

BLENDING LEARNING: REAL EXPERIENCES WITH VIRTUAL WORLDS

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Abstract

Increasingly the lines are being blurred between traditional face-to-face and online learning. With new technologies, we are increasingly able to provide pertinent interactive experiences that mimic the authenticity of real-world skills and experiences. This paper will review the options for creating in virtual worlds that offer a space in which a range of spatial and social phenomena may be simulated. In them students have been engaged in rich narratives that encourage students to engage in socio-scientific inquiry to solve problems. These worlds provide complex simulations that offer students opportunities to behave like scientists, designers and other professionals within a safe environment. However, it may be argued there is an opportunity available in creating virtual worlds that is being under-utilised in the case projects: the potential for students to actively design and construct their own artefacts within the virtual world. Options exploring Web 2.0 tools provide greater interactivity and enable blending of worlds in unique ways. Student design and construction of artefacts within the virtual world enables students to go beyond the pre-designed narrative, providing more open-ended activities through which students demonstrate their creativity and higher-order thinking.

Introduction

Higher education faces a number of pressures today that online learning may be able to help address. The economy is increasingly driven by knowledge and technology continues to evolve. At the same time, people are becoming more mobile while demanding lifelong learning to meet their educational needs. All of these pressures are coming to bear on academe, and universities are deciding whether and how to respond. (Hill, 2010)

Blended learning has been on the higher education agenda for several years. The pressure to address increased student enrolments in higher education, work with Business models of higher education, the decline in academic staff numbers, and different ways of creating links between learning contexts and learners have all caused reluctant academics to explore different pedagogical strategies to keep the students. In the United States over the past 30 years the proportion of state funding for higher educational institutions has diminished by more than 33% leaving the institutions to cover the shortfall in new and entrepreneurial ways (Tandberg, 2008).

Expanding Lee Schulman's earlier work, Mishra and Koehler (2006) have suggested that effective use of technologies in learning contexts requires an understanding of how the disciplines must be learned and what technologies best support the process. This recognition has begun to move the rather simplistic instructional design model into a world where authenticity and what passes for evidence within the discipline are actively included in the design of learning tasks. Early examples of this blended learning shift have been described in Lefoe and Hedberg (2006) where individual cases supported several design maxims such as the dependence on student driven learning strategies and the need to understand expectations of the roles of teacher and student in a communication context, where blending may require that students take a communication initiative (to evaluate and to question) and even show initiative (to judge and interpret) when the clarity of the task is not clearly understood. But most important is an understanding of the affordances of the technology and how they underpin the pedagogy appropriate to the discipline.

Enhancing Social Interaction

Web 2.0 was a term coined by Tim O'Reilly five years ago when he was trying to identify the shift in affordances of Internet applications; attributes that provide greater interactivity; and that supported a range of visual representations through which like-minded users might contribute to knowledge construction. These tools provide possibilities of shared construction of meaning; new ways of

representing ideas through visual and dynamic interactions; and multiple ways of communicating ideas to others. Both teacher and student have the means to convert between the forms that are used to represent an idea (Lee & McLoughlin, 2011).

Transduction, between the represented and its re-presentation, ensures that a text-based concept can be visually or digitally represented and hence require less description and less cognitive effort for interpretation. A range of new web-based tools support the visualization of ideas and how they might be displayed dynamically in new forms such as digital video. In the early days of educational computing, the tools used to create different representations were often drawn from integrated office application software.

The advent of annotation tools that 'float over' web pages or sites has enabled the creator to keep the original content pristine while enabling others to add to and comment upon it. Annotation enables a social component to knowledge construction and it is not constrained to text, as it may also include aural and visual media forms. With social construction we are no longer reliant on a single author, yet we can still retrieve the details of who has contributed to each element of the shared artefact. Wikis, for instance, typically provide a history to tell the story of how the current presentation came to be constructed and displayed as they report who, what and when of contribution.

