

Exploring the relationship between afforded learning tasks and learning benefits in 3D virtual learning environments

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In this paper, we build on our previously proposed model of learning in three-dimensional virtual learning environments (3D VLEs) (Dalgarno & Lee, 2010) by exploring the relationship between learning tasks that are afforded by such environments and learning benefits that arise from their use. We draw on data from a questionnaire in which 53 of the 117 higher education respondents described how they used 3D VLEs with their students and indicated the degree to which they believed each of the five potential learning benefits occurred. The results provide strong support for the idea that each of the benefits occurred, but suggest the links between learning tasks and learning benefits are, at this stage, unclear. We postulate some of the possible reasons for these findings and make recommendations for further research, discussing some of the challenges involved in designing studies that seek to relate afforded learning tasks to learning benefits through measurement of actual learning outcomes.

Keywords: 3D virtual learning environments (3D VLEs), virtual worlds, affordances, learning tasks, learning design, learning benefits, educator perceptions

Introduction

In an article published in the *British Journal of Educational Technology* (BJET) (Dalgarno & Lee, 2010), we systematically reviewed published research on three-dimensional virtual learning environments (3D VLEs) from the past 20 years and carried out a theoretical analysis based on that body of research, with the goal of identifying a set of unique characteristics of 3D VLEs as well as a series of learning benefits arising from tasks afforded by such environments. The results of that analysis led us to propose a model of learning in 3D VLEs (see Figure 1). The model includes 10 distinguishing characteristics of 3D VLEs, the first six of which relate to aspects of the representational fidelity of 3D VLEs, and the remaining four of which relate to the aspects of the learner–computer interactivity these environments are able to facilitate. We argue that the 10 environmental characteristics give rise to three characteristics associated with the experience of using or ‘being in’ the virtual environment (construction of identity, sense of presence and co-presence), and that the environmental and experiential characteristics, either together or individually, then afford various types of learning task, which in turn lead to a set of five potential learning benefits that are believed to accrue from the performance of those tasks. We conclude the BJET article by pointing to the dearth of empirical insight available about the precise nature of the relationships between each of the environmental and experiential characteristics of 3D VLEs, the types of learning task they afford, and their potential learning benefits. The focus of this paper is on the relationship between the afforded learning tasks and learning benefits, from the perspective of higher educators who have used 3D VLEs in their teaching.

Background and related work

Over the years, attempts have been made by a number of authors to classify or taxonomise applications and learning activities/designs in the area of 3D VLEs, and there has been substantial recent interest in such efforts, spurred by the advent and growth of the current generation of massively multiuser 3D virtual worlds such as *Second Life*. For example, Ryan (2008a, 2008b) outlines 16 pedagogical approaches or ‘ways’ of using *Second Life* and other virtual worlds as educational tools, supported by a range of different datasets including but not limited to survey responses, formal interview transcripts and notes from meetings and informal conversations, as well as her own personal observations, reflections and ethnographic journal entries. Some of the ‘ways’ Ryan suggests of using the technology are ‘to add a visual element’, ‘to house an interactive library or collection of learning objects’, ‘as a connection device (i.e. for communication)’, ‘as a role-playing device’, ‘as a simulation device’, ‘to facilitate games for learning’, ‘to conduct virtual tourism and field trips’, ‘for machinima creation’ and ‘for building “for the sake of learning how to build”’. A similar list is presented by Kay and FitzGerald

