Fostering collaborative learning in Second Life: Metaphors and affordances

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**Abstract**

In this paper we examine the transferability of the Jigsaw and Fishbowl collaborative learning techniques to the Second Life platform. Our aim is to assess the applicability of Second Life for collaborative learning by developing virtual tools and metaphors and exploiting the representational richness of this novel medium. In order to enhance the existing metaphors and affordances of SL, our research team implemented educational spaces, avatar clothing, and tools for non-verbal communication and visualisation. By implementing a blended learning evaluation approach we attempted to answer three research questions focusing on student collaboration, avatar representation and learning space awareness. We can conclude that SL can supplement and/or augment face to face interactions, improving upon previous approaches in distance collaboration and communication. Furthermore, although our team augmented SL’s ability to support collaborative learning, avatar representation does not seem to scale well. Finally, the majority of the implemented affordances and metaphors seem to have enhanced collaboration and learning space awareness.

**Keywords:** Cooperative/collaborative learning, Virtual reality, Interactive learning environments, Media in education, Second Life

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1. Introduction

Collaborative learning can generally be defined as learning activities expressly designed for, and carried out by, pairs or small interactive groups (Barkley, Cross, & Howell, 2004). Research has demonstrated that learning is most effective when students work in groups, verbalise their thoughts, challenge the ideas of others, and collaborate to achieve group solutions to problems (Johnson, Suriya, Won Yoon, Berrett, & La Fleur, 2002; Lehtinen & Hakkarainen, 2001; Shih & Yang, 2008). Moreover, students who work in small groups tend to achieve relatively higher levels of academic outcomes and are more likely to develop the skills needed for a successful career (Joseph & Payne, 2003).

According to Dillenbourg (2008), the borders between classroom/campus activities and distance activities are fading away. Similarly, the borders between computer-based and computer-less activities as well as virtual and physical campuses are disappearing. Computer-supported collaborative learning (CSCL) research can be divided into three categories (Bruckman & Bandlow, 2002): a) distance education, b) information retrieval, and c) information sharing. Therefore, within the context of distance CSCL, the present paper evaluates the feasibility of executing collaborative learning techniques in the Second Life (SL) platform and examines affordances and metaphors which can enhance the collaborative learning experience using a 3D virtual environment. Within the context of a 3D virtual environment, affordances can be defined as the actionable properties between an artefact and an actor (i.e., the way a user interacts with an object), while metaphors are artificial representations of real world objects modelling the behaviour of real world affordances. Examples of affordances and metaphors are given in Section 3.2 of the paper, where there is a discussion on the new SL features implemented by the research team.

This paper analyses the online transferability of two collaborative learning techniques (i.e., Jigsaw and Fishbowl) through the utilisation and augmentation of features, metaphors, and affordances available in SL. The applicability of the SL environment is assessed through the implementation of a blended collaborative learning approach which is comprised of three successive phases described later in this paper.

More specifically, research questions include:

- **RQ1:** Do students perceive SL as instrumental in the collaborative learning process?
- **RQ2:** How does avatar representation influence collaboration and performance in student groups?

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doi:10.1016/j.compedu.2010.02.021
RQ3: Which metaphors and affordances can be used to enhance learning space awareness?

This article is structured as follows: In the next section we present two perspectives of related work. On the one hand we focus on research within the context of traditional and computer-supported collaborative learning, while on the other we examine collaborative learning through the utilisation of the SL platform. Following this, we present and rationalise the new features implemented by our research team within SL. Next, a blended learning evaluation methodology which facilitated the realisation of a case study conducted at the level of tertiary education is described. The final sections analyse and discuss the obtained assessment results with regard to the posed research questions.

2. Cl. techniques background and related work

In this section we will present an analytical bibliographical research study of related work and publications. The study will focus on two directions which are relevant to the theme of this paper: a) the application of collaborative learning techniques in traditional and computer-supported educational settings, and b) the research being carried out regarding the applicability of the Second Life platform for effective collaborative learning.

2.1. Collaborative learning: traditional and computer supported

From a pedagogical and constructivist perspective, collaborative learning methods tend to encourage construction of knowledge, deeper understanding and greater skill development through their ability to engage students dynamically in the learning process (Jara et al., 2009).

Based on relevant research, this section will present specific collaborative learning techniques which have been successfully implemented in traditional educational settings and examine the design methodology of computer-supported collaborative learning. The pedagogical value of the collaborative learning approach is not examined in this paper since evaluation data regarding its effectiveness has been presented in exhausting detail by Slavin (1990) and Johnson, Johnson, and Smith (1991) who are considered the most prodigious compilers and reviewers of research on collaborative learning groups according to Barkley et al. (2004).

2.1.1. Collaborative learning techniques

In general, collaborative learning techniques can be organised into five types (Barkley et al., 2004): a) discussion: where student interaction and exchange is achieved primarily through spoken words, b) reciprocal teaching: where students purposefully help each other master subject matter content and develop discipline-based skills, encouraging interdependence, c) problem solving: where students focus on practicing problem-solving strategies, d) graphic information organising: where groups use visual tools to organise and display information, and e) collaborative writing, where students write in order to learn important course content and skills.

Depending on the set objective, collaborative learning techniques can be used independently of, or in combination with each other. As mentioned by Dillenbourg (2008), recent CSCL techniques are not restricted anymore to collaborative learning, but include individual learning activities (reading papers, writing a summary, etc.) as well as class-wide activities with the teacher (introductory lectures, debriefing sessions, etc.).