In many blended contexts, teachers and students are linked in a wide variety of new geographical relationships. Included amongst these relationships is the need to review the role of mobility and tools that support the development of students' voices. Shared spaces such as cloud computing and 3D environments provide a new set of affordances. Each exploration challenges us to manage a world where learning is not constrained by representations, by the location of information, nor by the method of its manipulation.

Learning activities and virtual worlds

Virtual worlds offer unique opportunities for authentic learning contexts, they offer a space in which a range of social phenomena may be simulated and represented by dynamic characters within a variety of conceptual contexts. The blend ensures learners can explore concepts and ideas in safe and scaffolded learning contexts that in turn, provide experiences to inform everyday practice.

The context has been described as 'a simplified and contrived situation that contains enough verisimilitude, or illusion of reality, to induce real world-like responses by those participating in the exercise' (Keys & Wolfe, 1990, p. 308). An important learning goal of virtual world contexts is to provide learners with an experience that can be transferred to activities that occur outside that world. It is also possible to explore assessment challenges in which the learner is not just recalling understandings and prior learning but is required to make choices and choose a course of action and commit to achieve an end goal (Cram & Hedberg, 2011).

Real-world contexts require flexible, non-linear narratives with uncertain outcomes. Virtual worlds can require learners to make choices through active decision-making, and provide a diverse set of opportunities for engagement with different parts of the virtual learning activity, attending to either linear or non-linear narratives. The value of virtual world interactions lies in the adaptability of focus in relation to real world contexts; while events and applications in the real world are sequenced in their eventuation, the virtual world may hold, accentuate, alter and fragment the actuality of any sequence and its parts. The implication for learning is in both the creative (imagination) and the practical (factual) focus and their cyclic and situated translocation between real and virtual world, in any number and combination of iterations to cultivate selected knowledge, skills and expertise. The verisimilitude of the context will partly determine how closely the learning experience generates similar experiences outside the virtual world to the achievement of goals and impacts both the choice of representation and how learners interact with objects.

Characteristics of the Virtual world

Several researchers have pointed to strategies for learning design by describing how the affordances of virtual worlds can be used to benefit learners. These include: extended or rich interactions, visualisation and contextualisation, authentic content and culture, identity play, immersion, simulation, community presence, and content production (Warburton, 2009) and spatial knowledge representation, experiential learning, engagement, contextual learning and collaborative learning (Dalgarno & Lee, 2010). In a similar fashion, Bell, Kanar and Kozlowski (2008, p. 9) describe how

certain features of technology-based learning contexts, relating to content, immersion, interactivity and communication, produce potential learning benefits including the enablement of emotional arousal, knowledge integration, real-time interactions and use of characters and agents.

Cram and Hedberg (2011) sought to extend understanding of the activities that include not only the features and affordances of the technology but also to suggest strategies that will help learners meaningfully interpret the objects and events in the simulated world. The elements that can be modified to achieve learning outcomes are:

- 1) *Representational opportunities*. While Schultze, Hiltz, Nardi, Rennecker and Stucky (2008) argue that the key affordances of virtual worlds relate to presence, placement, perspective and place. It is also possible to explore learning challenges that embody the elements of space, time, place (or particular context) and representations of the learners themselves (their avatars).
- 2) *Strategies for meaningful interpretations* are ways of structuring activities and choices within the world that enable users to progress through the world and interact with it. The strategies make use of the representational opportunities, as well as interactional opportunities between the user, the virtual world and other users. Three narrative strategies may be intertwined to structure the learning trajectory.
 - a) *Exploratory narratives* where learners are given or create tasks that guide their trajectory;
 - b) *Role play narratives* where learners assume roles, take positions and perspectives, and interpret the situations they encounter from their character's point of view;
 - c) *Design narratives* where learners use the simulation to design an artefact, usually in collaboration.
- 3) *Supportive modifiers* can be applied to combinations of the representational opportunities and the strategies for meaningful interpretation to modulate the learning trajectory of users. Modifiers can change the expectations and the progress of individual learners in terms of how they progress through their learning trajectory but also what they are expected to contribute and with whom. Varying the modifiers allows educators to provide appropriate guidance and support for individual learners. Thus in terms of design we can tweak:
 - a) *Types of goal* to refocus the range of options to include multiple solutions, one 'correct' solution, or a solution dependent on personal values;
 - b) *Game elements* to build extrinsic motivational goals, by rewarding certain forms of activity to encourage particular learner behaviour;
 - c) *Scaffolding* to suggest processes or specific information provides learners with a conceptual framework that offers a structure for the learners' understandings and actions;
 - d) *Collaborative options* to suggest the importance of other users and their skill sets or interests to jointly achieve a goal;
 - e) *Expectations of user contribution* for a rule set to govern interactions within the simulation to significantly impact opportunities for user contribution. Allowing learners to design elements of the virtual world provides further opportunities to form meaningful interpretations.
- 4) *Learner experience* is modulated by the choices made within three areas of design options: representational opportunities, strategies for meaningful interpretations, and supportive modifiers. A successful outcome is achieved when the elements of space, time, place and user representation are combined with strategies that in effect define the types of possible interactions available to the user. This in essence is experienced through the learning outcomes, the identity that the learner forms, and the degree of intrinsic motivation and engagement that supports their focus on the end goals (Barab, Dodge, Thomas, Jackson, & Tuzun, 2007; Clarke & Dede, 2005).