(2008), although the method and approach they followed to arrive at the list is largely unclear. Their list comprises categories of educational activity in *Second Life* including but not limited to the following: ‘self-paced tutorials’, ‘displays and exhibits’, ‘role-plays and simulation’, ‘data visualisations and simulations’, ‘historical recreations and re-enactments’, ‘machinima construction’ and ‘treasure hunts and quests’. Both Ryan’s ‘ways’ of using *Second Life* and Kay and FitzGerald’s types of educational activity in *Second Life* bear likeness on a number of fronts to the ‘educational activities’ dimension of the taxonomy developed by Jiang (2008) as an outcome of his analysis of virtual worlds in higher education. This dimension is one of six dimensions in Jiang’s taxonomy, which he used to classify the literature reviewed for his Masters research and also as a framework for discussing institutional case studies of the use of the technology in three UK universities. The categories in this dimension are ‘virtual quests’, ‘collaborative simulation’, ‘collaborative construction’, ‘virtual laboratory’, ‘virtual fieldwork’, ‘role-play’, ‘game-based learning’ and ‘attending lectures/classes’. Hew and Cheung’s (2010) international meta-analysis of studies reporting on 3D VLE use in K-12 and higher education culminated in the identification of three much broader categories describing the main purposes for their use: as communication spaces, for simulation of space (spatial) and as experiential spaces (‘acting’ on the world).

