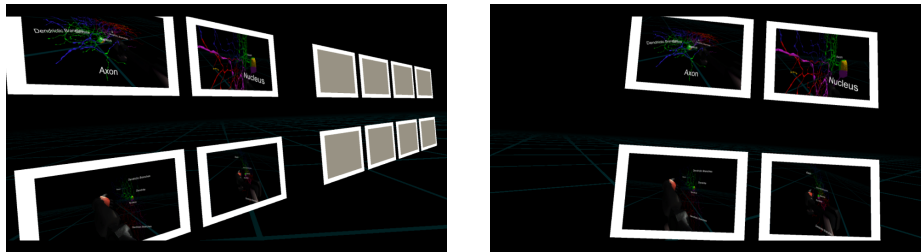


Fig. 2. The hyperlink panel captures object perspectives. New hyperlinks populate the gray squares.

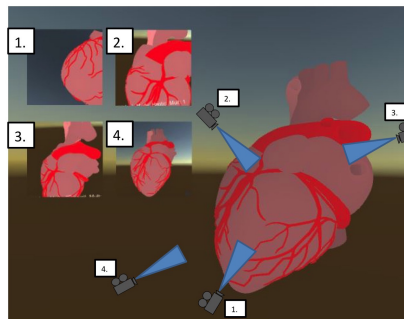


Fig. 3. The spatial scrapbook captures camera perspectives from different locations in a space or model.

5 Conclusion

Given that note-taking practices vary widely between individuals and even within the practices of single individuals, there is no reason to believe there will be a one-size-fits-all solution for virtual reality. Still it seems that a few basic tools - analogous to, let's say, the paper notebook and sticky note- may emerge and be widely adopted across many VR settings. We aim to discover these basic tools and shed light on how

they ought to be integrated with the process of learning, including learning with teachers and peers, individual study, and the subsequent review processes.

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Designing Immersive Transmedia Learning Experiences: Three Approaches, Three Games

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Abstract. We report on three transmedia games developed and implemented in three different settings. The *Now-and-Then* AR game introduced two different sets of attendees to the host city. *Broken Window* helped undergraduate students studying computer literacy through participation in a narrative that grounded their learning and served as a model for building their own transmedia experience to “show what they know.” Finally, *Villainous* asked middle school students design their own augmented reality game (AR) to illustrate knowledge of literature principles learned in as content to show transfer.

Keywords: Transmedia, games, immersive, middle school

1 Introduction

This presentation reports on three recent innovative transmedia game designs and their affiliated research. The designs we focus on here are a development sequence where we aspired to leverage emerging technologies and cross-media (transmedia) techniques in learning environments to develop a further understanding of how such technologies will optimally work in various learning environments and for what purpose. As instructional designers we aim to be on the forefront with innovative designs improving and enhancing learning for our students. As such, these designs have provided us the opportunity to research design challenges, learning and media affordances, as well as best practices.

2 Transmedia tools

QR-code and augmented reality (AR) tool use grows as mobile devices such as smartphones are increasing in numbers and the applications for continue to increase in complexity and sophistication. Wither, Tsai, and Azuma (2011) noted that AR is used both indoors and outdoors for both point-of-interest (POI) information (geo-located AR, see Munnerley et al., 2012) and for 3D content such as games. With artifact-based AR, a game experience is extended as markers or patterns are used as triggers

for prebuilt content such as movies, 3D animations, text, (Munnerley et al., 2012) and/or audio.

With both AR and QR-code technology, users access content through reader applications. Using a smartphone screen, AR app readers are aimed at a target or image. This triggers the device to display hidden content. QR-code apps read a particular kind of bar code that triggers a website to appear on the smartphone or device. Information provides consumers with product information prior to purchase or for additional information after purchase.

From this perspective, AR shares “overlays” on the environment by providing *additional content* on reality, making the experience greater; alternately, QR-codes share *real consumer information*. According to Mannerly et al. (2012), “AR technologies seek to integrate the real and the virtual together...” (p.44). Transmedia, sometimes called cross-media, allows a mix of media platforms to be used for an enhanced experience. By traversing various platforms, participating players seek out additional content needed for either a) finding clues that bring the story forward or b) enriching the narrative in which they participate.

3 Theoretical Framework

Situated learning functions as a framework that supports the innovations showcased with transmedia and was grounded in situated cognition, which itself was first described by Brown, Collins, and Duguid (1989). They based their theory on research by Jean Lave and argued that learning would be most meaningful if embedded in the social and physical context where it will be used. Formal learning Brown et al. concluded, differs from authentic activity in that it often can be seen as unreal to learners. The authors proposed a model of authentic practices “through social interaction and collaboration” (Brown et al., 1989), a leveraging of human communication towards personal and group goals, used to support learning. Having ownership in one’s own education Thorne (2003) argued, provides for “far more impact than a generic learning product” as learners are able to work on something meaningful and important to them (p.21).