Student-constructed artworks

The conceptualisation of the virtual world experience and its influence on the real world outcome for each learner is demonstrated in the following case. An analysis of the virtual world based on the conceptual framework is presented in Table 1, alongside both a description of the design elements of the virtual world, and the transfer of engagement from the virtual world tasks to real world tasks (Cram, Hedberg, Lumkin, & Eade, 2010).

Table 1: Description of the Student-Constructed Artwork Project

Representational opportunities		Strategies for meaningful interpretation	
<i>Space</i>	The 3-dimensional representations of the virtual objects are critical for learners' development of spatial awareness. The spaces created had specific spatial relationships that had to be considered by the learners.	<i>Design narrative</i>	Students are challenged to design virtual objects in response to certain criteria, encouraging them to develop interpretations relating to spatial awareness. However, the learners may also explore the space to inspect a number of pre-constructed artworks.
<i>Time</i>	Learners may view their artworks from multiple perspectives and stages of development. Although no learners did so, it is possible to design dynamically changing artworks.		
<i>Place</i>	The virtual world did not attempt to simulate the cultural meanings of the sites. Instead, learners have access to the actual sites within their school.		
<i>Avatars</i>	The embodied presence of the avatars is significant to developing an understanding of spatial awareness. However, the representation of the avatars was not meaningfully related to the activities.		
Supportive modifiers			
<i>Type of goals</i>	Design briefs are provided to students, who need to generate and implement their own creative ideas. Thus, although each student has the same objectives, the final solution is dependent on the learner's personal interests and ideas.		
<i>Game elements</i>	None.		
<i>Scaffolding</i>	Scaffolding within the simulation is achieved through the progression of activities from highly structured, well supported tasks through to tasks with less structure and support which require more creativity and spatial awareness from the learner. Additional scaffolding is provided outside the simulation, through visits to an art gallery, feedback from reports and classroom discussions.		
<i>Collaborative options</i>	While the learners form groups to collaborate on ideas for the final site-specific artwork, each learner is required to model and refine their own personal ideas for this artwork. In some groups, each learner modelled very different design ideas, while in other groups all the learners used a central, group-agreed idea to guide their design. Learners are also able to easily see the designs of other students, to compare and contrast different design ideas and uses of the virtual world tools.		
<i>User contribution</i>	Learners are expected to provide their own artwork ideas, and construct their own artworks.		

The *Student-Constructed Artworks* scenario provided year 9 fine art students with a supportive and easily manipulated environment to develop understandings of spatial awareness, and then to model their ideas for a site-specific artwork. Traditionally, the exercise would entail making model sculptures but the virtual world included replications of the physical spaces in which the site-specific artworks would be eventually constructed, and thus enabled learners to test and refine their ideas in a space that is verisimilar to the physical location. Through this process, the learners experience what it is like to be an artist, and gain a vocabulary, conceptual understandings and skills that can assist their artistic efforts.

