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PhD Thesis

Supporting Learning Activities in Virtual Worlds:  
Methods, Tools and Evaluation

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*To Abdallah,  
for his continuous support and care.*

*To my kids,  
for their smiles and fun.*

*To my parents,  
for their patience and prayers.*

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*Sharefa Murad*  
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## Abstract

Continuing advances and reduced costs in computational power, graphics and network bandwidth let 3D immersive multi-user Virtual Worlds (VWs) become increasingly accessible while offering an improved and engaging quality of experience. Excited at the prospects of engaging their Net Generation, students and educators worldwide are attempting to exploit the affordances of three-dimensional (3D) VWs. Environments such as Second Life (SL) are increasingly used in education, often for their flexibility in facilitating student-directed, self-paced learning and their communication features.

Research on the educational value of VWs has revealed their potential as learning platforms. However, further studies are always needed in order to assess their effectiveness, satisfactorily and social engagement, not only in the general didactic use of the environment, but also for each specific learning subjects, activities and modality.

A major question in using VWs in education is finding appropriate value-added educational applications. The main challenge is to determine learning approaches in which learning in a VW presents added value with respect to traditional education, and to effectively utilize the third dimension to avoid using the environment simply as a communication platform. In addition, the educational VW activities become more and more sophisticated, starting from the early ones based only on information displaying and teaching resources to simulated laboratory and scenarios. The more complex the learning activities are, the more the challenge of guiding students during their learning trajectories increases and there is the need of providing them with appropriate support and guidance.

The main contributions of this thesis are summarized as follows: (i) we propose an appropriate value-added educational application that supports individual learning activities effectively exploiting the third dimension. In particular, we adopt a VW to support the learning of engineering practices based on technical drawing. The proposed system called VirtualHOP trains the students in the way of learning-by-doing methodology to build the required 3D objects; (ii) we enhance an helping system with the avatar appearance and AI for helping the exploration of environments and fruition of distance didactic activities in SL; (iii) we empirically evaluate the didactic value and the user perceptions concerning both the learning setting and the avatar-based virtual assistant. The results demonstrate the usefulness of both the didactic experiences offered in SL and a positive attitude of the learners in terms of enjoyment and ease-of-use.



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# Chapter 1

## Introduction

### 1.1 Research context and motivation

Recent advances in educational technology are offering an increasing number of innovative learning tools. As Bonk *et al.* [12] reveal: "recent technological developments have converged to dramatically alter conception of teaching and learning process". Among these, 3D virtual worlds (VWs) represent a promising area with high potential of enhancing the learning activities.

VWs have an important role in modern education practices. Indeed, training in VW can provide a rich, interactive, engaging educational context that supports experiential learning-by-doing; it can, in fact, contribute to raise interest and motivation in trainees and to effectively support skills acquisition and transfer, since the learning process can be settled within an experiential framework. As Bruner highlighted [15] "performing the task enhances the learning process"; VW can provide a medium to learn by doing, through first-person experience.

Current virtual training applications in VW differ in terms of their technological/multimedia sophistication and of the types of skills trained, ranging from synchronous lectures and group work using virtual board to Virtual Labs.

According to Winn [136] the real added value of VW consists in the possibility for students to learn through first-person experience by the means of interaction and immersion. First-person experiences play a central role the daily activity in the real world and our learning about it. Similarly, virtual environments allow for constructing knowledge from direct experience by giving the participants the "perceptual illusion of non-mediation" between them and the computer [78].

As far as changes in educational culture are concerned, 3D graphics technology is not intended to entirely replace conventional classroom teaching techniques; nevertheless, as Dean *et al.* [31] point out, "properly implemented virtual environments can serve as valuable supplemental teaching and learning resources to augment and reinforce traditional methods." Anyway, good design and implementation are surely not enough to ensure effective results: the learning potential of the actual VW experience must be constantly integrated and managed by the teachers within the actual educational context.

## 1.2 Research problem and question

The potential of e-Learning to support individual learning processes and life-long-learning need not to be investigated anymore. Nowadays, the issue is to find pedagogical concepts and application domains that tap the provided potential fully. This requires high quality structured information and a modification of the traditional teacher and student roles into the roles of assistant and knowledge seeker, respectively.

A major question in using VWs in education is finding appropriate value-added educational applications. Two challenges have been identified. First, determining situations in which VW learning presents value beyond what traditional education can provide. Second, determining how to effectively utilize and adapt these worlds to support learning of different concepts and skills involving educators and developers at the same time.[84].

Second Life (SL) and other VWs are characterized by inducing a strong identification between the users and their avatars [67]. As a consequence, it appears natural exploiting this feeling to amplify the perceived quality of individual didactic experiences and to verify whether the VW setting influences user perceptions. For this aim, the following research question has been formulated:

**RQ** *Do Virtual Worlds satisfactorily and effectively support individual learning activities?*

It is important to emphasize that the focus of an effective educational experience should be on "learning", while many uses of VW are focused on "teaching" aspects: VW hosts synchronous distance lessons, conducted by projecting pre-loaded slides [30]. Thus, the current use of SL in education utilizes the environment as a communication platform and information display. In particular, the majority supports only group discussion [51], conferencing with slides [35] and group work in a meeting [79] activities.

However, analyzing the research question and the didactic usage of virtual environments in the literature the following lacks have been identified:

- Few didactic works effectively use the VW *Third Dimension* in an innovative way.
- *Individual Learning* activities generally propose simply content fruition.
- Few evaluations are focused on the didactic effectiveness of the proposed learning approaches. They are mainly related to the specific VW characteristics, such as *Presence, Awareness, Comfort with Communication* and *Belonging to Community Perceptions*.

## 1.3 Research contribution

This section presents the research contributions of this thesis derived from the analysis of the research question defined above.

### 1.3.1 Supporting Individual Learning Activities

We propose an appropriate value-added educational application that effectively support individual learning activities, while exploiting the third dimension of the VW. In particular, we developed a Virtual Lab supporting young students in the learning of technical drawing. This environment, named VirtualHOP, aims at improving the comprehension on the drawing of Orthogonal Projection by fully exploiting the three dimensions of the SL environments.

Orthogonal Projection graphical technique synthesizes a 3D object projecting its shapes on several views that resume the object profile on a 2D plane. According to its complexity, an object can be represented with a number of projections ranging from two to six [18].

In general, technical drawing requires neophytes to think in three dimensions while drafting the objects in two dimensions. The main difficulties perceived by learners are in moving from/to the two dimensional graphical environment to/from the reality [86], [103]. Field [39] argues that knowledge of drafting develops thinking in three dimensions (3D) and communicating in two dimensions (2D). He recognises the difficulties learners have in moving from two dimensionally dominant interactions into three dimensions through the principles of drafting to interactive solid modelling.

Sorby and Gorska [120] suggest that the physical nature of the drafting experience develops a deeper understanding of the meaning of lines and symbols on a page and helps to develop the ability to make mental conversions into 3D realities. In these scenarios Orthogonal Projections represent a first step toward drawing skills. The Orthogonal Projection graphical technique stresses all these points since students are always facing various problems connected with representing a 3D reality on a 2D medium. In some way, they need to understand how a flat image on the retina leads to the perception of three dimensional object, as well as coping with the problem of recovering the three-dimensional object that caused the image.

A strong contribution for teaching technical drawing may be provided by a VW, since these environments are usually equipped with construction facilities for their users and are, for their nature, a 3D representation on a 2D screen.