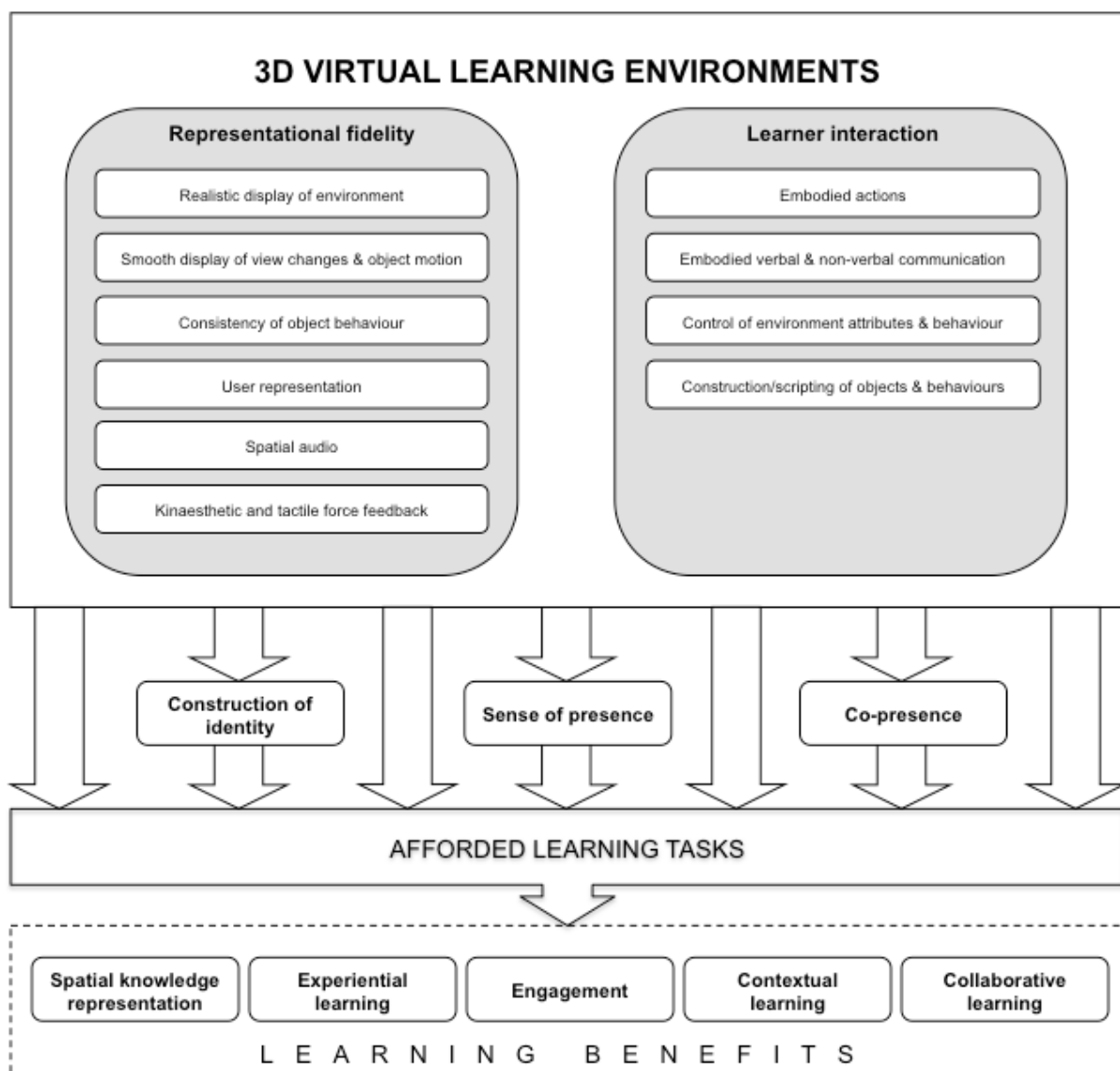


Figure 1: A model of learning in 3D VLEs (Dalgarno & Lee, 2010)

While evidence of the actual learning benefits brought about by the use of 3D VLEs is sparse (Dalgarno & Lee, 2010; Lee & Wong, 2008; McLellan, 2004; Mikropoulos & Natsis, 2011), much has been written in recent years about the possible and purported benefits, fuelled again by the burgeoning interest of educators in the current generation of 3D virtual world platforms. One approach to understanding the benefits of learning technologies is

to consider their use from an affordance (Gibson, 1979, Norman, 1988) perspective. In the most basic terms, an affordance of a tool is an action made possible by the availability of that tool. Hollins and Robbins (2008), for instance, discuss five broad educational affordances of virtual worlds – ‘identity’, ‘space’, ‘activity’, ‘tools’ and ‘community’ – drawing on their observations and data collected through their experiences as tutors, researchers, long-term residents of *Second Life* and players of other massively multiplayer online role-playing games (MMPORPGs). Warburton and Pérez García (2009), in their review of educational uses of virtual worlds focusing particularly on *Second Life*, characterise the main educational affordances of *Second Life* as being the creation of opportunities for ‘extended or rich interactions’ between individuals and communities, between individuals and artefacts, and among intelligent artefacts; ‘visualisation and contextualisation’ through the production and reproduction of otherwise inaccessible content; exposure of learners to ‘authentic content and culture’; ‘individual and collective identity play’; ‘immersion’ in the virtual environment; ‘simulation’ of contexts that may be prohibitively expensive, impractical or impossible to reproduce in real life; ‘community presence’ in the way of promoting a sense of belonging and purpose; and ‘content production’ opportunities enabling the creation and ownership of the learning environment and objects within it. Lastly, Lim (2009) derived a framework that he dubbed the ‘Six Learnings of *Second Life*’, based on his own experiences and reflections of using *Second Life* in his teaching and research. He recommends that in-world curricular interventions be designed to target one or more of the ‘Learnings’ of ‘Learning by exploring’, ‘Learning by collaborating’, ‘Learning by being’, ‘Learning by building’, ‘Learning by championing’ and ‘Learning by expressing’. These ‘Learnings’ may be viewed as types of affordance of 3D VLEs for learning.

In much of the extant literature in this area, including many of the aforementioned sources, there is no clear differentiation between the affordances and benefits of the use of 3D VLEs; the two concepts are often treated as one and the same. One exception is the work of Dickey, who has published the findings of a number of studies aimed at examining and comparing the affordances and constraints of specific 3D VLE platforms, including *blaxxun interactive* (Dickey, 1999), *OnLive! Traveler* (Dickey, 1999), *Active Worlds* (Dickey, 1999, 2003, 2005, 2011), *Adobe Atmosphere* (Dickey, 2005) and most recently, *Second Life* (Dickey, 2011). The approach taken in some of these studies (Dickey, 2003, 2011) has been to attempt to determine the affordances of the environment in question from the perspective of the user through methods such as participatory observations, class logs and interviews with students and teachers, while in others (Dickey, 1999, 2005) the affordance analysis has centred around a review of the software by the researcher to identify specific features and functionalities.