The case study presented later in this paper will focus on the combination of two reciprocal teaching collaborative techniques, by examining their applicability inside the 3D virtual environment of SL. These techniques are: a) Jigsaw, and b) Fishbowl. The Jigsaw technique is a cooperative learning method with a three-decade track record (Aronson & Bridgeman, 1979; Aronson & Patnoe, 1997) of successfully reducing racial conflict and increasing positive educational outcomes. In this technique, students develop knowledge about a given topic (Expert Groups-EG) and then teach it to others (Jigsaw Groups-JG).

Several pedagogical advantages have been attributed to the Jigsaw process (Aronson & Patnoe, 1997). These educational benefits include listening encouragement, engagement, and empathy by giving each member of the group an essential part to play in the academic activity. Group members must work together as a team to accomplish a common goal; each student depends on everyone else. No student can succeed completely unless everyone works together. Also, the Jigsaw technique is a typical method for researching certain collaborative interactions in a virtual environment. This “cooperation by design” facilitates interaction among all students in the class, leading them to value each other as contributors to their common task.

On the other hand, in the Fishbowl technique, students form concentric circles with the smaller inside group of students discussing and the larger outside group listening and observing. The goal of this technique is to familiarise students with the structure and characteristics of an in-depth discussion. Students are able to acquire the necessary skills in observing team activities taking place in a dialectic environment (Barkley et al., 2004). Also, their knowledge of the objects and themes they are debating is augmented.

The Fishbowl technique is effective in enhancing interactivity within the class (Miller, Benz, & Wysocki, 2002). Students can undertake social roles based on human relationships and through them exchange experiences, ideas and reasoning. Furthermore, through this process students identify the multiple dimensions of the debated issues, and ponder over the differing opinions, enhancing their critical thinking skills.

Furthermore, in Miller et al. (2002), Fishbowl is compared to computer-supported text-based conferencing (i.e., forums). The results indicate that the Fishbowl technique was perceived as providing somewhat greater benefits in solving research problems and as being more likely to promote helping behavior. On the other hand, the negative aspects of Fishbowl were considered to be: a) scalability, b) time limitations and c) lower participation. These results demonstrate that computers are most effective when used in conjunction with classroom instruction (i.e., blended learning).

2.1.2. Computer-supported collaborative learning

The following sections discuss the application of collaborative learning in a computer-supported educational environment. More specifically, CSCL design issues and the implication of user representation through avatars as derived from the study of a relevant bibliography are presented. Finally, the implementation of the Jigsaw and Fishbowl collaborative learning techniques in an online environment is debated and a design approach is suggested.

Please cite this article in press as: Andreas, K., et al., Fostering collaborative learning in Second Life: Metaphors and affordances, Computers & Education (2010), doi:10.1016/j.compedu.2010.02.021
2.1.2.1. CSCL design issues. If a tutor wishes to involve students in productive dialogue, simply providing a medium is not sufficient. Technology engenders no intrinsic effects. Rather, it has specific affordances. Designers, teachers, and students are those who turn affordances into learning outcomes. Learner involvement is facilitated by the instructional design principles that are embedded in the CSCL environment (Prinsen, Volman, Terwel, & Eeden, 2009).

Four important features of CSCL are presented by Wang (2009): individual accountability, positive interdependence, coordination, and monitoring. With regard to individual accountability, students take ownership for the learning task and for learning. To promote individual accountability, important aspects are making the learning task meaningful, equality, instructional strategies and random checking, or individual skill demonstration.

On the other hand, positive interdependence refers to the consideration of the contribution of each individual in the success of team work. It can be increased through a strong feeling of community, friendship and instructional support on resources, rewards, roles, or the environment. Coordination pertains to the external scaffolding strategies used to organise, coordinate, and reflect upon the on-going ideas of the students. Useful strategies include social discourse, process prompts and displays, web based tools (e.g., bulletin boards, shared workspaces) and scripts (i.e., collaboration, epistemic, social). Finally, monitoring can be utilised to identify strengths and weaknesses of the instructional design. This way, teachers can adjust learning activities promptly and provide appropriate support when needed.

2.1.2.2. Virtual representation through 3D avatars. An avatar is an interactive, social representation of a user which allows him/her to interact with a simulated environment and/or with other people. Research (Meadows, 2008) has shown that the use of avatars lowers inhibitions and increases social interactivity. Most 3D virtual environments offer full customisation of an avatar’s appearance and gestures, allowing users to strongly identify with the chosen representation for their avatar and easily distinguish the other participants. This customisation greatly influences the perceived sensation of presence and awareness (De Lucia, Francese, Passero, & Tortora, 2009).

Avatars in a Virtual Learning Environment (VLE), can mediate important information about participants by their appearance and behavior. Loomis (1992) mentions that all contact with the physical world is mediated. In the particular case of a VLE the media is the avatar. Collaborative educational techniques depend greatly on users’ interaction with each other and with the environment. Thalmann (2001), describes a direct relation between the quality of a user’s representation and his/her ability to interact with the environment and other users.

While providing pre-built avatars may partially democratise the group, it is noticeable that almost the first action desired by 3D virtual environment users is characterised by questions on how to change and individualise their appearance. According to Salt, Atkins, and Blackall (2008), requiring students to remain in their initial pre-built form may be counter-productive and hamper rather than foster the feelings of engagement with the environment.

However, as described by Johnson et al. (2002), a definable set of characteristics common to all collaborative work groups includes: a) a definable membership, b) awareness of one’s membership, c) a shared sense of purpose, d) member interaction, and e) the ability to act as an individual unit as well as a unit of individuals. These are all important aspects to take into consideration when designing virtual group representation through avatars.