Following these needs, we design a VW setting specific for developing the orienteering and synthesizing capabilities required to a technical drawer. In particular, we propose a system that supports the creation of simple 3D objects starting from their orthogonal representation and drives the students in the dimensional shift required by the drawing process (from 2 to 3 dimensions and vice-versa) with a specific didactic activity.

### 1.3.2 Assisting the Didactic Activities

VWs training actions are not limited to class time: the teaching resources are available 24 hours, 7 days a week and it is almost impossible to provide a tutor for assisting the students whenever they access the didactic world.

The Unisa Computer Science Island [81] that hosts the VirtualHOP is a SL setting in which several distance didactic actions have been experimented, ranging from in presence distance lectures [81] to virtual labs [93] and groups collaboration activities [80].

Because of the variety of settings and activities offered in this Virtual Campus, a novice student can feel lost in the Virtual Space. To this aim, we created a visitor assisting system, named AIBot, embodied into an SL avatar, which supports the newcomers in their



learning experience and also ensures the presence of at least one inhabitant, avoiding "the lonely island" phenomenon that can affect an SL setting.

The main contribution of AIbot, differently from traditional helping systems, is that it has third dimension appearance that exploits VW presence and awareness perceptions to be better integrated in the environment and accepted by the learners. In this way, AIbot adopts the same interaction style that all the users have when moving and communicating in VWs, but it is controlled by an Artificial Intelligence engine.

### 1.3.3 Evaluation Of The Proposed Approaches

To answer the research question **RQ** we evaluate the didactic value and the user perceptions concerning both the individual learning setting and of the avatar-based virtual assistant as following:

- **VirtualHOP Evaluation:** two evaluations has been performed. (i) A first subjective evaluation provided positive results in terms of user performances and impressions [93]: the VirtualHOP environment enhances the student experience with a synthetic view of space and objects that helps them during successive hand writing sessions as a good mental model of Orthogonal Projections drawing activities. (ii) An empirical evaluation, conducted as a controlled experiment, objectively evaluated a didactic experience that presents the concepts behind Orthogonal Projection by naturally exploiting the SL third dimension [92]. The evaluation task was a learning-by-doing activity where learner had to reproduce an existing 3D object sample composed of primitive basic 3D objects like cubes, pyramids, cones, etc. to clarify the relation between the concrete artefact and its Orthogonal Projections.
- **AIbot Evaluation:** we investigate on (i) how the VW environment influences the learner perception of Artificial Intelligence when embodied into an avatar and (ii) whether AIbot satisfactorily supports individual didactic activities in SL. To this aim, two evaluations have been conducted. The first has been performed as a modified Turing Test (TT) in a Virtual Lab. The aim is to evaluate the AIbot system when its intelligent behaviour interacts in a learning VW with respect to the perception of the same discussions through a traditional interaction modality based on a text chat. The evaluation is based on the student perception and intelligence performance comparison.  
The second AIbot evaluation aims at investigating whether it satisfactorily supports an individual learning activity, specifically a technical drawing activity proposed in a SL Virtual Lab.  
The first evaluation results revealed that the learning environment enforces the human credibility of the virtual assistant while the second evaluation showed a positive attitude of students towards the AIbot adoption in terms of enjoyment and ease-of-use during individual learning activities.

## 1.4 Thesis organization

This thesis is composed of 6 chapters including this chapter. The rest of this thesis is organised as follows:

- Chapter 2 discusses the state-of-art of the use of VWs environments in education, followed by a detailed description of the Unisa Computer Science Island activities in SL.
- Chapter 3 gives an overview on technologies used in this thesis, describing SL features and the avatar anthropomorphic characteristics contribution in e-learning activities. Then, it explains the ChatBot technology, highlights its state of the art, comparing its use with the bot presented in this thesis. After that, it presents basic definitions and concept of the Turing Test (TT) methodology adopted to evaluate Chaterbots performances.
- Chapter 4 represents the core approaches discussed in this thesis;
- Chapter 5 shows the evaluations of the proposed approaches through several case studies.

Finally, Chapter 6 gives conclusion remarks and directions for future work.



## Chapter 2

# Virtual Worlds and Education: State-of-the-Art

*"[...] thoughtful application of VW technology will significantly enhance the experience and transfer of learning."*[25]

This chapter reports previous works on the use of 3D worlds in education. In particular, it describes several didactic experiences and evaluations on the VWs support carried out by different researchers.

3D VWs are of great research interest since they support various forms of learning and collaboration. This is mainly due to some specific characteristics of this kind of environment that favour the creation of persistent, avatar-based social spaces. One of these characteristics is the support provided to the users' notion of space, obtained through a three-dimensional environment where objects appear and events take place in specific positions and directions [49]. However, a 3D VW goes beyond providing a mere perception of space since they allow users to construct their own permanent world within that space, which can be populated by other users who are co-present through their avatars. This way, users act, converse, exchange and continually introduce in the virtual environment new social meaning, convention, roles, and events. Due to these specific characteristics, 3D VWs acquire the property of a place, transforming the environment into something more than a 3D space that becomes familiar to the user and where social interaction among remote users, virtually in co-presence, naturally occurs [102]. According to the same author, these places can be characterized as adhering to three different criteria: outlook, structure and role. In this way, the outlook provided could be a realistic one, when it reproduces a place that exists or could exist in the real world, or an abstract or fantasy one. With regard to the structure, both the physical structure as well as the social structure should be considered. The former refers to the structure of the virtual physical elements of the environment, and the latter to the ownerships of the objects or building as well as the way of leaving the traces of social activities in the place.

Finally, with regard to the role, these virtual environments can be designed to serve as meeting places, information spaces, virtual stages, demonstrations or exhibitions, and workplaces [102]. The sensation of being in a place makes 3D VWs an appealing tool for supporting learning activities. Firstly, it induces a strong sensation of presence, meaning that the learner experiences the perception of being in the place specified by the virtual environment, rather than just watching images depicting that place [50], [116], [137]. The stronger this sensation is, the more meaningful the experience is and therefore the greater

the immersion of the learner in the task performed in the VW. These conditions are in line with the ones required to support situated learning [14], during which the learners would acquire knowledge and skills through their application in a realistic situation, which could be replicated in the VW. Secondly, the avatar representation of the users increases the awareness of the experience and the feeling that other users are really present in the environment [111]. This means that users can not only locate themselves in the place but also they can locate other users and understand what they are doing (action awareness). This makes possible contextualizing the learning experience as a social-cultural practice by replicating not only the appearance of a real situation but also the interactions among the actors that would participate in that situation.

The use of 3D VWs can also report benefits in terms of the motivation of the learners, as their specific features provide the means for designing intrinsically motivating learning environments in accordance with the taxonomy of Malone and Lepper [83]. In this way, they clearly support individual motivation factors for learning including sensory curiosity, fantasy and control. Interpersonal motivation for learning such as cooperation and collaboration are also achieved by the sensation of being in a place where social communication can occur. This sensation is enhanced by the support provided by most 3D VWs to non-verbal communication, which allows the representation and perception of facial expressions, gestures, body and hand movement, etc. [68]. Since the results of the activities carried out by a learner are visible to other people, the motivation of having our efforts and accomplishments recognized and appreciated by others is also well supported.

Moreover, it has also been claimed that 3D virtual environments can help to acquire spatial knowledge [134], and that they can be useful in dissolving social boundaries which, in turn, might lower social anxiety [59]. The user perceives the learning environment as a virtual social space where she/he can socialize and collaborate with other users, which is essential to improve learning [10], and facilitates the creation of communities [121].