In proposing our model of learning in 3D VLEs (Dalgarno & Lee, 2010, see Figure 1), we adopt a view that is consistent with the conception of Norman (1999), who differentiates between ‘real’ and ‘perceived’ affordances and argues that until an affordance is perceived it is of no utility to the potential user. Our view that what is ‘afforded’ is not specific learning benefits or outcomes, but rather the tasks that educators/educational designers and learners perceive the technology as being useable for. The model recognises that the technologies themselves do not directly cause learning to occur, but that the afforded learning tasks *may* give rise to certain learning benefits. Importantly, our model is explicitly framed and presented as a theoretical one that encapsulates what scholars are asserting to be the distinguishing characteristics and potential learning benefits of 3D VLEs, as well as those that are implicit in the design of 3D VLE applications described in the literature. As argued in Dalgarno and Lee (2010), many of these assertions and implicit assumptions are in need of further empirical investigation and validation; the research reported in this paper is an attempt to partially address this need. Specifically, the aims of the research were to:

1. determine the extent to which higher educators perceived the five learning benefits in Dalgarno and Lee’s (2010) model to be occurring when using 3D VLEs with their students; and
2. explore the relationship between the afforded learning tasks (as identified through a grounded analysis of the higher educators’ descriptions of the 3D VLE-based learning activities their students undertook) and the perceived learning benefits.

Methods and data sources

The research described in this paper was part of a larger scoping study on the use of 3D virtual environments for learning and teaching in higher education in Australia and New Zealand (Dalgarno, Lee, Carlson, Gregory & Tynan, 2011a). The scoping study was sponsored by the Distance Education Hub (DEHub at <http://www.dehub.edu.au/>), a federally funded cross-university research consortium, during 2010 and 2011. It included an online questionnaire completed by 117 academic staff from higher education institutions across Australia and New Zealand, as well as follow-up semi-structured interviews with a number of those staff. Several educational designers/developers and information technology support staff were also interviewed.

This paper reports on the responses of the 53 academic staff who indicated in their questionnaire responses that they had used 3D VLEs in their teaching, then proceeded to describe in detail their use of the technology with their students in a particular subject or unit. Specifically, responses to the following questions are reported here:

Question 116. *Please describe the main learning activities that your students undertook within the 3D immersive virtual world environment.*

Question 120. *With respect to the outcomes you have observed in this subject/unit, please indicate the extent of your agreement with each of the following statements. The use of 3D immersive virtual worlds:*

- a) assisted learners in developing familiarity with a place and the objects within it;*
- b) was motivating and engaging for learners;*
- c) led to improved transfer of learning to real situations;*
- d) led to more effective collaborative learning;*
- e) allowed learners to learn through experience in context.*

Question 116 was an open-ended question designed to obtain a descriptive account of the learning activities carried out by students. Data from this question were inductively analysed using the constant comparison method (Corbin & Strauss, 2008), with each of the responses initially being read at face value to produce a preliminary (candidate) list of codes. The codes were gradually refined as subsequent passes were made through the data and the content was reviewed in greater detail, allowing common strands to be factored out. As part of this iterative process, codes were added, deleted, merged, split and renamed. Ten categories eventually emerged from this analysis, as discussed in the next section.

Question 120 required responses on a seven-point Likert scale ranging from 'Very Strongly Disagree' to 'Very Strongly Agree'. The five categories of learning outcome were intended to align with the five learning benefits in the Dalgarno and Lee (2010) model.

Results

Categories of learning activity

The responses to Question 116 were each assigned one or more of the following 10 grounded categories of learning activity emerging from the analysis:

- Place exploration;
- Concept exploration;
- Task practice;
- Role-play;
- Gaming;
- Communication;
- Slide show;
- Building or scripting;
- Instruction; and
- Machinima.

The types of learning activity assigned to each category are discussed in the subsections below. It is important to note that the categories are not mutually exclusive, that is, some of the responses (indeed, most of them) described learning activities belonging to more than one category. Conversely, some responses did not fit into any of the categories and were thus assigned an 'Other' category. One of the responses was unable to be coded based on the information provided.

Place exploration

These are activities in which learners visit and experience simulated places. The virtual places visited may be models of real-world places or may alternatively be virtual spaces designed to exemplify particular aspects of the real world. For example, a Religious Studies lecturer described an activity in which her students explored virtual spaces modelled on places of worship and were presented with informative note cards, landmarks and links at various points during their exploration.