In contrast to avatars controlled by users, artificial intelligence avatars (usually called agents) can also be defined. There are many types of agents. Relative to the context of this study are pedagogical agents. These can inhabit virtual environments and can be represented by an avatar or a special object (e.g., a book). Their role is to interact with the users. Pedagogical agents can further monitor student’s interactions as well as guide and advise them. According to Bouras, Philopoulos, and Tsatsos (2000, pp. 604–607), the main advantage of pedagogical agents over conventional intelligent learning is that they enable closer and more natural interactions between students and intelligent coursework.

2.1.2.3. Supporting Jigsaw and Fishbowl by ICT. According to Barkley et al. (2004), Jigsaw is characterised by moderate online transferability. However, this characteristic is attributed based on the utilisation of 2D virtual learning environments. For example, separate forums for each Jigsaw group were suggested. Likewise, Fishbowl has also been characterised by moderate online transferability by Barkley et al. (2004). Again, this conclusion is based on the exploitation of 2D educational tools such as chat rooms and forums. For example, when conducted synchronously, individual students are assigned to “virtual” inner or outer circles through chat sessions. On the other hand, when asynchronous, it is suggested to create two forums, corresponding to the Inner and Outer Circle. Therefore, this research gap on the affordance of 3D technology to support collaborative learning techniques justifies our research.

The example approaches presented above are clearly lacking when compared to the representational capabilities of 3D virtual worlds in conveying presence and space awareness and in supporting multiple communication channels (i.e., text, voice, and body language). In our design, we envisaged exploiting the representational richness of 3D by implementing the approaches depicted in Figs. 1 and 2.

In Fig. 1, the Jigsaw CL technique is presented. The above metaphor dictated the creation of separate rooms for each (Jigsaw or Expert) group. Each Jigsaw room would be separate from the rest, maintaining group privacy and collaboration. We expected this design to afford the augmentation of group intimacy and confidence, as well as group work cohesion.

The case study presented in a later section will focus on the combination of the Jigsaw and Fishbowl CL techniques. For facilitating this combination, the approach presented in Fig. 2 was considered. Just like in a real world setting, this metaphor would require the formation of concentric circles, with the smaller inside group of students discussing and the larger outside group listening and observing. The diagram presented above imposed two requirements on the design of the e-learning environment: a) a method for distinguishing two concentric circles, and b) a method for distinguishing Jigsaw/Expert groups.

2.2. Collaborative learning in Second Life

According to Jarmon, Traphagan, Mayrath, and Trivedi (2009), there has been a growing demand for empirical research studies that inform instructional design and practices in 3D virtual worlds. This section will present the contemporary research being carried out in the context of collaborative learning through the Second Life (SL) platform. Based on this research, there will be a description of how SL features currently facilitate collaborative learning, and suggestions on how the platform can be further augmented to support meaningful learning.
Our team opted to utilise the SL platform based on the results of previously published research (i.e., Konstantinidis & Tsiatsos, 2008; Tsiatsos & Konstantinidis, 2009). Various platforms were examined to better assess their design adequacy for online learning by validating their features, philosophy and policies against some basic design principles for collaborative virtual learning environments. Based on evaluation results we can deduce the increased pedagogical value and educational possibilities of the SL platform.

Our selection is also justified by the majority of the relevant bibliography. For example, Jarmon et al. (2009) mention that the literature to date suggests that when the SL instructional activities have been well-planned and integrated into the core course content, using SL can be conducive for project-based experiential learning of interdisciplinary communication. Furthermore, SL is the most popular Internet-based virtual world, if measured by number of subscribers and money exchange. There are over 15 million registered users within the SL virtual world, and over 1 million active users. Statistics from December 18, 2008 indicate that 1,437,910 residents had logged in to SL within the previous sixty days (Beard, Wilson, Morra, & Keelan, 2009).

Moreover, it is largely adopted for academic, social and business purposes. In particular, many educational institutions have begun to explore SL as a platform for education, and other kinds of organisations are already using the SL platform to support distance learning (De Lucia et al., 2009). Almost all reports of educational activity in multi-user virtual environments (MUVEs) are about SL. It has been identified...
by many educational institutions internationally, as having significant potential for teaching and learning and there is a current plethora of projects looking at educational possibilities (Salt et al., 2008). The areas covered include astronomy, medicine, music, literature, biology, history, forensic science, ecology and tourism.

In the research published by Jarmon et al. (2009) focus group participants reported that learning in the course was facilitated by various supportive characteristics of SL. One of the major affordances that students commonly mentioned was that the 3D virtual environment in SL fostered real life applications (metaphors) of the theories and strategies studied in the course curriculum. In addition, it was concluded that learning was enhanced by several of SL’s affordances combined with the project-based instructional design.

Other results reveal that the virtual environment successfully supports synchronous communication and social interaction (De Lucia et al., 2009). Also, the tutors referred that students were really motivated and noticed that participants less accustomed to using the environment asked others for information or looked at them to understand where to go or what to do. In terms of the educational potential of SL, the leading responses were for role playing (65%), artistic expression (65%) and simulation activities/scenario based training (57%).

2.3. Discussion

Several negative aspects of the SL platform, however, are also pointed out in international publications. In De Lucia et al. (2009) SL ranked lowest in terms of usefulness, ease-of-use, team attitude, and perceived team attitude, when compared with: email, forums, video conferencing, and MSN. It came off the bottom of the rank in perceived team enjoyment (Salt et al., 2008). More specifically, there was mention of a steep learning curve and difficulty in virtual setting navigation by users inexperienced in 3D computer games (Jarmon et al., 2009). It should be noted, however, that these aspects were also reported by Monahan, McArdle, and Bertolotto (2008) with regard to the evaluation of a different 3D virtual environment.