The potentiality of the use of VWs for supporting learning process is therefore appealing, and this fact has not gone unnoticed in the research community. However, despite the considerable amount of experiences carried out, specific findings on the efficacy of VWs as didactic tools is somewhat lacking and needs to be further investigated, as some of the claimed benefits associated with their use are still subject to discussion.

In order to facilitate the analysis and comparison of the results produced in the literature we have classified them in three groups based on the social component of the experience and the roles played by their participants, as detailed in the following of this chapter, where also considerations on previous evaluations of didactic use of VWs are reported.

## 2.1 Collaborative Learning Activities

Collaborative learning is a popular instructional method which relegates the instructor to a role of supervisor while it emphasizes the importance of social interactions among the students during the learning process. This way, students work together toward a common goal, obtaining benefit from the exchange of ideas and perspectives and devel-

oping transversal competencies as communication skills. When the collaborative task carried out by the students is to some extent supported by an information system we can talk about Computer Supported Collaborative Learning (CSCL). 3D VWs offer vast possibilities for supporting collaborative work and learning, because they were born as online multiplayer games with the functions of a social network [35] and this, therefore, allows for the structuring of activities characterized by a common goal.

Several experiences have been conducted exploring and evaluating these possibilities. For instance, Mason and Moutahir [85] presented the Global Outreach Model, a service learning, project-based, educational experience where the student teams identify a social issue and develop a technological solution to help solve a real world problem. Without using a formal assessment method, researcher concluded that SL is suitable for interdisciplinary team-based projects. As another example, in the experience conducted by Chang *et al.* in [19], students had to work together on a collaborative essay writing exercise. In this experience the importance of being previously acquainted with the environment was highlighted, as was the importance of collaborative tools in obtaining a successful experience.

Another example of collaborative learning is provided by Wrzesien *et al.* [140], where a serious VW for teaching children natural science and ecology is presented and evaluated. Students are involved in both collaborative and competitive play and revealed greater enjoyment and engagement respect to a traditional class.

An eye tracking hardware has been adopted as a method of investigating immersion in VWs [122]. The study investigated immersion in a gaming environment (RuneScape) compared to social world interactions (SL). The evaluation revealed an increased end-user focus in RuneScape, while the social aspects of the SL environment were positively considered, but can provide distraction.

The Second DMI campus had also been used for supporting several collaborative learning activities. In [81], the virtual campus was adopted to support an experience based on the well-known instructional technique of the jigsaw classroom. Each participant of the experience played a different role, such as meeting leader, participant, minute taker or speaker. Each role was assigned with a set of tasks that should be carried out using four virtual interactive whiteboards which all participants shared and used collaboratively. The same set of roles was used in the learning activity described in [80], in which participants had to collaborate to inspect and analyse pieces of code written in C programming language. In addition, in the experience described in [30] the third dimension provided by SL was fully exploited as the participants had to collaboratively program SL 3D objects, using the "pair programming" technique typical of extreme programming practices.

All these controlled experiments have shown positive performance results as well as positive student impressions. In fact, students participating in distance collaborative activities obtained results productively comparable with the same activities conducted in a face to face modality [80]. Details of the results of the evaluations can be found in [81], [80] and in [1], but it is worth noting that in addition to the satisfactory responses obtained in terms of sense of perception of belonging to a community, presence and immersion, the results concerning the ease of communication are of particular relevance. Indeed, communicating in the proposed collaborative environments was perceived as being just

as comfortable as in face to face situations. The communication modality offered by SL seems to make it easier for subjects to participate, even in cases where there are differences of opinion within the discussion group. Interestingly, the open comments in the questionnaires revealed that this is due to a key characteristic of such a virtual environment which interposes the avatar filter among human interactions.

## 2.2 Direct Instruction

Direct instruction is probably the most popular teaching strategy. Although there is no universally-accepted definition, the term direct instruction usually refers to an educational process characterized by a strong presence and dependence on the teacher, who is in charge of guiding the learning process of the student by providing, sequencing and explaining the learning content, and taking corrective actions when required. The direct instruction paradigm is strongly linked with lecturing, as lectures and presentations are the most commonly used method for presenting and explaining the learning material to the students. In this kind of activity, the use of VWs offers interesting possibilities as it allows geographically distributed students to follow the same lecture, while maintaining levels of presence and awareness difficult to achieve in 2D virtual environments. These possible outcomes have been analysed by different authors which have conducted lectures either in SL based virtual environments [77] or in other VWs such as CLEV-R [90]. The results of these experiences are mostly encouraging. For instance, 78% of the participants of the experience described in [90] reported to feeling a sense a community, and a 100% of them reported being engaged and interested during the experience. These positive results have also been confirmed in [81] a total of 26 students participated in three different lectures carried out in the virtual campus. The aim of the experience was to analyse the student's impressions concerning presence, awareness, communication, comfort with the virtual environment and sense of belonging to a community. The results obtained were mainly positive for all the factors analysed. Indeed, participants also reported finding it easier to communicate with the teacher in this environment by using only SL textual chat, while the teacher used the vocal chat for lecturing and answering [81].

## 2.3 Individual Learning Activities

This kind of activities is strictly related to this thesis work investigating whether VWs can also be used to successfully support learning processes the learner is required to undertake on his/her own, neither in the presence of a tutor nor in collaboration with his/her fellow colleagues, and thereby does not exploit the social dimension provided by this technology.

In the literature there are several examples of this type of use of VWs, such as navigating around a virtual museum, like NASA's International Spaceflight Museum [96] shown in Fig.2.1. This virtual museum is placed in SL and hosts exhibitions and events about real-world spacecraft, rockets, and space missions. Among the different learning activities supported by this virtual space, one which particularly stands out because of the immersive effect it has on the user is the option of experiencing a walk on Mars or a tour around the solar system, something that would be difficult to obtain using other technologies.



Figure 2.1: NASA's International Spaceflight Museum

VWs can also be used to set up experiences which help learners to understand phenomena not visible to the human eye and to relate them to the physical world. For instance, the Virtual Labs described by the authors of [109] allows a student to visualize using augmented reality techniques the magnetic and/or electric field lines around a small magnet, as shown in Fig.2.2. The control of the experiment was performed using a VW created using the Wonderland Project. VWs can also be used for implementing more traditional individual learning activities, such as the ones supported by a Learning Management System (LMS).

The Sloodle (Simulation Linked Object Oriented Dynamic Learning Environment) platform was proposed by [76] and is supported by the San Jos State University School of Library and Information Science. It allows for the integration of a Moodle instance in a VW, like SL or OpenSIM, providing links to many of its functionalities through different 3D objects. Some of the key features (individual and collaborative) provided by Sloodle are the following:

- *Web-intercom.* A chat-room that brings Moodle chatroom and SL chats together. Students can participate in chats in SL using the accessible Moodle chatroom. Discussions can be archived securely in a Moodle database.
- *Quiz tool and 3D Drop Box.* The assessment is performed in SL, while the grades are visible in Moodle. Quizzes or 3D modelling tasks are set in a 3D environment. Figure 2.3 shows a quiz session in SL using the Sloodle Chairs. Grades are quickly and easily reviewed in the standard Moodle gradebook.