Concept exploration

These are activities in which students explored visualisations and interactive examples of concepts in action. For example, a lecturer of a foundation-year Management subject described an activity in which students explored and manipulated a simulation of a business environment to develop an understanding of specific theoretical concepts.

Task practice

Activities in this category focus on the practising of procedural tasks in a virtual simulated environment. Such tasks might be overly expensive, dangerous, time consuming or inconvenient to practise in the real world. For example, one respondent described an activity in which Midwifery students used a simulated environment to practise the management of a postpartum haemorrhage.

Role-play

In these activities, students take on and act out roles as part of a given scenario in order to develop an understanding based on firsthand experience from the perspective of one or more of the roles occurring in the modelled situation. One respondent described an activity in which Criminal Law students role-played the delivery of trial submissions within a simulated virtual courtroom environment.

Gaming

Activities assigned to this category sought to challenge learners as they worked towards the achievement of individual or cooperative goals. Typically, in these activities, there was a sense in which the student 'won' the game once the goal was met. For example, an Education lecturer described a game in which educational psychology theories and concepts had to be mastered in order to achieve the goals within the game.

Communication

Many respondents described activities that had communication between students as a central purpose, for instance to discuss the ideas within a subject or to work on group project tasks. As an example, one respondent described an activity in which students worked collaboratively to develop accessible web sites for organisations and used *Second Life* to meet with clients based in other countries.

Slide show

This category included activities in which students viewed or created slide shows within the 3D VLE. For example, PowerPoint images, photographs and other two-dimensional graphical content are able to be rendered on a 'screen' in *Second Life* with the help of a special slide projector object. The content can be browsed independently by students or used as visual aids during a lecture or other synchronous class activity.

Building or scripting

Activities in this category required students to construct places and objects, and in some cases write programs or scripts, within the virtual world. In one activity, Information Systems students created software artefacts embedded in objects in *Second Life* and integrated them into scenarios to model processes applicable to a real business case.

Instruction

In this category were activities in which teachers delivered lectures, tutorials or content-based presentations to their students within the 3D VLE. It also included activities in which the students themselves delivered their own 3D VLE-based presentations.

Machinima

A few respondents' learning designs involved students creating or using pre-created 'machinima' – animations or 'movies' that record action occurring within a 3D virtual environment. Respondents described the use of machinima sequences for various purposes, including as introductory material to foreground exercises and concepts to be covered in face-to-face lessons, as well as to provide a narrative context and scaffolding for 3D VLE-based activities. In some cases the students viewed the machinima clips while immersed within the 3D VLE; in others, the clips were embedded in a subject/unit website or courseware package external to the 3D VLE.

Reported learning benefits

Responses to the five parts of Question 120, which asked respondents for their degree of agreement with a series of statements about the possible learning benefits of the 3D VLE-based learning activities, were scored from 1

(Very Strongly Disagree) to 7 (Very Strongly Agree). The responses in relation to each possible learning benefit are summarised in Table 1. Most noteworthy here is that most respondents agreed with all five statements, that is, regardless of the design of the particular activity, it would appear that most respondents thought that all five learning benefits occurred. The following section, then, looks at the relationship between the category of learning activity based on the analysis discussed above, and the reported learning benefit.

Table 1: Summary of responses relating to the reported learning benefit of each virtual world implementation

Reported learning benefit	Frequency (N = 53)							Mean
	Very Strongly Disagree (1)	Strongly Disagree (2)	Disagree (3)	Neutral (4)	Agree (5)	Strongly Agree (6)	Very Strongly Agree (7)	
Assisted learners in developing familiarity with a place and the objects within it	2	0	5	8	16	19	3	5.0
Was motivating and engaging for learners	0	0	0	3	13	21	16	5.9
Led to improved transfer of learning to real situations	0	0	2	11	8	20	12	5.5
Led to more effective collaborative learning	1	0	1	6	12	23	10	5.6
Allowed learners to learn through experience in context	0	0	1	5	9	26	11	5.8

Comparing learning activities to reported learning benefits

In order to determine whether there was a difference between the learning benefit perceived to have occurred by respondents that were using different categories of learning activity, a Multivariate Analysis of Variance (MANOVA) procedure was carried out, with the 11 categories of learning activity as independent variables and responses to the five parts of Question 120 as dependent variables. Table 2 shows the mean response to the parts of Question 120 relating to each of the five learning benefits, broken down according to the categories of learning activity identified. Where the MANOVA procedure indicated there was a significant difference in response between those whose reported activities were assigned a particular category and those whose reported activities were not, this is also shown in the table.