Other observers are also skeptical about SL’s educational horizons (Mason & Rennie, 2008, pp. 87–90; Rosenberg, 2009). The major reasons are that: a) SL, like the Internet, has its share of adult activities and regions, b) it is difficult to guarantee that an avatar is being operated by the appropriate user, c) some educators believe the virtual classroom cannot match the face to face learning that takes place in a real classroom, d) it is not considered suitable for PowerPoint presentations, e) it requires a reasonably high level of technical infrastructure in terms of broadband access, network speed, graphics capability and processing speed on individual machines and f) it doesn’t have a seamless interface with other web products.

Based on this information, we concluded to focus our research on these questions:

- Do students perceive SL as instrumental in the collaborative learning process?
  o We endeavour to explore the students’ perspectives on the effectiveness of this novel technological and pedagogical approach as well as their future expectations. Furthermore, advantages, disadvantages and suggestions will be considered for the augmentation of the platform.
- How does avatar representation influence collaboration and performance in student groups?
  o The effectiveness of CL techniques relies heavily on face to face interaction. Therefore, to compensate for this, special attention was paid to enhancing group and user awareness through the implementation of affordances and metaphors relating to avatars. These were evaluated with regard to collaboration, communication and learning.
- Which metaphors and affordances can be used to enhance learning space awareness?
  o Approximating face to face interaction is not enough to justify the use of 3D virtual environments. It is necessary to improve upon conventional instruction, in order to rationalise additional time and costs. Therefore, this question examines tools and metaphors which can be utilised to augment the virtual approach, and increase its competitiveness when compared to traditional and distance collaborative learning methods.

3. Implementing CL techniques in SL

In order to support our blended collaborative learning approach to evaluation which will be presented later in this paper, several existing and new SL features were utilised. These features can be categorised into: (a) educational spaces, (b) user representation, (c) avatar animations and gestures, and (d) virtual tools and metaphors. Detailed descriptions of existing and new implementations are presented in the sections that follow.

3.1. Existing CL features in SL

Second Life provides an opportunity to use simulation in a safe environment to enhance experiential learning, allowing individuals to practice skills, try new ideas, and learn from their mistakes (Beard et al., 2009). According to Dillenbourg (1999), every virtual environment that integrates the following features can be characterised as a collaborative e-learning environment:

- Users who have different roles and rights can visit the environment.
  o SL supports the creation of groups and the assignment of roles at the representational level. In other words, a current limitation in SL is that users cannot be restricted and specific privileges cannot be attributed.
  o The educational interactions in the environment should change the simple virtual space to a communication space.
  o SL provides multiple communication channels, which enable users to interact with each other, and with the virtual space.
  o Communication channels include text and VoIP chat, as well as non-verbal communication through avatar gestures.
- The environment should be represented by various representation forms, these can range from simple text to 3D worlds.
  o SL supports multiple representational forms, ranging from text and graphics to audiovisual media.
- The learners in the environment should not be passive, but should be able to interact.
3.2. Educational spaces

The environment should support various e-learning scenarios. SL supports the creation and modification of avatars. Through avatars, users can interact with others, with 3D objects and with the environment.

- The system that supports the e-learning environment should be able to integrate various technologies.
  - This is a major drawback of the SL platform. Currently, there is no support for popular file types and the integration of various technologies is a complicated task. Furthermore, shared tasks, such as co-browsing the Internet, or co-authoring a document are not supported.
- The environment should support various e-learning scenarios.
  - SL can support role-playing, simulations and experiential learning (Salt et al., 2008). The objective of this study is to examine SL’s ability to support traditional collaborative techniques.
- The environment should have common features with a physical space.
  - The representational richness of the SL platform allows it to simulate detailed realistic environments.

It is clear from the observations made above that, in its current form, SL does not completely meet the requirements imposed on an educational collaborative e-learning environment. In the following section we will present the features implemented by our team in order to counteract these limitations, by taking advantage of the modelling and programming potential of the SL platform.

3.2. New CL features in SL

This section presents the metaphors and affordances which were implemented by our research team in SL. These features facilitated the application of the collaborative learning techniques under examination. Their ability to enhance collaboration, interaction and communication were assessed.

3.2.1. Educational spaces

The construction of the educational space followed the requirements revealed by the analysis of the selected collaborative scenario’s needs and the review of the results of similar evaluation studies (e.g., Konstantinidis & Tsiatsos, 2008). The educational space consists of two basic areas: rooms for the support of educational activities and rooms for socialising and meeting informally.

Surveys have revealed that students desire to have such places in order to satisfy their need for privacy (Büscher, O’Brien, Rodden, & Trevor, 2001, chap. 5, pp. 77–98). According to Kreijns, Kirschner, and Jochems (2003), this is a usual pitfall of social interaction. In other words, there is a tendency to restrict social interaction to educational interventions aimed at cognitive processes while social (i.e., psychological) interventions aimed at socio-emotional processes are ignored, neglected or forgotten. Students need to trust each other, feel a sense of warmth and belonging, and feel close to each other before they willfully collaborate and recognise this collaboration as a valuable educational experience. The presence of non-task contexts positively affects the building of an affective structure and, thus, the building of communities.