Figure 2.2: The Magnetic Virtual Lab

- *Multi-function SLOODLE Toolbar*. Enhances the SL user interface. Use a range of classroom gestures, quickly get a list of the Moodle user names of the avatars around or write notes directly into to your Moodle blog from SL.
- *Presenter*. Quickly author SL presentations of slides and/or web-pages on Moodle. Present in SL without having go through lengthy processes to convert or upload images.

## 2.4 Effectiveness Of Learning In Virtual Worlds

In order to identify the effectiveness of VWs as learning environments Ketelhut *et al.* [65] designed a scientific experiment in the virtual environment, which was called "Rivercity". They found the same effects in a virtual environment as in a real lab. They concluded that the virtual experiment is significant in its effectiveness in terms of instructional design. Teachers and students who participated in this inquiry recognized this environment as an instructional process, not just as a changed instructional method. As a result, it is possible to conduct scientific experimentation without laboratory materials. This analysis implies that virtual environments may harness diverse types of learning which are available for authentic learning experiences.



Figure 2.3: The Sloodle Quiz Chair

Shen and Eder [115] examine students intentions to use the VWs for education, based on the Technology Acceptance Model<sup>1</sup> (TAM). They reconfirm the TAM process in VWs. Computer self-efficacy makes learners recognize VWs as a useful tool in learning and, in turn, satisfaction and behavior are affected through this process. In order to experience enhanced learning students should recognize the ease of use of VWs and perceive the usefulness of VWs in terms of TAM. In addition, students ability to control this technology should be ensured and guidance on how to use this media when we design instruction within this environment should be provided.

Barab *et al.* [8] developed a virtual learning environment similar to River City, named Quest Atlantis (QA), a project-based learning environment based on various quests. The quests were designed to engage students in authentic and complicated situations to improve problem-solving ability within the virtual space. Students practiced various problem-solving strategies such as ecological, ethical and social. They focused their attention on the results, demonstrating that such three-dimensional virtual environments facilitate motivation, engagement and various learning performances. Annetta *et al.* [4] reported that students were satisfied with their learning in VWs. Students reported that the environment was effective for distance education.

A significant body of research related to the effectiveness of using VWs has been conducted on diverse topics (examples: [129], [34], [115], [141], [98], [107]). These works examined the VWs characteristics, such as presence, context awareness, comfort with communication, etc., in affecting the didactic flow. Such a variety of research implies that we should consider this environment as a significant learning environment and exploit this as a new learning tool. Further details of the VW features and there influences are reported in the Background Chapter 3. Implications based on this research are that the characteristics of VWs should guide those who want to design instruction utilizing this environments in order to maximize students satisfaction of learning. In this sense, Nelson

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<sup>1</sup>TAM is an information systems theory that models how users come to accept and use a technology. The model suggests that when users are presented with a new technology, a number of factors influence their decision about how, when they will use it. Davis [28] presented that perceived ease-of-use (PEOU) and perceived usefulness (PU) affects users intention to use. And users PEOU affect PU.

[94] states that guidelines of instruction are required for learning in VWs, admitting that to utilize VWs as a simple tool is like using a boat without paddles on the sea.

Dickey [32] also identified that distinguishing VW features are 3-D space, avatars and the interactive chatting environment; these features have an "affordance" applicable to constructivist distance learning environments. However, in terms of their applicability, she suggested that we should use support from empirical research on how to design instruction utilizing VWs, and how people learn within this media. Therefore, we need to summarize research on which characteristics of VWs influence students flow experience and implement empirical research for proving these relationships. Based on such research, VW learning environments should be designed so that students can develop and maintain their optimal experiences in learning [21].

# Chapter 3

## Background

The cornerstone of this thesis is based on VW environment characteristics that provide a rich learning platform for distance learning activities. In this chapter, the technologies used are presented in order to put the work described in this thesis in a wider context. In particular, we introduce the VWs technologies with a brief caption of SecondDMI Island in SL where the presented work of this thesis is held. The second section discusses the main characteristics of SL environments, and describes how the sense of *Presence*, *Awareness*, *Communication* and *Belonging to a community* features of SL supports our didactic settings development. Then, we explain the ChatBot technology, highlighting its state of the art, comparing its use with the bot presented in this thesis. After that, we present the basic definitions and concepts of the Turing Test (TT) methodology used to evaluate Chatterbots performances. In this context we also discuss its structure and modified versions.

### 3.1 3D Virtual Worlds Technologies

Nowadays there exist a wide variety of platforms for design and create 3D virtual environments. Many of these worlds have been created just for entertainment purposes, such as the popular Massive(ly) Multiplayer Online Role-Playing Games (MMORPGs). On the contrary, other worlds do not have a specific purpose other than provide a space where users of different ages; distributed in different locations can all gather and socialize. Examples of popular social worlds are Habbo Hotel, Active Worlds, VZones, Moove, and Coke Studios.

The users of VWs take the form of customizable avatars graphically visible to others and are often connected each other with text or voice chats. These avatars can be depicted as two-dimensional or three-dimensional graphical representations ranging from the most realistic to the more fictional ones.

In [82], Macedonia foresees, on the basis of the current web technological explosion trend, the fulfilment of the visions of Neal Stephenson's science fiction classic *Snow-Crash*, and foresees a near future in which "the 3D internet worlds will be part of our everyday reality as cell phones and e-mail are today". Also Hendaoui *et al.*, in [53], affirm that "eighty percent of active Internet users will have a 'second life' in a Virtual World by the end of 2011". Resuming these affirmations we can imagine that 3D web VWs may really represent a likely hypothesis on the future of the web and it can be easily foreseen how the evolution of web exploration scenarios and interaction metaphors will go towards

more natural real world practices and attitudes.

Since the 1970s some of these general-purpose VWs have been adopted to support education activities [76] to a different extent. Messinger *et al.* [87] identifies over 80 educational worlds, which have been created for the specific purpose of supporting education and providing training in several educational areas. One of the oldest 3D VWs of this type is Active Worlds<sup>1</sup>, which was originally released in 1995 and nowadays is able to offer a very realistic environment for in-class activities, and a range of features for importing educational content.

Another example of this type of world is Forterra that, based on the Online Interactive Virtual Environment Technology Platform <sup>2</sup>, targets large institutions offering them scalable 3D VWs for supporting training-through-simulation and collaboration for e-learning in military, healthcare, and entertainment areas.

Nevertheless, the most popular choice for conducting this type of didactic experience is still Second Life<sup>3</sup> (SL). According to [88] there are at least 300 universities around the world that teach courses or conduct research inside the VW of SL. With regards to open source platforms two interesting alternative are Open Wonderland<sup>4</sup> and Open Simulator<sup>5</sup>. The latter allows setting up 3D VWs in personal servers that can be accessed using the same viewer as for SL, and which can also be connected creating a grid of sims, in a similar way as the islands of SL create the archipelago metaphor.

Nevertheless, at present, these 3D VWs do not yet provide the same graphical quality and the avatar features offered by SL, and also present some problems of scalability. On the other hand, they can easily overcome some of the drawbacks that proprietary 3D VW exhibit. For instance, SL does not allow application sharing whilst in the Open-Wonderland users can easily create meeting rooms which contain different boards for collaboratively editing text, drawing diagrams, etc.

Resuming, when designing a learning environment, didactic specialists must take into account the special features of the actual learners: in a fully technological enabled environment it is crucial to take advantage of all the abilities of today's students, which can be considered, in the most part, technology power users<sup>6</sup>. Today's students have grown with Internet and video games and are usually very practiced in MMOGs and instant messaging and it is natural and pleasant for them to adopt these environment's metaphors for cooperating and learning. Power Users embody and extend all typical features of Web 2.0 users: they learn by experimentation, are self teachers, and build their competencies on the knowledge of others by sharing information.