Learners start by completing three developmental activities within the virtual world. Activities are aimed at orienting learners within the virtual environment while cultivating skills in using the virtual world construction tools. A third activity introduces learners to concepts of spatial awareness, encouraging learners to consider how to use different forms to generate relationships between an artwork (*positive space*) and the surrounding space (*negative space*).

The fourth activity is more blended, with students initially conducting a photographic survey of the physical design site, developing initial ideas within their Visual Arts Process Diary, testing and refining their ideas within the virtual world simulation space, and finally physically constructing their artworks within the installation site. Due to restrictions in the number of available sites and the requirements of building a significant physical artwork, the final physical artwork was constructed in groups of two to four learners. Each learner develops their own design ideas, which may be subsequently integrated within the final physical artwork.

An evaluation of the Student-Constructed Artwork context was completed with 15 Year 9 students over 10 weeks. All learners successfully completed the activities, and participated in the construction of a group artwork at a selected site within their school. The simulation both supported the learners' development of spatial awareness and provided an efficient tool to model design ideas. Although the first two activities were intended as opportunities for students to develop virtual object construction skills, the representation of learners as avatars within the virtual world prompted consideration of the relationship of person and artwork. For example, when designing the sculpture, one student noted that 'avatars can fly through' a hole in the middle of the sculpture.

Students had an opportunity to focus on the development of their spatial awareness. Each student was given an identical virtual space (Figure 1), which contained relatively basic spatial elements. Figure 2 shows one learner's design, demonstrating an effective resolution of the design space through use of lines, colours and repetition.