The main educational building was realised with two floors (Fig. 3). The ground floor consisted of five Jigsaw rooms (one for each jigsaw group) and a wide common meeting hall containing bulletin boards. Each Jigsaw room was separate from the rest, maintaining group privacy and collaboration. The rooms also included boxes containing clothing specific to each avatar group. The entire first floor was dedicated to the Fishbowl scenario, where students and teacher debated and groups presented their collaborative work on a presentation board. Decoration in the educational places was kept at a minimum, aiming at reducing the students’ cognitive load.

3.2.2. Exploiting avatars wear for user role representation

The implementations that concern the avatars’ appearance are mainly related to the clothes that they wear during the online meetings. Many of the eligible requirements about an avatar’s appearance (e.g., avatar’s name) are already covered by SL’s built-in functions. Our research team implemented the following objects, regarding avatar attire:

- Moderator Hats: Five colored hats were designed; one for each group, in order to easily differentiate the user assigned the role of moderator in the group collaboration activities and discussions.
- Jigsaw Shirts: different colored shirts were designed, one for each Jigsaw group. Group members were differentiated based on shirt color. Shirts had indicators for Group name and number. Our aim was to design shirts that would allow the differentiation of groups from afar and from as many viewpoints as possible. Therefore, we placed group indicators on four different points of the shirt: front, back, and left/right arm.
- Expert Group Jackets: were implemented as “transparent” Jackets containing only the expert group indicator label, intended to be worn over the Jigsaw Shirt. Expert group indicator labels were placed again on three different points of the jacket: front, back, and left/right arm.

3.2.3. Non-verbal communication

Collaborative educational techniques depend greatly on the affordances of the environment and of the user to user interactivity. It seems collaborative learning environments can be made more effective by implementing structures that scaffold processes of epistemic, argumentative, and social interactions. Furthermore, non-verbal communication (NVC) seems to be highly beneficial to user interactions in collaborative virtual environments (CVEs). The term NVC is commonly used to describe all human communication events which transcend the spoken or written word (Knapp, 1978).

Therefore, in order to support, facilitate and improve collaborative interactions and student awareness, for the online scenario in SL, we designed and implemented several features concerning the enrichment of the avatars’ NVC, their virtual appearance and virtual tools to enhance the collaborative processes between them. SL already offers a set of basic gestures for world residents. Collaborative scenario interaction analysis revealed some basic gestures, animations or poses needed to support users in collaborative activities. Table 1 presents
the new gestures our team implemented, as well as some existing SL gestures which were augmented. The trigger column refers to the way the gesture/animation is activated through the text chat window.

### 3.2.4. Virtual tools and metaphors

Visual metaphors are an essential part of virtual worlds such as SL. In Heilig (1992) it is revealed that 70% of information uses the optical channel. We assume that visual metaphors in e-learning can boost collaboration in collaborative virtual environments and produce effective learning. In order to evaluate this assumption we designed virtual tools implementing useful visual metaphors, which are described below:

- **Student Voice Tool (Fig. 4a):** One major problem in online 3D meetings is the difficulty in distinguishing a person who speaks when in a crowd. To overcome this issue, we designed the Student Voice Tool, which enables the differentiation of the speaking user through a ring with the denotation “Speaker” over his/her avatar’s head and a microphone near the mouth. More specifically, if a student wishes to speak then the following sequence of actions takes place:
  - The student declares his/her request to speak by raising his/her hand (use of Raise hand gesture)
  - The Discussion coordinator (who uses the “Now Speaking tool” presented below) assigns the “speaker role”.

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**Table 1**

<table>
<thead>
<tr>
<th>Action-statement</th>
<th>Description</th>
<th>Trigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raise Hand</td>
<td>Avatar raises hand, requesting permission to speak</td>
<td>/hand</td>
</tr>
<tr>
<td>Encouragement</td>
<td>Avatar hand animation for encouragement</td>
<td>/encourage</td>
</tr>
<tr>
<td>Show avatar</td>
<td>The avatar points at someone else</td>
<td>/you</td>
</tr>
<tr>
<td>Show self</td>
<td>The avatar points at itself</td>
<td>/me</td>
</tr>
<tr>
<td>Clap</td>
<td>The avatar claps</td>
<td>/clap</td>
</tr>
<tr>
<td>Doubt</td>
<td>The avatar's facial expression shows doubt</td>
<td>/hmm</td>
</tr>
<tr>
<td>Agreement</td>
<td>The avatar shakes its head up and down</td>
<td>/yes</td>
</tr>
<tr>
<td>Disagreement</td>
<td>The avatar shakes its head left to right</td>
<td>/no</td>
</tr>
<tr>
<td>Ignorance</td>
<td>The avatar shakes its head left to right and frowns</td>
<td>/don’t know</td>
</tr>
</tbody>
</table>

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The speaking avatar obtains the Speaker Label and a virtual microphone object.

- **Now Speaking** (Fig. 4b): The “Now Speaking” tool is used in combination with the “Student Voice” tool in order to achieve better coordination for the online group meetings in SL. The tool is worn by the person(s) who has been assigned the discussion coordinator role (who might also be the tutor). The following sequence of actions takes place:
  - The user’s name is highlighted in yellow, on the Head-Up Display (HUD) table that includes all participating students (with their real and SL names).
  - In Local Chat, the phrase, “[AvatarName] wants to speak” appears.
  - When the coordinator determines that the previous speaker has completed his/her argument, he/she assigns the “speaker role” by clicking on the student’s name.
  - The speaker’s name is then highlighted in green.
  - In Local Chat the phrase, “Now speaking [AvatarName]” appears.