### 3.1.1 SecondDMI in SL

In the last years several research efforts have been devoted to the development of a SL Virtual Campus, named SecondDMI [81], depicted in Figure 3.1(a), on the Unisa Computer Science Island. A picture of this island is shown in Figure 3.1(b).

The design of the virtual campus was carried out by the authors of the University of Salerno following a realistic approach, which is the most popular design approach

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<sup>1</sup>Active Worlds: <http://www.activeworlds.com>

<sup>2</sup>OLIVE: <http://www.saic.com/products/simulation/olive/>

<sup>3</sup>Second Life: <http://secondlife.com>

<sup>4</sup>OpenWonderland: <http://openwonderland.org>

<sup>5</sup>OpenSim: <http://opensimulator.org/>

<sup>6</sup>Technology Power Users: <http://powerusers.edc.org/aboutpu.htm>

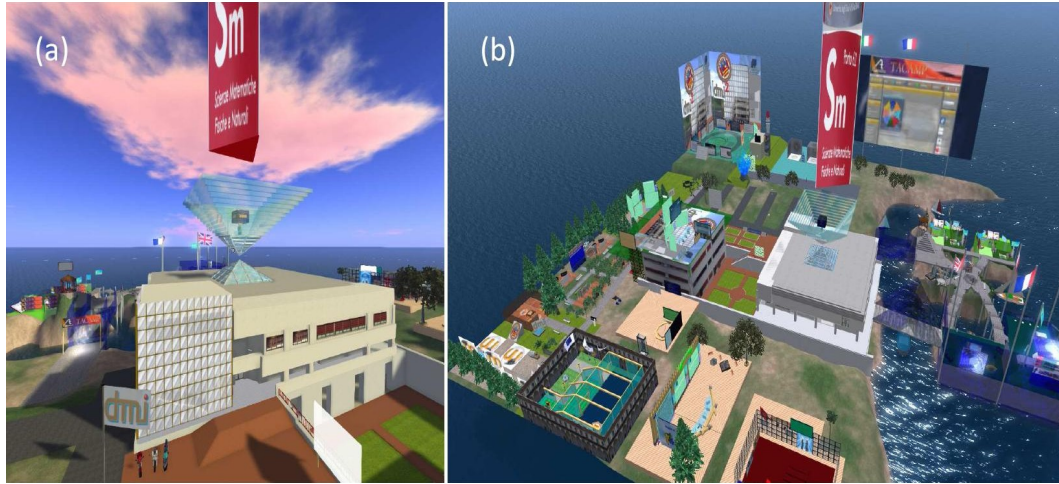


Figure 3.1: (a) The SecondDMI building (b) The Unisa Computer Science Island full view

according to the results of the study presented in [60] in which the virtual presence of 170 accredited educational institutions in SL was analysed. Authors of this same study made a distinction between realistic campuses, according to whether they were operative and reflective virtual campuses: in operative campuses the institution’s mission is maintained in a virtual location that does not replicate the real world whilst in reflective campuses, the real campus layout and its buildings are to some extent reproduced, providing several connections between the virtual campus and the physical real environment.

The design of the SecondDMI Island combines characteristics of both types of virtual campuses. In this way, it was not only designed to support didactical experiences carried out by Computer Science students of the University of Salerno, but also reproduces the physical building of the Department of Mathematics and Informatics (DMI) of the University of Salerno, to give the students the perception to belong to their real community and to be in a place connected to their educational institution, while other environments are fantasy places. Some of the DMI classrooms were reproduced with a high level of detail. Avatars could open the doors of the classrooms and sit on the chairs, as they would do in the real campus.

An example of fantastic setting is the glass inverted pyramidal conference room depicted in Figure 3.1 (a), which allows users to carry out virtual meetings, avoiding the difficulty of directing avatars into an indoor environment. In particular, SecondDMI proposes four distinct types of virtual spaces: common student campus, collaborative zones, lecture rooms and recreational areas. An ad-hoc developed Moodle plug-in has been integrated in SL to provide LMS services. SL environments and objects have been designed and programmed to support synchronous lectures and collaborative learning. The SL environment has also been equipped with multimedia tools enabling students and teachers to navigate among multimedia contents.

The effects of the activities proposed in these environments on the students have been evaluated in the case of synchronous distance lectures and collaborative activities. De Lucia *et al.* proposed SLMeeting, a hybrid system hosted between SL and an external

Moodle based web site [80] [81]. Detailed description presented in the state of the art chapter 2.

## 3.2 Second Life-related user perceptions

VWs have distinct media characteristics, not only complementing web based learning environments weaknesses but also enhancing their strengths [48]. Abundant previous research indicates that this media fosters students motivation and engagement. There are diverse descriptions of VWs advantages such as motivational, engaging, fun and enjoyment, all of which converge into students flow due to their unique characteristics.

Bricken [13] reports that virtual environments could possibly provide learner centered interactivity with knowledge. Omale *et al.* [98] contends that visually appealing, animated and interactive interfaces such as three dimensional space, avatars, and comic style bubble dialog boxes promote students motivation. Dickey [33] lists three dimensional graphical user interfaces, anonymity, real-time communication, identity, interaction, and explorable spaces as VW media features. Shen and Eder [115] also point out that the gamelike three dimensional interface of VWs affects learning motivation due to the playfulness of the game. Tuzan [129] categorizes thirteen factors as motivational elements in VWs. Furthermore, he points out several factors related to media characteristics: identity presentation, social interaction, immersive context, ownership, and control, which affect learners motivation.

Wu *et al.* [141] focuses on the media features of online games. They conducted an empirical research on why learners are engaged in online games, which features engage learners in online games, and how they are correlated. They found that game story, graphics, length of game and control elements of game affect learners engagement.

Most studies showed that students have experienced flow in learning through VWs. Furthermore, here is a complementary assertion. Sancho *et al.* [107] conducted an empirical inquiry to answer the question "Do these media really enhance motivation?" They indicate that previous researchers have represented possibilities of this medias enhancing motivation. However, those researchers have not found an explicit answer as yet. They developed NUCLEO framework which included a 3-D interface and LMS (Learning Management System), so that learners could study by facilitating motivation, self-centered learning and collaborative learning.

Mare Monstrum is a virtual learning environment developed by Sancho *et al.*. It includes a GUI, avatar, and graphic tools among the VWs features. From this research, they found that 3D GUI and Game features significantly influence learning, but VoIP (Voice over Internet Protocol), textbased chatting environment do not affect learning effectiveness. The reason of these results was due to the fact that the majority of students were unfamiliar with chat for educational purposes.

Summarizing, social learning aims at supporting students in the interaction with other people, such as teachers or fellow students (real or computer-simulated), during learning activities [22]. One of the virtual places where this happens is SL. SL is an interactive VW in which its inhabitants create their own avatar that represents themselves in the interaction with the simulated world and with the alter egos of other people. Exploring SL drives users in a mixture of worlds ranging from extreme realistic to very fantastic places. Due to the feeling to be in a place where social communication happens, SL has a significant advantage over virtual communities based on "2D" technology: SL



induces a strong sensation of presence and awareness, enforces communication and also the perception of belonging to a community [81].

In next subsections we detail how the SL features and the avatar anthropomorphic characteristics may contribute to increase the social dimension of e-learning activities.