3.1 Educational Communications Theory/LTCA

The learning theory that supported these innovations was formerly called learning and teaching as communicative actions (LTCA), now known as Educational Communications Theory (ECT) (Wakefield, Warren, Rankin, Mills, & Gratch, 2012; Warren, Wakefield, & Mills, 2013). ECT is focused on fostering designing learning activities to foster five fundamental types of communications as the medium for instructional messages:

- 1.) *normative* (expectations- and rule-based)
- 2.) *emotional* (cognitive-affective support)
- 3.) *directive* (teacher-led)
- 4.) *discursive* or argumentative (learner-led)

- 5.) *identity* (individual-expressive)

3.2 Relating ECT theory to a PBL approach

Within this holistic theory, a problem-based approach was used to construct the gaming conflict, used to drive play. Further, it built on the ability for learners to conglomerate earlier “learned principles, procedures, declarative knowledge, and cognitive strategies in a unique way within a domain of content to solve previously not encountered problems” (Smith & Ragan, 2005, p. 218). Smith and Ragan (2005) further noted that any problem stands out as a problem when the learner has a goal, but lacks the knowledge of how to achieve it. Problem-based learning is a teaching strategy that is ill-structured in nature; that is, it involves problems with multiple solutions, which requires “students to learn content while solving problems” (Jonassen, 2011, p.154). As such, we may see problem solving as something students may need to engage deeply in to arrive at solutions; further, if the problem is of interest to students, it will likely motivate them.

4 Three games, three subjects, three approaches

Each game took a different approach in terms of story, but the underlying approach employed media distributed across the internet. Some could be accessed by smartphone apps, while others were played entirely online through web browsers, YouTube, and through virtual worlds and game spaces such as *Second Life* or *World of Warcraft*. The following offers synopses of each major design.

4.1 Villainous: A student led, teacher guided augmented/alternate reality experience

Students, exposed to challenging case-based and project-focused curricular problems, were engaged by their instructor in game design, producing an augmented reality game about the old city center and the history of the area through a ghost story developed by the learners themselves in response to the information they collected through analog and digital sources. This experience provided learners a holistic view with a goal of providing authentic contacts with the surrounding world and community members set into place to create creative and critical thinkers as well as guide learners in communication skills and to provide a means by which those in the community can critique and give learner feedback about their products and solutions.

4.2 Now and Then: An augmented conference experience

This case study presents how a transmedia story, or mixed media narrative shared over various social platforms, was initially developed and shared with a goal of supporting an international conference. This game-based curriculum informally introduced conference attendees at an academic conference, seeking to situate them in the place, history, and culture of conference host city. The transmedia story initially

shared over social media, led up to an augmented reality game that attendees could play during the conference using a free app for both iPhones and Android handsets. The main goal of the experience was to familiarize participants with the host city both *informally* and *voluntarily* and in a holistic manner. This case study specifically sought to answer how conference attendees perceived such an experience that leveraged augmented reality transmedia that uses layering, screen-reading applications such as Aurasma.

4.3 Broken Window: Transmedia experienced, transmedia designed

This game fostered undergraduate participation in an alternate reality game play and their own transmedia development in a computer applications course. The innovation was set into place to enhance students' critical thinking skills, immerse them into the learning, and allow them buy-in on the unfolding story which took place over the course of eight weeks where their TA mysteriously went missing and they had to assist in finding out where he was and how to help him return. In their search for clues, students traversed both the real near environment and a narrated environment. The narrated environment was rich with media: email, blogs, videos, websites, and the learning management system where both individual and collective thinking took place. Design considerations related to such a story-driven online-hybrid course curriculum will be shared.

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Online Instruction, eLearning, and Simulations in Prisons

A conceptual overview

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Abstract. As society has moved online, prison education has significantly lagged behind, hampering efforts to prepare released prisoners for work, education, and life outside a prison cell. Prisons have lacked the technology and educational programming to ready inmates for reintroduction into a digital society. This paper explores the benefits and challenges of eLearning in prisons and the role simulations could play in reducing recidivism and preparing released inmates for a technology-driven world.