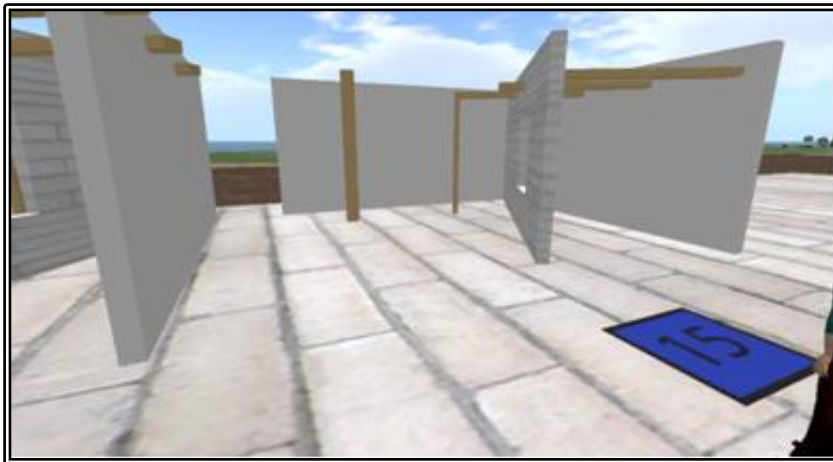


Figure 1. The virtual world space

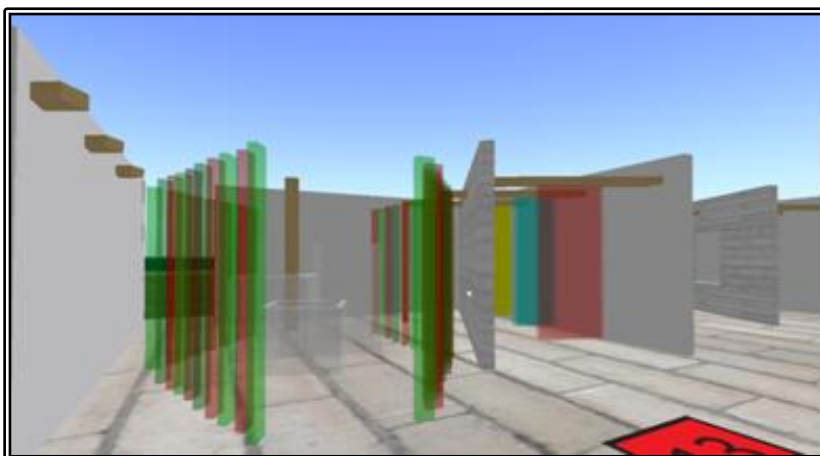


Figure 2. One student's design response

Figure 3 shows one student's design process in – from initial idea, to virtual model, to physical construction within the actual site within the school. The progression of the idea can be seen through the different design forms. Initially, the idea is represented using a black and white sketch. Even at this early design stage, the learner is approaching the artwork design as an artist would, considering both the audience and the environment. Audience participation is to be encouraged by allowing viewers to add new pieces of origami to the artwork. The environment is considered by using the coloured paper to contrast with the colour of the tree. Based on the initial design idea, the learner was able to explore different ways that this idea may be executed by modelling the idea within the virtual world.

After completing their virtual models, the learners worked in groups of two to four to construct the physical site-specific artworks. The physical construction of the artwork was very similar to the virtual model, with some additional elements that were drawn from models of the other learners. Not all learners were able to contribute their virtual model ideas to the final physical artwork. Some of the learners' virtual models could not be physically constructed, partly because the learners were not aware of which physical materials would be available to construct their models.