### 3.2.1 Presence

*Presence* is the sensation to be part of the virtual environment, feeling of "being there". This expression denotes the perception of being in the place specified by the virtual environment, rather than just watching images depicting that place. A strong presence perception provides a more significant experience. 3D environments have a significant advantage over virtual communities based on "2D" technology: they induce a strong presence sensation [137]. Users move in a virtual space generated by the computer, react to actions and change their point of view on the scene with movement. Most of the users have a sensation to be part of the virtual environment (feeling of being there [50], [116], [117], [130] and [137]) and the more this sensation is strong, the more the experience is meaningful. Presence and learning are strongly related: increasing perceived sense of presence also increases learning performance. As stated by Witmer and Singer [137], several factors contribute to increase presence: Control, Realism, Distraction and Sensory input. Thus, when the user interacts with the environment in a natural manner and controls the events, (s)he sees his/her avatar behaving as expected and the 3D world changing accordingly to his/her commands. The minimization of distractions that can occur when a user has problems in controlling the avatar, as an example, should increase immersion and participation. The presence measures are not sufficient when the experience to evaluate is synchronous multi-users and should be extended with other measures.

### 3.2.2 Awareness

Multi-users virtual environments are characterized by the synchronous interaction among remote users. Once in the environment, people have a first person perspective in which other participant actions immediately take place: they participate, do not only watch [9] and [45]. Several awareness types have been individuated [111]. In particular, social awareness concerns with the ability to feel the presence and the location of collaborators in a learning environment. "Who is there", as well as awareness on "what is going on" should be supported. The users should be able to locate themselves, the other users and to understand what each one is doing. Peripheral awareness concerns the possibility to know where everyone is in the VW. Awareness should be instantaneous: no active notification or request of information should be necessary, but the virtual environment should enable each participant to know what the others are doing just looking at their avatars, the means used by users for visually representing themselves. Most of the virtual environments enable to customize avatars, in such a way that users strongly identify themselves with their own chosen representation and easily distinguish the other participants. This customization greatly influences the perceived sensation of presence and awareness [9], [17]. Awareness is also supported when it is possible to see where the interest of a person is focused and what a person is doing. In particular, action awareness enables the users to be informed about what is happening to objects they care about, what actions are being taken to investigate or modify them, and who is carrying out such actions. When



it is possible to distinguish people having different roles group-structural awareness is also supported [45]. A decoration or a posture of the avatar could represent the role or the status of a user. Social awareness is also increased when a virtual environment provides the possibility of expressing non-verbal communication, as better detailed in the following.

### 3.2.3 Communication

Verbal messages are generally exchanged in an underlying emotional context that needs to be understood and communicated [105]. As a result, the verbal message must be supplemented with corresponding non-verbal communication provided by a visual medium. The communication context is enforced by this dual channel of verbal information and visual body language. According to Corraze [23], non-verbal communication consists of information concerning the affective state of the sender, his/her identity and the external world. In particular, it is improved by visualization and perception of facial expressions, of the body and its moves including gestures, postural shifts, and movements of the hands, head, trunk, etc. (Kinesics [68]). Other relevant factors are the artifacts linked to the body or to the environment and the distribution of the individuals in space (Proxemics, [46], [75],). As a consequence, the possibility to provide avatars with emotional gestures, expressions and postures has a great relevance to improve communication in CVEs [37]

### 3.2.4 Belonging to a community

One of the most attractive features of VWs is the opportunity of *creating communities*. Large numbers of users with similar interests and goals meet in the VW to share and collaborate. The more the users feel to belong to a community, the more their experience is effective.

It is common opinion that creating a virtual social space for students to congregate in is essential to improve learning, (e.g. [10], [47]). The virtual space should be designed to favour informal meetings among students as classmates, rather than having to explicitly log on to a social environment [105]. To this aim the virtual environment should offer appropriate communication and collaborative tools, and means to access information. Nevertheless, most Computer Supported Cooperative Learning environments are focused on the functionalities, often disregarding explicit support for the social (emotional) aspects of learning. If the environment simply behaves as a graphically rich communication tool, without exploiting these communication elements, it does not act as a virtual place but as a teleconferencing and video-conferencing tool, without supporting social concerns and peripheral awareness. When organizing learning activities it is fundamental to consider social psychological processes, such as the creation of groups, the definition of the group structures and the maintaining of social relationships [72]. Indeed, when participating to a learning program people are interested in acquiring not only knowledge but also to be involved by membership perception, support and personal affirmation. It is also important that individuals may contribute valuable information to get a positive sense of efficacy, that is, perceiving that they have had some effect on this environment [7].

### 3.2.5 Avatar Realism

Users feel a strong identification with their representing characters and this often reflects in their social and environmental perceptions. Several research work have been devoted to the investigation on users/avatars relationships for evaluating their importance and utility in the VW applications. As an example, concerning the research in interpersonal communication, Vasalou *et al.* [131] examined the influence of avatar customization on the online interaction with other users: three studies investigated whether user strategies for customizing online avatars increase their self-focused attention, also known as *private self-awareness*. Study 1 showed that a high number of users adapt their avatars to reflect their own appearance. Study 2 demonstrated that users who perceive their avatar to be similar to their own appearance are characterized by a high private self-awareness. In Study 3, a high private self-awareness, as increased by an avatar that is representative to its user, is related to a high social interaction. Basing on the results of their research on interpersonal communication, the authors deduct that the avatars that increase their owner self-focus may underline users characterized by an active online behaviour in the context of social computing.

Schmeil *et al.* [110] conducted an experiment to compare the effectiveness of collaborative work in virtual teams when avatars communicate using only text-based chat. Their study demonstrated that virtual teams adopting avatars were able to more effectively share and retain knowledge. In [62] Jin and Park investigated the effects on video game players of self-construal attitude, i.e., the attitude to identify oneself by his relationships. Results demonstrated that high self-construal individuals have more interactions with the avatars and feel that the avatars on screen are their real self, when compared to people with low interdependent self-construal. The study, conducted in a multiuser team based gaming environment, highlighted that individuals, while using avatars, immerse themselves completely into the environment and closely associate the avatars with their identity.

A research by Garau *et al.* [43] examined the impact of avatar realism on the perceived quality of communication in a VW, and found evidence that avatar realism had a significant effect on the behaviour of individuals. Schouten *et al.* [112] used the media synchronicity theory to investigate the team collaboration effectiveness in VWs, using avatar as compared to text based computer mediated communication. The experiment, conducted on a sample of 70 teams, showed evidence that understanding of shared information was higher in teams using avatars in a 3D virtual space. This enhanced the task performance of the team concerning consensus, satisfaction, and cohesion. Research work also suggests that in VWs, individuals perceive the others basing on visual cues of the target individuals avatar [11]. If the avatar is chosen in a way that does not reflect the real-self, one can perceive himself to be relatively anonymous, and can deceive others [42]. In this direction, Midha *et al.* [89] examined the effect of perceived similarity of an user with his avatar on the perceptions of his identifiability within a virtual team. Their results confirmed that higher the users perceived similarity with their avatars, higher the user's perceptions of identifiability within the virtual team will be.