Keywords: online instruction, prisons, educational technology, correctional institutions, simulations, computer simulation, correctional education

1 Introduction

Globally, more than 10.2 million people are in prison [1]. In 2014, there were an estimated 1,561,500 prisoners in the United States [2]. The goals of imprisonment are the seclusion and rehabilitation of those who have been convicted of a crime. Their seclusion ensures the safety of the public and their rehabilitation is intended to prevent further criminal activity. Men and women who are educated while incarcerated are 43% less likely to return to prison [3]. Education readies inmates for the workforce, prepares them for continued studies upon release, and facilitates their reintroduction into society. However, in terms of technology, the prison environment is vastly different from the rest of society and traditional prison education and job training are limited in their ability to prepare prisoners for life after release [4]. Technology can improve and expand prison education and better prepare inmates for the outside world.

2 The Benefits of Education in Prisons

Education benefits both inmates and society at large. Studies have shown that prisoners who receive education while incarcerated are much less likely to return to

prison [3], [5], [6]. According to a 2012 report, the total cost to taxpayers to imprison offenders in 40 of the 50 United States was \$39 billion [7]. It costs taxpayers anywhere from \$14,000-60,000 a year to imprison one offender in the United States [7]. In 2011, the average cost to imprison an individual in a U.S. federal facility was \$28,893.40 [8].

Education helps build inmates' social skills, collaborative skills, and time management skills. Taking classes builds routine and structure into inmates' daily schedules, keeps inmates from being idle, and reduces boredom. Education helps inmates form peer relationships with other motivated inmates. Prisoners engaged in education take on the identity of *student* in addition to their other identity as *offender* or *prisoner*. This student identity can help inmates to expand their horizons beyond their past mistakes and the prison walls [9]. A student identity also helps some prisoners to better integrate into society [10]. Incarcerated students report that their educational experiences provide more than academics; they teach social skills such as how to get along with people and how to work in groups; they build self-confidence; they foster study skills such as time management, task management, and prioritization; and classes provide structure and routine [11]. Student inmates have academic achievement rates comparable with regular non-imprisoned students and higher than other groups of disadvantaged students such as students with disabilities and those on financial aid [12].

3 The Benefits of eLearning and Technology in Prisons

Released prisoners face a world that demands technology literacy for everything from paying bills and maintaining a bank account to applying for jobs and staying socially connected to family, friends, and community support systems. Without technology skills, prisoners are significantly disadvantaged professionally and socially when trying to reintegrate into society [13]. Access to technology can facilitate prisoners':

- Communication and maintenance of relationships with family members
- Access to information about benefits, job opportunities, and housing
- Ability to create a resume
- Access to education
- Access to library eBooks to encourage reading and improve literacy

eLearning in prisons can expand what is offered beyond what each facility can provide physically within their walls in a face-to-face format. It can also expand the number of prisoners who receive education and training. eLearning can be used to differentiate content and create self-paced learning. Digital accounts such as course or degree progress and ePortfolios can follow prisoners when they transfer to another facility or are released [14]. Digital records can also facilitate and expand assessment of learning outcomes and programming, leading to the implementation of program improvements.

4 Simulations

Simulations are a logical choice for use in prison eLearning because they mimic real life events and activities. Simulations provide a way to teach to events that would not occur frequently in real life, or in the prison environment, events that never occur. For example, simulations could safely teach life skills, social skills, parenting skills, and job skills. Simulations are commonly used in subjects that might not be physically safe to accomplish without a simulation, for example in the fields of nuclear plant operation, pharmacy, and homeland security. Safety and security issues are a top priority in the prison environment. Because of this, there are subjects and tasks that could only be safely taught in prison through the use of simulations. Simulations can also be used to teach critical thinking skills and higher order reasoning skills [15], problem solving, and decision making, skills desirable in rehabilitated offenders.

Many incarcerated students have had negative experiences with schooling in the past and they associate school with failure which can limit both their interest in learning as well as their confidence as a student [16]. Some incarcerated students are intimidated by the vulnerability of making mistakes in a class environment [17]. Simulations allow for self-paced learning so students can study at their own pace and repeat exercises as many times as they choose to reach mastery. They create learning situations where students can practice skills in an emotionally non-threatening environment. Simulations also give early and usually immediate feedback providing useful formative assessment.

In some digital simulations, such as Second Life, a simulated environment allows for collaborative and social learning to take place. Communities of practice can be formed by working together [18]. In the prison environment, simulations can broaden and increase collaborative learning opportunities in a safe and secure way.

There are social and affective benefits of simulations and virtual reality that could be especially helpful for incarcerated individuals. Virtual simulations have been found to increase prosocial and altruistic behavior in individuals even after the simulated experiences have ended [19]. Further, the act of playing prosocial video games has been shown to increase empathy [20].