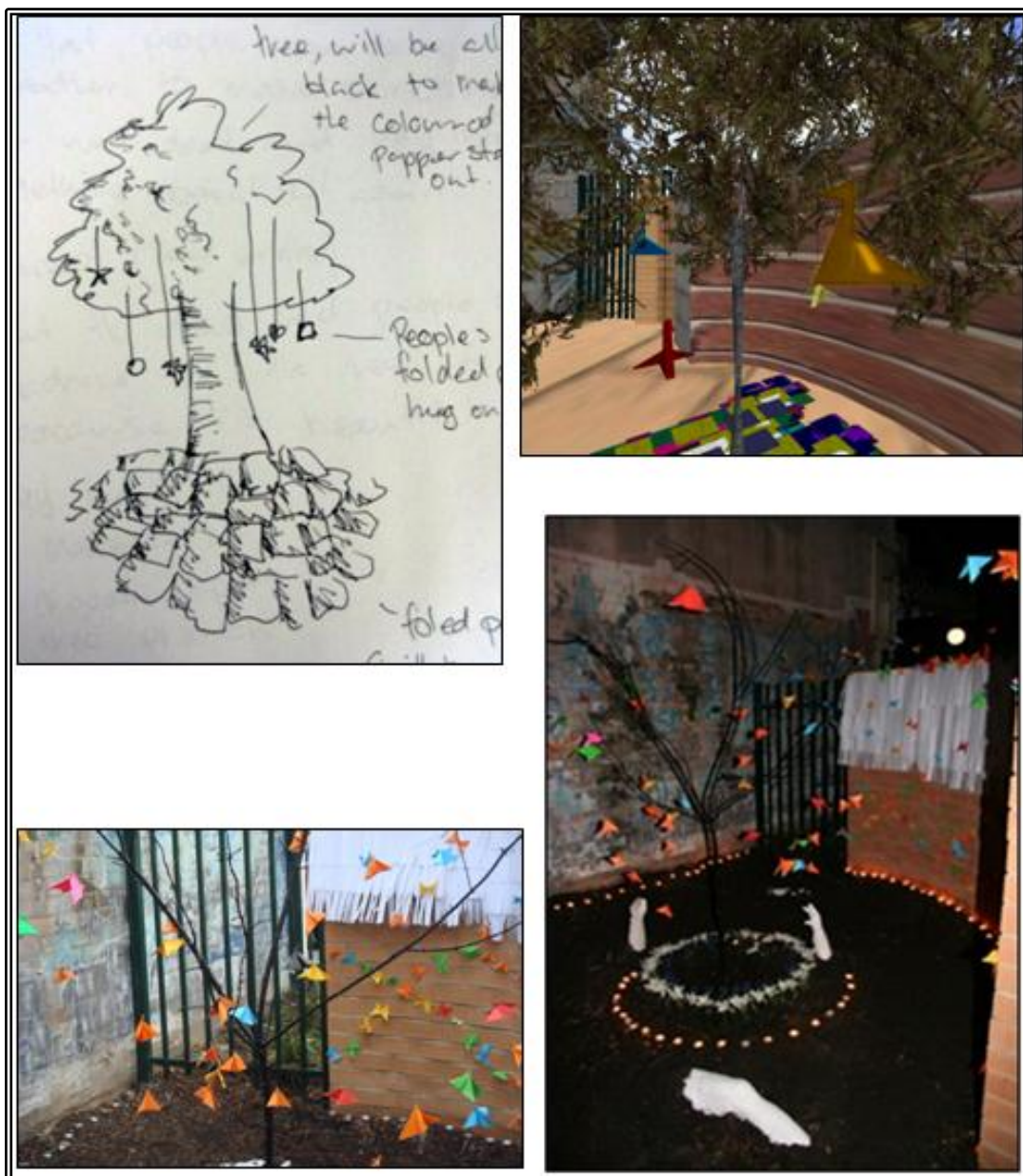


Figure 3. One student's process for artwork design. Clockwise from top left: initial sketch of idea, virtual model of idea, physical artwork at night and the physical artwork during the day.

The virtual world construction tools were particularly suited to allowing learners to efficiently test and refine their artwork ideas. The learners reported that modelling and refining their ideas within the virtual world assisted them to improve their artworks, by identifying the forms, colours and feel of the artwork that would work within that space. Through this process, the learners came to appreciate how to apply spatial awareness to develop site-specific artworks.

Students were highly motivated throughout the study. When asked, the students reported the sources of their motivation as learning about artworks and mastering virtual construction skills, avatar customisation, play and exploration of the space and technological capabilities, the opportunity for creativity, and socialisation.

Mobility and meaningful learning contexts

Blending learning also occurs with the combination of mobile learning and spatially-linked learning sequences. Effective use of mobile technologies enables a seamless connection between learning environments where both teacher and students can access a wide range of activities and resources as well as their own materials to support learning across time and place. The broad aspirations held for high quality learning and teaching are based on the application of social-constructivist perspectives. The nature and role of learning in the field demonstrates the use of mobile technologies to support student learning and the pedagogical principles associated with this pedagogy.

Spatially-linked pedagogy can be viewed from three related aspects: the activities designed for the event, the artefacts produced as a result of the event and the assessment strategies for the event. In addition, it is possible to consider how learning can be scaffolded in particular contexts, where traditional instruction becomes unwieldy and inadequate. The wider context necessitates further considerations of issues such as the appropriate placement of spatial experiences within a learning sequence, and the administration and management of field activities.

Study of the research into mobile pedagogies reveals scant detail of the activities designed for learning in the field. Broad categories of activities are identified and these include: field identification of plants and animals; observation using the senses; development of fieldwork skills such as sketching, data collection; development of team work skills; problem solving activities (e.g. Baumgartner & Zabin, 2008; Chew, 2008; Cook, 2008).

The activities for a real-world based learning event can be conceptualised by considering the ways in which the particular group of students can achieve a set of learning outcomes and experiences envisaged for the field work. Articulating the purpose for the spatial learning context serves as a lens to focus the teaching and learning activities students will encounter and experience during the event. Clear learning outcomes also inform the nature of assessment that can be used to determine of students have achieved these outcomes. With each different pedagogical requirement teachers can select those technologies and the affordances they provide to support and enable particular learning activities (Bower 2008).

Pedagogical decisions involved in designing learning activities for mobile contexts often include:

- positioning field work within the teaching sequence of the topic being studied,
- the content and structure of the day's activities,
- selection of appropriate technologies to support student activities,
- organisation of student groups and student roles within the group.

The following example explores the pedagogical decisions made in these four areas. It appears that each mobile device has its own set of pedagogical issues that can be identified within the context of its selection for use.

Baumgartner and Zabin (2008) stress the importance of producing 'significant and useful artefacts' (p108) as part of processes involving mobile learning activities. To record the processes of the

experience, modern technology provides many options including high quality digital photographs, graphs, tables and charts.