- **Query Visualisation Tool** (Fig. 4c): This tool visualises users wanting to ask a question, in a discreet manner, without disturbing group or class meetings, by using a metaphor. When a user wishes to visualise his/her request, s/he just types three question marks in local chat (i.e., “???”); from that moment and for 60 s, discreet, yet distinguishable, question marks will emerge from the avatar’s head. This tool was embedded in the Student Voice HUD and was implemented using the Linden Scripting Language (LSL).

- **Idea Visualisation Tool** (Fig. 4d): This tool functions in a similar way to the query visualisation tool. When a student has an idea, s/he can easily express it by typing three exclamation marks in Local Chat (i.e. “!!!”). Light bulbs and the word “idea” emerge from the avatar’s head for 60 s. This tool was also embedded in the Student Voice HUD and was implemented using LSL.

- **Armchairs** (Fig. 4e): The armchairs were placed in the Fishbowl classroom and they can automatically adjust their color, depending on the user’s Jigsaw group, when a user sits in them.

- **Jigsaw Boxes** (Fig. 4f): Five different boxes were created (one for each group). These were placed in the group’s virtual collaborative working space (Jigsaw Rooms). The boxes contained: a) jigsaw shirts, b) additional clothes for students, and c) note cards with instructions on how to apply the clothing.

- **Gestures and animations stand** (Fig. 4g): The stand was placed in the exterior space of the plot, easily spotted upon a student’s entry to the environment. The stand contained: a) gestures, b) animations, c) poses and d) note cards with instructions, which could be utilised by the students.

- **Bulletin Boards** (Fig. 4h): Two Bulletin boards were placed at two different points on the first floor of the main building in order to assist novice SL users. These boards contained note cards with instructions on basic SL operations.

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**Fig. 4.** Some of the implemented visual metaphors.
4. Case study: evaluating collaborative learning in Second Life

This section presents the methodology of the evaluation, carried out by our Informatics Department, with the participation of postgraduate students in a virtual collaborative learning environment inside the SL platform. This environment integrates the virtual educational spaces, the specific tools and metaphors presented in the previous section.

4.1. Methodology

We chose to implement and evaluate the Jigsaw and Fishbowl collaborative learning techniques by implementing a blended learning evaluation approach. To enable the augmentation of the face to face training, a blended learning approach combines the use of distance learning methods in SL with the interactions which occur within a traditional classroom. Instructors mention that the blended learning model enables them to complete their educational goals more effectively than the traditional model. Moreover, most instructors note increased interaction with students and of the students between them (Garnham & Robert, 2002).

The research questions of this study, which were stated in the introductory section, define the dual aim of this evaluation. The first research question (RQ1) aims at determining the transferability of the Jigsaw and Fishbowl collaborative learning techniques in SL. On the other hand, answering research questions two (RQ2) and three (RQ3) aspires to uncover usability problems regarding both the SL platform and the designed learning space and also collect requirements for additional functionality in order to better support collaborative learning techniques in general.

We are examining both the online transferability of specific collaborative learning techniques and the platform’s suitability for distance education. By utilising the Jigsaw and Fishbowl collaborative learning techniques, students were asked to debate with regard to the information they had retrieved from various sources on the Internet (i.e., information retrieval and sharing).

Subjects of the experiment were postgraduate students attending the Educational Virtual Environments course of the Postgraduate programme in Informatics at our University. It would be unsafe to assume that the characteristics of this specific group of students correspond to the general student population of this level, we can however comment on the homogeneity of our subjects. According to questionnaires evaluating the previous experience of the users, we conclude that the majority of the subjects in the group were experienced in collaborating online through 2D interfaces. On the contrary, the majority of students were inexperienced in the use of 3D virtual environments for either education or entertainment.

The Jigsaw CL technique (Fig. 5) functioned as the backbone of the evaluation. Therefore, the case study was performed in three successive phases. The phases are briefly presented in Table 2 (striped cells mean that no action was taken), while the next sections describe them in detail. Each phase consists of distinct information on goals, pedagogy, data collection methods and results. The results will be analysed in detail in Section 5: Evaluation Results.

![Fig. 5. The Jigsaw and Expert Group formation methodology.](image-url)
4.2. Phase 1

The goals of the first phase were to: a) allow students to familiarise themselves with the capabilities of the platform, and with the available collaboration and communication tools, b) gather information regarding students' previous experience, c) organise the students into Jigsaw groups and assign study topics, and d) gather first impressions and usability requirements.

To achieve these goals, an introductory offline presentation regarding SL was given to the students. Following this, the students participated in a pre-test questionnaire. The students were organised into five Jigsaw groups (see columns in Fig. 5). Each Jigsaw group received a certain assignment in the area of VLEs. These included: a) design a VLE supporting learning through communities of practice, b) 3D virtual environments supporting CSCL, c) adaptive collaborative learning environments, d) a 2.5D adventure game as a VLE, and e) design a VLE supporting problem-based learning. After studying for a week, each Jigsaw group gave a presentation from within SL, through the Fishbowl technique.

To gather the required information regarding students' previous experience, students answered a pre-test questionnaire which inquired about facts such as previous experience with 3D VEs in general and Collaborative Educational Virtual Environments (CEVEs) specifically. Based on these results, the students could then be organised into formal (Johnson et al., 1991) homogeneous Jigsaw groups if necessary. In this way, during the evaluation process the participants would be able to relate to each other more easily and thus facilitate collaboration. Also, being of the same level, users could generally proceed in a more uniform manner. After the virtual session, face to face interviews were carried out, in order to collect information on first impressions, problems and suggestions.

Based on the interviews we concluded that first impressions were positive. However, several complications did arise. These included difficulties such as: a) finding someone, b) understanding who is speaking, c) putting on group clothing, and d) speaking in turns. Furthermore, the Fishbowl furniture arrangement was considered rather stuffy and some users experienced echo in the VoIP communication.