5 eLearning in Prisons

eLearning in prisons includes both blended learning and fully online experiences. Prisoners generally receive unique logins to use technology, allowing their individual activity to be monitored. Privileges can be determined individually and high risk inmates such as those that have been convicted of cybercrimes are routinely excluded.

Thin clients are frequently used to provide restricted access to servers permitting access to “whitelisted” sites which have been pre-screened and approved. This restricted access occurs in dedicated computer labs or classroom spaces and is combined with monitoring and surveillance. In many instances, a modified version of

a learning managements system (LMS), often Moodle, is utilized, such as in Australia, Belgium, Spain, Sweden, the UK, and the United States. Modification disables some features including access to live internet links. Communication with teachers and other students is usually disabled as well. Instead, messaging is sometimes facilitated via a secure relay system between student and teacher. In two Australian prisons, inmates have access to an intranet and can email approved contacts. Prison staff remotely monitor and control inmates' desktops and can push pop-up alerts and power desktops on or off.

eLearning in United States prisons generally falls into one of the three following categories: isolated local server, where content is stored on a local access network, requiring uploading of content that is only accessed offline; point-to-point secure line, where approved content is streamed online; and restricted internet connection, which uses routers and firewalls to deliver live content [6]. Ohio is a leader in using educational technology in prisons. They currently use Android tablets with the following modifications: a clear case, tamper resistant screws, disabled Wi-Fi, and modified ports, cords, and content delivery [6]. Students access websites via restricted Internet access. In one pilot, students used a combination of Canvas LMS, kiosks, and tablets. Content was pushed to kiosks where tablets were synced. Students completed work on the tablets, then submitted their work by syncing their tablets to the kiosks. IM chats relayed instructor feedback when students synced their tablets. The tablets also support PDFs, TXT files, html files, videos, photos, Microsoft Office Suite, and digital publishing.

The Oregon Youth Authority (OYA) has been a pioneer in bringing technology and eLearning into youth prisons. In partnership with the Oregon Department of Education (ODE) offerings include online tutorial programming, dual-credit courses, college courses, and access to MOOCs [21]. The OYA has pioneered a blended learning model that uses wireless servers with a Wi-Fi signal using RACHEL (remote area community hotspot for education and learning) to deliver simulated restricted Internet content. A computer installed with RACHEL can act as a server so nearby devices can access content through their web browsers. In Oregon youth facilities, educational staff use RACHEL to provide access to content such as Khan Academy Lite as well as instructors' own content loaded onto the servers. Those students who received access to eLearning have been shown to have greater achievements in reading and math than those who only had access to classrooms without eLearning [6].

Elsewhere in Oregon, simulated natural environments are currently being used to calm inmates in solitary confinement. At the Snake River Correctional Institution in Oregon, a "Blue Room" is used to project videos of nature onto a wall combined with sounds of nature or classical music. The project, Nature Imagery in Prisons Project, originated from an idea developed by biologist Nalini Nadkarni. In preliminary feedback from inmates, this simulated environment is soothing and calming [22]. Prison administrators have found that there are fewer disciplinary referrals among inmates exposed to the Blue Room [23] although research findings are pending publication. Informal observations indicate that the use of the Blue Room has also been found to reduce chaos and mental health crises [24] which is significant because

almost two-thirds of solitary confinement inmates at Snake River have moderate to severe mental health issues [22]. The program has expanded to other facilities in Oregon and Washington.

Other global leaders in prison eLearning include the University of Southern Queensland's *Making the Connection* program, the UK's Virtual Campus, and Norway.

6 Challenges

Delivering any kind of education in prisons presents challenges. Challenges of eLearning include prison priorities, security, access to technology, funding, staffing challenges, public opinion, and inmate isolation. Education is not a top priority in the prison system and consequently both funding and support are lacking. Maintaining security and order are the priorities for administration and staff and the charge to maintain secure prisons limits inmates' access to technology. For inmates, top priorities can include dealing with separation and isolation, detox, prison culture, and court appearances [25]. In prisons that have a prominent work culture administration's attitudes can be challenging if prisoners' work tasks are prioritized over their education [9].

eLearning equipment and staff costs limit the number of computers and the hours that computer labs are open in correctional facilities. Many facilities have outdated technology and require replacement equipment. Funding and staff costs are incurred to implement and maintain equipment and to monitor equipment use and student activity on computers [6]. Staff training is another cost. Other costs include software, licensing and copyright fees, and subscription fees. In an eReader trial conducted by researchers at the University of South Queensland, obtaining copyright and file conversion permissions was costly and in one instance incurred fees over \$3,000 [26]. File conversion is also time consuming and incurs additional staff costs.