Traditionally a teacher-designed paper worksheet completed by students during fieldwork served as the record of the event. The nature and effectiveness of this record can be greatly enhanced with the use of mobile technologies (Stewart, Thompson, Hedberg & Wong, 2009). Students are able to access permanent high quality representations of their experience captured as they are engaged in the moment. These data and image artefacts can then be used as part of larger, richer tasks associated with the topic itself. Technologies and their associated pedagogical scaffolds can be employed to ensure effective completion of the fieldwork tasks and activities. The scaffold may take the form of a teacher or student created artefact saved on a hand-held computer or a web-based activity sequence accessed in the field. Pedagogical decisions about the nature of the artefacts of fieldwork include:

- determining the nature and extent of *scaffolding* required for students to achieve the learning outcomes of the field work events in the context of the wider outcomes of the unit,
- determining the *nature of the product/record* of field work, and
- selection of *appropriate technologies to underpin the production of the field record* and those that document the learning trajectory.

There is always tension between the need to provide all step-by-step instructions and support, and the desire to allow a completely student-designed solution. The designer's concern is to ensure that the learning activity is not wasted time or overly prescriptive circumscribing alternate processes or sequences. The choice of the wrong artefact might lead in turn to the loss of data or the loss of the place at which it was collected thereby limiting its use in some tasks.

There is a close relationship between learning outcomes, the artefact and the final assessment. The desire is to ensure that assessment task is not trivialised to be simply a completed worksheet, but at the same time to capture process and product, strategy and solution. The choice of appropriate activity, artefacts and technology will resolve many of the assessment challenges, as the cases which follow illustrate. Several principles can help to guide the choices to be made by the learning designer, such as:

- Technology stamping of place and time.
- Using tools that capture the message or piece of data every time they are collected reducing the risk of loss of evidence
- Assessment strategies to capture evidence in visual, textual, numerical and temporal modes,
- Assessment processes that demonstrate the sequences of solution and the choice of elements in the final solution.

Mobile Learning Example: Real-time debates using spatial data

The learning task in this example required students to adopt, collect evidence, and defend non-congruent social perspectives about land use in the same neighbourhood. Teams of students explored a bounded area, looking for sources of evidence that they could use to support non-congruent points of view. They recorded these pieces of evidence pictorially, again using mobile phones, and exchanged these pictures and texts in real time while still in the field, but physically separated from each other. By analysing the pictorial exchange, the researchers were able to identify which particular aspects of their local environments the students perceived to be relevant to the given geographical themes.

Johnson and Johnson (1979) have suggested that *Structured Academic Controversies* can be employed to stimulate intellectual conflict by designing a highly structured learning task where one student's ideas, information, conclusions, theories, and opinions are incompatible with those of another. The different perspectives can then be used as the basis of a dialogue through which the positions are potentially reconciled. In fact they suggest the proponents seek to reach a consensual agreement by engaging in Aristotelian 'deliberate discourse' (Johnson, Johnson and Smith, 1997).

Garrison and Anderson (2003) suggest that learning facilitated online through network technologies can result in a 'community of inquiry' and the need to resolve multiple and differing perspectives can encourage higher-order learning.

The task in this case required students to adopt and defend non-congruent social perspectives about the same neighbourhood. Teams of students explored a bounded area, looking for pieces of evidence that they could use to support non-congruent points-of-view. They recorded these pieces of evidence pictorially, using mobile phones, and exchanged these pictures in real time while still in the field, but physically separated from each other. Students used the evidence to explore given geographical issues within the bounded area. As the students sought evidence for their task and their potential solution, they started piecing together quite complex text and images to support it.

In a similar way the students can collect evidence and submit it in real time. In this case each team had supporters back in the classroom, who collated the evidence as it was collected. By comparing one group's evidence against another it was possible to send out for additional evidence if there were omissions while the team was out in the field.

By analyzing the pictorial and text exchange, it is possible to identify which particular aspects of the local environments the students perceived to be relevant to the given geographic challenge of land use and planning. Current mobile phones also attach the geo-spatial position at which the image was taken automatically enabling a reference link between the evidence and its positional source. Analyses of the results enabled the extent of the assumed contribution of multimedia-messaging to students' powers of observation, cognitive mapping abilities and appreciation of multiple points-of-view to be determined.