4.3. Phase 2

The goals of the second phase included: a) organising the students in Expert groups, b) the specialisation of students in specific tasks, and c) gathering usability, communication and pedagogy requirements.

Within the context of these goals, each Jigsaw group member selected a specific theme to specialise in. This theme is what defined the Expert groups (see rows in Fig. 5). The students could choose from four tasks to complete: 1) Review technologies supporting VLEs, 2) Collect VLE functional and usability requirements, 3) Review presentation and design methods of VLE scenarios (e.g., UML, use cases, etc.), 4) Review VLE evaluation frameworks. The deliverable of this second phase necessitated a presentation by each Expert team from within the SL environment, in the form of the Fishbowl collaborative learning technique.

In order to gather usability, communication and pedagogy requirements, the research team recorded and reviewed the virtual session. Furthermore, face to face interviews were again carried out in order to document problems and suggestions.

The results of the first phase were taken into consideration, by augmenting specific features of the platform. For example, the Fishbowl learning space was reorganised and virtual notes were handed out describing clothing functionality. Moreover, the student voice tool was implemented, alleviating confusion in VoIP communication. All these enhancing features were positively commented upon by the students.

4.4. Phase 3

The goals of the third phase were to let the students: a) conduct a final series of presentations, and b) evaluate the overall experience by submitting an online questionnaire.

Please cite this article in press as: Andreas, K., et al., Fostering collaborative learning in Second Life: Metaphors and affordances, Computers & Education (2010), doi:10.1016/j.compedu.2010.02.021
In the third phase, students returned to form their initial Jigsaw groups. Again, after studying for a week, each team had to present their work from within the SL environment, in the form of the Fishbowl CL technique. At the end of this phase, each group had to hand in its final deliverable, and each student had to answer an online questionnaire recording his/her experience and suggestions.

5. Evaluation results

This section presents and analyses the statistical conclusions derived from the answers on the pre and post evaluation questionnaire as provided by the participating students.

As described in Table 2, the results presented in this section were gathered from multiple sources. The two main sources of information are the pre and post evaluation questionnaires. Other sources include interviews and analysis of the in-world video recordings and text chat communication. By utilising the framework presented by Tsiatsos, Konstantinidis, and Pomportsis (2010), we chose to focus our evaluation on: a) Pre-analysis, b) Usability and c) Learning.

Pre-analysis is concerned with the technical and theoretical background of the target group. This information can be utilised to organise individuals into advanced and novice CVE users and determine learners’ learning styles if necessary. Usability involves the discovery of issues regarding the affordances of the most important parts of the user interface. Furthermore, problems concerning communication and collaborative operations can be uncovered. Finally, Learning collects further requirements and suggestions on additional functionality, discovering the pros and cons of the VE and determining the appropriateness of metaphors implemented through different kinds of learning scenarios.

5.1. Pre-analysis

According to Jarmon et al. (2009), future research would benefit from gathering data on the students’ levels of technical ability in SL prior to the educational activity under study. Based on this, we asked students to complete a questionnaire prior to participating in the evaluation. This questionnaire inquired about the technical and theoretical background of the students with regard to collaborative virtual environments in general.

After analysing the pre evaluation questionnaire responses, we gathered that the majority of students were in possession of a computer platform capable of running the SL environment. More specifically, all students possessed broadband network connections, 88% of them had a current generation PC, equipped with speakers and microphone for VoIP communication. With regard to previous experience, 72% of the students had used collaborative software in the past, while only 55% of them were experienced in 3D virtual environments.

5.2. Usability issues

Overall, usability issues were limited. However, regarding the available communication channels, the analysis of the questionnaires reveals the students’ preference of voice chat over text chat (94%). Moreover, the notes tool and the modeled 3D objects were both considered satisfactory and beneficial by the majority. On the other hand, students felt that SL hindered their ability to share resources among the group. Most groups utilised MSN in coordination with SL in order to collaborate more effectively.

The avatar clothing implemented by the research team was proven to be effective according to the questionnaire responses. For example, most students (93%) commented on the ease with which they could identify their group. This is thought to have augmented the overall collaborative mood of the teams (97%) and students agree that the new features implemented (i.e., armchairs, clothing, student voice tool) enhanced the potential of the collaborative activity.

With regard to avatar functionality, 60% of the students consider it important that the avatar representation is as realistic as possible and 85% think that SL’s avatar customisation feature is satisfactory. Also, most of the students believe that the avatar enabled them to interact effectively with others (79%), as well as with the available learning objects (86%). Relating to the avatar gestures, 69% of the students consider them instrumental in collaboration and communication.

Finally, according to the results, the major drawbacks of the SL platform are considered to be: a) the hardware requirements, b) discussion coordination, c) lack of impulsiveness, d) scalability, e) disorientation. Other problems included overhead (e.g., functionality familiarisation, avatar preparation), lack of shareable applications and limited interaction. On the other hand, the major assets of the SL platform are recorded as being: a) the novelty of the approach, b) distance learning support, c) multiple communication channels, and d) graphical representation.

5.3. Pedagogical/learning process issues

In general, by analysing the questionnaires answered, we can conclude a positive reaction regarding the overall experience of the collaborative learning techniques by the majority of the participating students. More specifically, over 70% of the students used the platform beyond the limits of the case study after familiarising themselves with it. The majority of these students document in their answers that they wished to explore the capabilities of the platform and witness the possible virtual worlds. Furthermore, 27% of the questionnaire respondents used the platform to meet and collaborate with their peers and work on the project that had been assigned to them.