The amount of work required to modify internet-based courses to non-internet eLearning cannot be overlooked as a significant challenge. Communication workarounds and restricted internet access can be intensive and time consuming work for IT and teaching staff. Finding teaching staff who are technology-literate and proficient at online and blended learning can also be challenging.

Public opinion affects what happens in prisons as well as who is imprisoned and for how long they are imprisoned. Views vary from country to country. In the United States and the UK, society leans more towards a punitive than rehabilitative view of imprisonment. Penal populism, "tough on crime" policies, and rising prison populations create a gap between those in prison and the rest of society [27]. David Scott has described this effect of rising penal populism as defining prisoners as "irredeemable outsiders" [28]. Society may lean towards thinking that increased access to technology makes prison life too comfortable for prisoners deserving of

punishment [5]. Similarly, eLearning also runs the risk of being at odds with views of victims' rights organizations.

eLearning works best when learners have support from teachers and/or tutors. Especially in prison, isolation is to be avoided [29,30]. Prisoners need at least the same amount of support that non-prison online students receive. Prisoners may need additional support if their computer skills are lacking or out-of-date or if they have a learning disability. Because prison is an isolating experience in and of itself, prisoners engaged in eLearning need to have contact with instructors or tutors, and in the best case scenarios, other motivated students. LMS discussion boards are generally not available to prisoners studying in an LMS modified for non-internet use in a prison.

Simulations have their own set of challenges in any environment in which they are deployed. Reality can never be entirely replicated. Some things in life cannot be predicted and then reproduced in a virtual environment. Some students may need more support than others and without sufficient guidance may feel overwhelmed [18]. Simulations need to very accurately imitate real situations. If they do not, the risk is that learners will not learn the task or skill correctly [31,32]. Users may need to invest time to figure out how to work a simulation, for example, maneuvering an avatar in Second Life. Like other forms of eLearning, simulations can be cost-prohibitive.

7 Discussion

If we look at imprisonment with an eye more towards rehabilitation than punishment, education is an undeniable factor in rehabilitation and reduction of recidivism. If rehabilitation seeks to support successful reintroduction post-release which in turn can deter future criminal activity, individuals in prison need greater access to technology, technology literacy instruction, eLearning, and simulated environments. While security is a top priority, it should be noted that security breaches occur in prisons without any use of technology. At the present time there is no evidence that the use of technology in prisons has increased security breaches.

Corrections technologies such as modified eLearning also have the potential to expand education in areas of the world where internet access is limited, restricted, or unavailable. Offline workarounds can benefit more than just prisoners; they can allow some students who would otherwise need to leave their communities to pursue education to stay and support their communities physically and financially. In this way, innovations for prisons can benefit communities outside of the prison system worldwide.

Peter Scharff Smith [13] raises an interesting question about internet access in prisons. As we have entered an age whereby an individual can conduct most of their life online, from professional to social activities, if a digitally-driven person like this is imprisoned with internet access, would there be much difference from their regular life? Smith suggests that perhaps our entire view of imprisonment might need to be reevaluated in light of this hypothetical situation. On the other hand, lack of access to

technology that is commonplace for communication and management of everyday tasks outside of prisons widens an already existing chasm for prisoners while they are incarcerated and after they are released. As a society, we must address whether that profound difference is wanted or needed, and whether it benefits society as a whole. If the intention is to rehabilitate offenders into individuals who can merge with society, Smith argues that the chasm between prison life and non-prison life be constantly identified [27]. At the least, our views about punishment and rehabilitation require a vigilant examination and the use of technology in prisons needs to be a part of that examination.

8 Conclusion

With a world prison population at more than 10 million and the steep costs to taxpayers and governments to house inmates, it makes sense to rehabilitate and release offenders whenever possible. Despite many challenges, in prisons around the world various workarounds are being piloted to provide access to technology in a secure and safe way. With security measures in place, simulations, eLearning, and online instruction can expand rehabilitation, training, and educational opportunities. If successful, this expansion has the potential to prepare inmates for re-introduction into society, reduce recidivism, and lower the overall costs to society of crime and incarceration.

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CORRIGENDA

The following corrections should be made in a recent paper published in these proceedings, page 18. The table appearing on pages 26-29 which provides a list of requirement categories, requirements and sub-requirements has been replaced with an updated version of the table required by reviewers.

The following corrections should be made in a recent paper published in these proceedings, page 47. The paper appearing on pages 47-48 has been replaced by an updated version of the paper.