Nowak and Biocca [97] examined the influence of anthropomorphism and perceived agency on presence, co-presence, and social presence in a virtual environment. The experiment varied the level of anthropomorphism of the image of interactions: high anthropomorphism, low anthropomorphism, or no image. Perceived agency was manipulated by telling the participants that the image was either an avatar controlled by a human, or an

agent controlled by a computer. The results support the prediction that people respond socially to both human and computer-controlled entities, and that the existence of a virtual image increases telepresence. Participants interacting with the less-anthropomorphic image reported more co-presence and social presence than those interacting with partners represented by either no image at all or by a highly anthropomorphic image, indicating that the more anthropomorphic images set up higher expectations that lead to reduced presence when these expectations were not met. In case of SL avatars, they belong to the intermediate category. Also the adoption of textual chat instead of voice chat goes in this direction: a user has too high expectation related to the audio quality and the voice expressiveness, often related also to the bandwidth, while the interaction of a textual ChatBot is less rich, but more human-like. In any case the technology is quickly evolving: good results of human-like spoken conversation are reached by SIRI, the Speech Interpretation and Recognition Interface provided by iPhone, even if it sounds synthetic and without inflection.

The results provided by these studies indicate that the usage of avatars has a significant impact on self-awareness and behaviour of individuals in the virtual space, the users feel a strong identification with their VW representing characters and they adopt similar behaviours as they were in reality. In this paper, we aim at understanding the effects of such features on Artificial Intelligence driven conversations. In particular, we investigate the impact of the SL-related perceptions on the credibility of an Artificially Intelligence bot assistant and on the student satisfaction.

### 3.3 Chatbots

Chatbots are programs designed to simulate an intelligent conversation with one or more human users via auditory or textual methods. Traditionally, the aim of these simulations is to fool the user into thinking that the interlocutor is a human, as in the case of the Turing Test<sup>7</sup>.

*Chatbots* are also called *Conversational Agents*, *Chatterbot*, *Visual Agent*, *Visual Assistant* or *Visual Human*. They provide a natural language interface to their users. Their design has become increasingly sophisticated and their use adopted in various fields, like Entertainment, Commerce and industry service [29], Gaming<sup>8</sup>, public sector<sup>9,10</sup> and Education [61], [104]. In particular, they are largely adopted for educational purposes, because they are more interactive than traditional e-learning systems. Indeed, students can continually interact with the bot by asking questions related to a specific field.

The development of Chatbots has been extensively investigated in literature, since the first ChatBot ELIZA [135]. It analysed input sentences and created its response based on reassembly rules associated with a decomposition of the input. This produced an impression of caring about its users, but it held no memory of the conversation and so could not enter into any form of targeted collaboration or negotiation. The syntactic language

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<sup>7</sup>Chatterbot:<http://en.wikipedia.org/wiki/Chatterbot>

<sup>8</sup>Blue Mars:[http://create.bluemars.com/wiki/index.php/Chatbot\\_Technology\\_Comparison](http://create.bluemars.com/wiki/index.php/Chatbot_Technology_Comparison)

<sup>9</sup>West Ham and Plainstow NDC. 2005. New Deal For Communities. "Splodge" New Deal For Communities chatbot assistant. [www.ndfc.co.uk](http://www.ndfc.co.uk).

<sup>10</sup>Bath & North East Somerset Council. 2006. Council web site Citizen Information Service Agent. [www.bathnes.gov.uk/BathNES/Search/ask/default.htm](http://www.bathnes.gov.uk/BathNES/Search/ask/default.htm).

processing used by ELIZA has been developed significantly, leading to the development of a number of language processing chatbots <sup>11</sup>.

A.L.I.C.E. [132] is a chatbot built using Artificial Intelligence Markup Language (AIML). The chatbot is based on categories containing a stimulus, or pattern, and a template for the response. Category patterns are matched to find the most appropriate response to a user input. Further AIML tags provide for consideration of context, conditional branching and supervised learning to produce new responses.

The Jabberwacky <sup>12</sup> chatbot has as its aim to "simulate natural human chat in an interesting, entertaining and humorous manner". Jabberwacky learns from all its previous conversations with humans. It functions by storing everything that is said to it, and uses contextual pattern matching techniques to select the most appropriate response. It has no hard-coded rules, instead relying entirely on previous conversations. It is explicitly not intended to do anything useful, instead being simply to chat.

### 3.3.1 Chatbots in Education

Several research work have investigated the adoption of ChatBots for educational purposes. In particular, the Virtual Patient bot (VPbot) is an educational bot used at the Harvard Medical School. Medical students can interact with the bot and ask it information on medical topics, while the VPbot answers them via audio or text [114]. Another ChatBot used for educational purposes is Sofia [69]. It was developed for the mathematics department of Harvard. The main purpose of this bot is to teach algebra. Students interact with Sofia by asking specific questions related to mathematics and teachers can at the same time improve the bot's knowledge. This is done by analyzing the chat logs to see which types of questions the students frequently ask and which questions need better answers. This analysis is helpful in improving both the bot and teacher ability.

Freudbot is another example of a successful bot [52]. The aim of this text based ChatBot is to let psychology students interact with a virtual Sigmund Freud. They discuss Freudian concepts, theories and biographical events. It is an attempt to use technology for improving distance education. In the survey that was taken after the experiment the students gave a very positive feedback and appreciate the feeling of talking to the real Freud. In [71], a bot for teaching information security, called Octavius, was proposed. Adopted as an aid in teaching the Octave risk analysis method, the system is based on the ALICE bot, extended to be able to open Wiki pages as part of the answer. The students were introduced to the bot in a 10 weeks course and had the choice of using the bot, only the Wiki or neither. Nearly all of them preferred to talk with the bot.

In their study on ChatBots and education, Kerly *et al.* [64] suggested that allowing students to discuss content not strictly related to their learner subject may help them in building a relationship with the ChatBot. This is important to keep students engaged in the discussion for as long as possible and to permit the maximum possible freedom on the discussion topics.

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<sup>11</sup>an exhaustive list can be found at:Open Directory Project Computers: Artificial Intelligence: Natural Language: Chatterbots  
[http://dmoz.org/Computers/Artificial\\_Intelligence/Natural\\_Language/Chatterbots/](http://dmoz.org/Computers/Artificial_Intelligence/Natural_Language/Chatterbots/)

<sup>12</sup>Carpenter, R. 1997-2006: [www.jabberwacky.com](http://www.jabberwacky.com).

### 3.3.2 Chatbots in Virtual Worlds

When hosted in 3D VWs, ChatBots are often in the form of automatically controlled objects or characters (the avatars). They seem to be particularly useful in this kind of environments. Indeed, without the interpersonal relationship with teachers and classmates, the student tends to feel discouraged by the artificiality of the human-machine interaction, resulting in loss of interest in the educational process [125]. The application of ChatBots as virtual assistants can stimulate the students, decreasing their feeling of isolation in these environments. Additionally, ChatBots provide feelings of satisfaction and of being assisted, because they are always available to chat to settle the student doubts. In [57] a ChatBot in the Open Wonderland VW is proposed to support language learning, mainly for developing writing skills and to simulate real-life situations in the learning environment. Audio data adopted to reproduce the Bot conversations are obtained using a Text To Speech technology. James and Vales [58] presented a virtual health care assistant, an automated avatar in the SL setting. This ChatBot supports the user in the interactions with healthcare databases, answering the user avatar questions. In [24] a ChatBot represented by a object immersed in the VW interacts with a user avatar by asking basic questions, leading the user to make a selection from a simple menu of key words. The object proposes further options to the avatar, depending on his previous choice.