Messages were collected at all stages of the learning task, the exploration for evidence, the integration of evidence and the resolution of position phases. The unit of transcript analysis is blurred when applied to the analysis of text-messages as they are limited to 160 alphanumeric characters and most were even shorter.

An analysis of the messages sent during the learning tasks showed that of a total of 806 messages, 60% were sent during what Garrison, Anderson and Archer (2000) term the exploration phase. For the integration phase, 30% messages were sent, and for the resolution phase, 10% of the messages were sent. It would appear therefore that the application of the controversy in the context of a mobile learning environment does result in a worthwhile outcome for the students, as they collect real-world evidence and seek to support their position.

CONCLUSION

The two examples of blending described in this paper are the tip of the proverbial iceberg. They have been chosen to illustrate where e-learning contexts might next explore to ensure that elements such as authentic contexts, real-world processes and scaffolded learning sequences that are embedded in the context. The design framework and its use in the development of virtual world contexts has shown that it is possible to ensure that simulations in a virtual world can be constructed to generate real world learning outcomes. In comparison to many learning designs, the effective employment of the virtual world can scaffold the skill set of the learners to create differential performance in complex real world scenarios. The cases chosen each contained very open elements that required learners to progress through judgment and intentional choices, thus facilitating higher order learning outcomes. The cases also illustrate that creative outcomes are achievable in inquiry-based learning that relies on the technologies for support and evidence, the assessment of actions and in the use of the space to develop not only a creative product but more importantly an understanding of the artistic object and the participant.

In each example, the links between the virtual experience and the user's ability to apply the learned understandings within the real world have shown that negotiated tasks within a virtual context that can be extrapolated into the real world. These examples all point to valuable outcomes for learning because students gained the knowledge, skills and expertise of how complex tasks can be undertaken in the real world. This in itself contributes to a literature that is limited at this point.

In the effort to attain authentic learning environments, the particular strength of virtual worlds is that they can support real-world transfer through the use of verisimilar assessment activities. In particular, they enable learner-generated scenarios while generating real world emotions about the relationship between the learner and the other people within the situation.

The *Student Constructed Artworks* example supports planning as a function of learning complex tasks in a simulated site that mimics the real world but enables the user to construct and explore a variety of design responses more efficiently than concrete materials would allow. The adaptability of design alternatives facilitates experimentation with alternate plans and provides immediate feedback on their success and failure to accentuate learning; *in situ* decision making establishes a logic of justified design in parallel with decision making associated with creating, evaluating and judging. Although the time to learn the tools is not insubstantial, the gains in design refinement once mastered still result in more extensive exploration than other learners using real world models. Where such approaches are adopted in subsequent study, the designs may be reused for different cohorts and the skills may be re-used in other programs. The emergence of additional learning outcomes and knowledge artefacts, such as the dimensionality and the ability to squeeze through gaps in the sculpture that produced unexpected gains for the students' development of spatial awareness, suggest the generative nature of blending to learning designs. Where real-world learning follows a logic of learning that is linear and at best based on problem-solving for set aims, blending proposes serendipitous learning that is catalysed by the learner and richly contextualised by the set task. The overall implication of the generative learning setting proposed by the finding is that a personalised discovery is able to spontaneously channel learning toward additional and required learning outcomes because its setting is one of creating, evaluating and judging planning in design decisions. The implication to learning indicates that learning outcomes are somewhat co-constructed by learners in generative learning settings that potentially merit greater fluidity in assessment practice, such as the teacher-student approach suggested in the case of assessment portfolio by Biggs and Tang (1997).

Explorations of further opportunities for blending are currently underway at several research sites. Overall, the challenge is always the alignment of learning outcomes to activities that can be supported by virtual worlds; secondary challenges include supporting students to master the construction tools in reasonable time, as well as providing sufficient support to allow students to manage the complexity involved in designing and constructing solutions to challenging problems.

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