Table 2: Mean response to questions about learning benefits for each category of learning activity and MANOVA results showing where a significant main effect of learning activity was found

Learning activity category	Learning benefit (1 = Very Strongly Disagree – 7 = Very Strongly Agree)				
	Assisted learners in developing familiarity with a place and the objects within it	Was motivating and engaging for learners	Led to improved transfer of learning to real situations	Led to more effective collaborative learning	Allowed learners to learn through experience in context
Place exploration (n = 9)	5.6	5.4	5.6	5.2	5.6
Concept exploration (n = 7)	4.0	5.9	5.7	6.1	6.3
Task practice (n = 5)	6.0	5.6	5.6	6.4	5.0
Role-play (n = 23)	6.0	5.7	5.6	6.0	5.0
Gaming (n = 1)	5.0	5.0	5.0	5.0	4.0
Communication (n = 21)	5.8	6.0	5.8	6.0	5.0
Slide show (n = 7)	6.2	5.7	5.7	6.0	4.8
Building or scripting (n = 9)	5.3	5.7	5.7	6.1	5.2
Instruction (n = 12)	6.1 <i>significant</i> F(1,40)=4.841, p = 0.034	6.2 <i>significant</i> F(1,40)=4.136, p = 0.049	5.8	6.3	5.4
Machinima (n = 6)	6.2	5.7	5.7	6.0	4.8
Other (n = 11)	5.6	5.3	5.0	5.9	5.5
Uncoded (n = 1)	7.0	7.0	7.0	7.0	6.0
Mean (N = 53)	5.0	5.9	5.5	5.6	5.8

Discussion and recommendations for future research

Based on the theorised relationship between learning activities and learning benefits within our model (Dalgarno & Lee, 2010), we hypothesised that the perceived learning benefits of each implementation would vary depending on the characteristics of the learning activities undertaken by the students. For example, we expected learning activities categorised as ‘place exploration’ to be more likely to ‘assist learners in developing familiarity with a place and the objects within it’, and to allow ‘learners to learn through experience in context’. We also expected learning activities involving ‘task practice’ or ‘role-play’ to result in ‘improved transfer of learning to real situations’, and learning activities involving ‘communication’ to lead to ‘more effective collaborative learning’. However, there were statistically significant differences according to the category of learning activity in the responses for only two of the learning benefits, namely those relating to place familiarity and motivation and engagement. In both cases, respondents whose learning activity included ‘instruction’ had a higher mean response rate, while there were no significant differences for any of the other learning activity categories. The finding that instructional learning activities were perceived to result in higher levels of place familiarity and engagement than other activities such as place exploration and gaming is surprising, as is the absence of any other significant main effects of learning activity on perceived learning benefit.

There are a number of possible explanations for the results of this analysis. One explanation relates to the fact that a majority of the learning activities were found to belong to more than one category. This suggests that the tasks set by the educators for their students were often quite holistic, perhaps involving a number of quite different learning activities. For example, if a learning task required students to take in instruction, then explore locations within the virtual environment, and while doing so communicate with one another using the tools provided, it would not be unlikely for multiple learning benefits to occur. Additionally, a wide range of 3D VLE-based learning activities are likely to be intrinsically motivating and engaging, so a lack of difference in perceptions about the degree to which this learning benefit occurred across different learning activities is understandable. Nevertheless, one would still expect to find that across the sample, differences in perceived learning benefits between tasks that involve a particular type of learning activity (e.g. place exploration or communication) and those that do not would still be detectable.