On the other hand, the students are divided regarding the capabilities of the platform to support collaborative learning techniques, as opposed to the traditional face to face method. More than 40% of the students said that it was harder to collaborate through SL in comparison to the traditional method, while 50% of the students believe that the effectiveness of collaboration was reduced. In general, students find the traditional method easier (87%), more direct (93%), and more useful (62%). On the other hand, they find the SL approach to the collaborative technique much more interesting (87%).

Also, regarding the potential educational use of the SL platform by our department, 75% of the students would like to see more collaborative learning techniques being implemented and more than 80% of them would be interested in participating in online lectures.
Finally, more than half of the students said that they will continue to use the SL platform even after the collaborative activity was over for tasks including: collaboration (31%), entertainment (19%) and as a social platform (6%).

6. Discussion

This section will analyse, discuss and elaborate upon the results, with regard to the specific research questions introduced in previous sections.

6.1. Do students perceive SL as instrumental in the collaborative learning process?

We tend to agree with Freitas and Neumann (2009), in that learning is not always easy to assess or validate in formal contexts, because in particular with e-learning, immersive learning environments and simulations, it is often an open-ended, exploratory and experiential learning process. Although the pedagogic implications of our approach are difficult to evaluate, we can focus on the collaboration and communication aspects which are integral in every learning context.

Based on the evaluation results, we can compare the SL approach to two scenarios: a) face to face computer-supported collaborative learning, and b) distance computer-supported collaborative learning. According to Dillenbourg (2008), if face to face interactions are available anyway, the question is not how to imitate them but how to complement them. By analysing the students’ opinions we can conclude that the SL approach can in no way substitute face to face interactions. It can however supplement and/or augment them. These results are mostly due to the necessary learning curve introduced by a new medium, since SL functions (as every tool does) as a mediator. On the other hand, this disadvantage is not inherent in face to face collaboration.

With regard to distance computer-supported collaborative learning, we can conclude that SL improves upon previous approaches in the context of facilitating collaboration and communication. The evaluation results reveal an increase in student interest, participation and amusement. For example one student noted: “It was nice being able to watch the other teams collaborate, but I generally feel that coordination is harder and more time consuming in SL than in face to face.”

Finally, with respect to the evaluated collaborative e-learning techniques, we can conclude that due to SL’s lack of shared applications and limited file sharing capabilities, support of the jigsaw technique is restricted to an organisational and representational level. In other words, even though the necessary group dynamics of the jigsaw technique are sufficiently simulated, collaboration is not assisted to a sufficient degree. On the other hand, both the organisational and functional requirements of the Fishbowl technique are adequately met through metaphors, avatar representation and VoIP communication.

6.2. How does avatar representation influence collaboration and performance in student groups?

Based on the evaluation of the features we implemented with respect to avatar representation, we can surmise a beneficial impact to the communication, interactivity and usability capabilities of the SL platform. Furthermore, since communication, interactivity and usability are considered integral parts of collaboration, we can conclude the augmentation of SL’s ability to support collaborative learning.

Avatar gestures were highly commended by the majority of the students for their usefulness. However, it should be noted that compared to real life, SL’s gestures can appear faked or artificial. This observation is based on the fact that real life gestures are mostly executed subconsciously and in combination with speech. Therefore, the integration of gestures with the core communication mechanism of SL, with the goal of appearing more natural, could constitute future work.

In addition, it should be noted that avatar representation does not seem to scale well in SL. Major issues arise when in large crowds; these include finding individuals, distinguishing speakers, network lag and navigation. For example one student noted: “I knew who was speaking because I recognised their voice, but I couldn’t distinguish them easily in the crowd because when the avatars where close together their labels formed a cloud.”

Future research could focus on alleviating said issues through novel use of affordances and metaphors such as automatic perspective adjustment, crowd blending and interactive maps.

6.3. Which metaphors and affordances can be used to enhance learning space awareness?

According to Dillenbourg (2008), imitating natural situations has not produced better technologies or better learning. Interesting learning technologies have emerged where there is no traditional model to imitate. Therefore, success is often due to design features that make the interface even better than reality, while failure is due to lack of intuitive and creative uses of the interface.

Based on student testimonials, the implementation of group specific avatar clothing and group recognition armchairs seems to have enhanced collaboration and learning space awareness. Furthermore, implemented metaphors such as query and idea expression, although underused in the present study, hold the potential to augment representation, enhance perception and efficiently convey meaning.

7. Conclusion and future work

In general, we conclude that SL can effectively be incorporated as the online part of a blended learning approach. Moreover, based on the summary of results presented in the previous sections, we can conclude that the SL platform combines a rich feature set, facilitating communication and collaboration, improving upon performance levels as set by previous distance learning methods. However, in order for SL collaboration to be competitive in comparison to traditional approaches (i.e., face to face), existing metaphors and affordances must be augmented, and absent ones developed. Case studies, such as the one presented, can aid researchers in identifying the weak spots of 3D collaborative learning platforms and enhancing their pedagogical applicability based on user suggestions, comments and requirements.

Future research work includes the examination of several more CL techniques, in order to assess their applicability and effectiveness when applied through a 3D CEVE. More specifically, we can examine and increase the potential of CL techniques which have been tagged as
having low or moderate online transferability by the research community. By implementing specific functionalities and realising particular didactic approaches, we can effectively transfer these techniques to the 3D online environment. Finally, we can study the scalability of our approach in groups of 30 or more, which has yet to be determined in SL, as well as examine the sociological impact of avatar use on racial conflict.

References


