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 Life[1] (SL) and OpenSimulator[2] (OpenSim) virtual world platforms into Formare[3], 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 Labs[4], (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 where 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, se 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	Automatically create, manage, and delete synchronous training sessions or generic 3D course space (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' sumaries (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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