Another possible explanation for the lack of significant differences lies in the very high levels of agreement expressed by the respondents with regard to all five statements about the learning benefits arising from the activities (see Table 1). An earlier finding from the Australian and New Zealand scoping study of which the present research is a part was that there are substantial barriers to the use of the technology, and that institutional support is often limited (see Dalgarno, Lee, Carlson, Gregory & Tynan, 2011b). Given this, we might expect that many of the respondents to the questionnaire were passionate and enthusiastic adopters of 3D VLEs who were prepared to use such environments in their teaching despite the obstacles and challenges that exist. If this was indeed the case, it is possible that the respondents' tendency to agree or strongly agree with all five statements about the learning benefits could be more a reflection of their enthusiasm and positive attitude towards the use of 3D VLEs than an evidence-based assessment of the actual learning benefits occurring from the specific activities their students undertook.

In light of the above, future research needs to consider alternative ways of exploring the relationship between learning activities in 3D VLEs and the actual learning benefits occurring. One approach that could be considered is the use of controlled studies where the actual learning outcomes of students undertaking activities in a 3D VLE are compared with those of students undertaking equivalent, non-3D VLE-based activities (e.g. using other online technologies, or in a face-to-face environment). As pointed out by Clark (1994), however, it is very hard not to confound instructional method with media in such studies, and consequently, such studies are unlikely to identify learning benefits caused solely by the virtual environment. The use of controlled studies of this type in an authentic university context is also problematic because of the ethical issues involved in providing some students with access to a particular learning experience while denying others access to it. Another alternative approach would be to collect data from students to gauge their perceptions of the learning benefits of a particular 3D VLE-based learning activity. Given the fact that many students are initially somewhat cynical of the benefits of such activities (see Dalgarno et al., 2011a), student responses to a questionnaire on the learning benefits of a particular activity could possibly be more realistic than those of the academic who has enthusiastically designed the learning tasks, often investing a substantial amount of his/her own time. Care would need to be exercised in the construction of such a questionnaire to ensure that the terminology used is understandable to students. Terms like 'motivation' and 'engagement' are likely to be reasonably well understood; however, notions such as 'transfer of learning' may require some explanation and clarification.

Furthermore, just as future studies should consider students' perceptions of learning benefits in addition to those of educators, so too should they seek to recognise the differences in perceived affordances (Norman, 1999) between students and educators. In the present study, the various categories of learning activity were derived from educators' descriptions of the activities undertaken by their students within 3D VLEs. It would be worthwhile to ask students to describe what they consider to be appropriate and/or valuable uses of 3D VLEs for learning and teaching and how they would like to see the technology integrated into their courses, to serve as a basis for comparison with the educators' views and intentions. The ways in which students interpret assigned learning tasks and carry out activities (Goodyear & Ellis, 2007; see also Goodyear, 2000) within 3D VLEs and how these might be influenced by the affordances they perceive in the technology also warrant further investigation, as these factors may impact upon both the perceived and actual learning benefits arising from the activities.

Conclusion

The study reported in this paper, which sought to extend our earlier theoretical work as presented in Dalgarno and Lee (2010), explored the relationship between the characteristics of 3D VLE-based learning activities and the learning benefits perceived to have occurred, as reported in an online questionnaire completed by Australian and New Zealand academic staff who had used 3D VLEs in their teaching. There was almost no statistical

difference between respondents' degrees of agreement with five statements about the learning benefits across different categories of learning activity. Two plausible explanations for this unanticipated result are firstly, the possibility that many of the learning tasks set for the students involved multiple categories of learning activity and consequently led to a wide range of learning benefits, and secondly, the possibility that respondents' high levels of enthusiasm for the use of 3D VLEs may have caused them to perceive learning benefits beyond those actually occurring. Further research exploring this issue will need to consider alternative approaches to measuring the learning benefits, including, for example, elicitation of students' perceptions as well as assessment of actual learning outcomes achieved, although the latter in particular will not be without its difficulties. Studies are also needed that take into account the perceived affordances of 3D VLEs from the point of view of students, and the effect these might have on their interpretation of learning tasks and performance of learning activities.

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