## 3.4 Turing Test

### 3.4.1 Original Form

The Turing Test was originally described by Turing in terms of a game the "imitation game" [127]. The imitation game is a very curious game, and we hazard that most people who know of the Turing Test are not aware of its original form. In this game, there are three participants: an interrogator, a woman, and a competitor (who is a man). The interrogator knows the other two as and , and his task is to determine which of them is the woman. To do this, the interrogator asks them questions like "how long is your hair?" Questions and answers are exchanged using a teletype machine (the equivalent of a modern chat session). The woman is assumed to be trying to help the interrogator with her answers, while the mans task is to deceive the interrogator. Could the man deceive the interrogator 10% of the time or 20% of the time or 50% of the time? Turing proposed this game of deceit as a test of the mans thinking ability. Turings contention was that, if a computer could play the imitation game as well as a man, then the computer must be, in some sense, thinking (i.e., it must be an intelligent entity). Later in [127](p. 442), the woman disappears and the imitation game is recast as a game with three participants: an interrogator, a man, and a computer. The interrogator now has to identify the man. The man tries to assist the interrogator, while the computer tries to deceive them. Turing then makes his famous prediction that by the year 2000, a computer would be able to deceive the interrogator at least 30% of the time, given five minutes of questioning. Note that, in modern versions, gender is removed entirely from the test, replacing "man" above with "human" [54].

### 3.4.2 The Loebner Prize

Since 1991, Hugh Loebner has been organizing an annual competition known as the Loebner Prize, based on the Turing Test. While the exact conditions have changed slightly over the years, it is in essence a competition for programmers to create a program (a "chatterbot" or "chatbot") that can hold a chat session with an interrogator, during which session the interrogator tries to determine whether they are chatting with a human or a program. The term "judge" is used to mean an interrogator, and "confederate" is used to refer to the human in the imitation game. We will use the same terminology from now on. The format for the 2009 competition is as follows <sup>13</sup>.

- Each game is between a judge, a chatbot, and a confederate.
- The judge converses with the chatbot and confederate using a split-screen chat program. There is no interaction between the chatbot and the confederate, and neither can see the judges conversation with the other. Thus, the conversations are essentially independent.
- The interface is such that the judge can watch the others "typing" their answersmistakes can be corrected and characters appear in "real time."  
(This introduces a behavioral aspect to the test that was not present in the Turing Test.)
- After 10 min of conversation (in previous years the time limit was 5 min), the judge has 10 min to consider, and then must nominate one or the other as the human.
- There is no restriction on the topics of conversation (in early years of the contest, the topics were restricted).
- There are four judges, four confederates, and four chatbots in the final. (This has varied; for example, in 2008, there were 12 judges.)
- Every judge meets every chatbot and every confederate once, but not in the same combinations.
- After all the games, each judge rates the four entities they judged to be nonhuman on a humanness scale from 1 to 4.(The average rating is to be used in case of a tie.) No chatbot has ever passed the test (the first to do so wins a US\$100 000 prize), but, for example, the 2008 winner, Elbot, deceived three out of 12 judges. A number of commercially successful chatbots, including Elbot, had their origins as Loebner Prize entrants.

### 3.4.3 Bots Imitating Humans

Researchers have used a variety of techniques to try to make their bots more human like. A few examples are in [54] as follows: behavior-based techniques from robotics [5] were applied in [66]; Tatai and Gudwin [124] introduced a technique called "semionics" to control bot actions, with the aim of creating human-like bots; and hidden semi-Markov

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<sup>13</sup>H. Loebner, Rules for the 2009 Loebner Prize, 2009 [Online]. Available: [http://loebner.net/Prizef/2009.Contest/LP\\_2009.html](http://loebner.net/Prizef/2009.Contest/LP_2009.html)

models and particle filters were used in [56] to predict opponent movement, and the performance of the resulting bots was compared with human performance. Some researchers have not only created bots based on AI/CI methods, but have also proposed tests to measure the humanness of their bots.

In [73], Laird and Duchi examined some factors that make bots appear more human-like. One reason for their interest in humanness of bots was their work on simulating human pilots using Soar [74]. They made modifications to bots that played the first-person shooter Quake. Although their results were only indicative (due to high variance in the data), they found that decision time and aiming skill were critical factors in making bots seem more human-like, whereas aggressiveness and number of tactics were not. Their methodology for evaluating humanness was a kind of Turing Test, except that the judges did not actually interact with the bots. Video recordings were made of games played from the point of view of the bot. Similar recordings were made from the point of view of five human players of different skill levels. A panel of eight judges, of varying skill levels, viewed the videotapes (three judges viewed each tape) and made judgments about the humanness and skill levels of the players (human and bot). The judges were asked to assign humanness ratings, and also to make a binary decision as to whether the player was human. They achieved an accuracy of 16/18 humans correctly identified, and 27/48 bots correctly identified.

In [44], Gorman *et al.* used imitation learning (in this case, reinforcement learning) to "train" bots in navigation and movement tasks, and then tested their humanness using a "believability test." In this test, subjects are shown video clips of bot behaviors and asked about their game playing expertise, and then asked to rate the likelihood that the bot is human on a scale from 1 to 5. These data were then combined to calculate a kind of weighted average called the "believability index." They found that, according to this test, their bots were just as believable as humans.

In [119], Soni and Hingston report on experiments in which subjects played games against standard scripted bots, and against bots trained to play "like a human" (the bots used a neural network, trained on recorded examples of human play). Subjects were then asked which bots they preferred to play, which were more challenging as opponents, which were predictable, and which appeared more human-like. Subjects reported the trained bots as being more human-like and more fun to play against.

# Chapter 4

## The Proposed Individual Learning Activities in SL

This chapter details the proposed tools and activities to support individual learning in SL. The research outlines a *Virtual Help for Orthogonal Projections* (VirtualHOP) lab to carry technical drawing classes and a *Virtual Assistant for SecondDMI* (AIbot) island in SL. AIbot is an Artificial Intelligent Chatterbot embodied into an SL avatar that assists student during their VW experience. It supports the newcomers to ensure the presence of at least one inhabitant, avoiding "the lonely island" phenomenon that can affect an SL setting.

The chapter is organized as follows: Section 4.1 describes the VirtualHOP lab, while Section 4.2 details the AIbot assistant main features.

### 4.1 Virtual Help for Orthogonal Projections

This Section presents a Virtual Lab supporting young students in the learning of technical drawing. VirtualHOP is a SL setting design to support individual Orthogonal Projection didactic activities.

This environment aims at improving the comprehension on the drawing of Orthogonal Projection by fully exploiting the three dimensions of the SL environments. The main difficulty of technical drawing consists in representing a 3D object on a 2D medium. This restriction imposes to human mind to be able to summarize the spatial properties of objects on the paper. The proposed system trains these capabilities by requiring students to build, in the simulated environment, simple objects represented with 2D drawings. In this way, the students are not only pushed to move themselves between different dimensionality spaces, but also they benefit of the 3D spaces for moving and exploring the models they are building.

With the system, we introduce also a didactic experience that presents the concepts behind Orthogonal Projection by naturally exploiting the SL third dimension. The learning experience in VirtualHOP is based on the learning-by-doing approach, usually adopted in Virtual Labs. The learner has to reproduce an existing 3D object sample composed of SL prims (primitive basic 3D objects like cubes, pyramids, cones, etc.) to clarify the relation between the concrete artefact and its Orthogonal Projections.

This Section is organized as follows: Section 4.1.1 defines the used individual learning model, Section 4.1.2 describes the learning-by-doing methodology adopted, while Section 4.1.3 details the proposed VirtualHOP system.



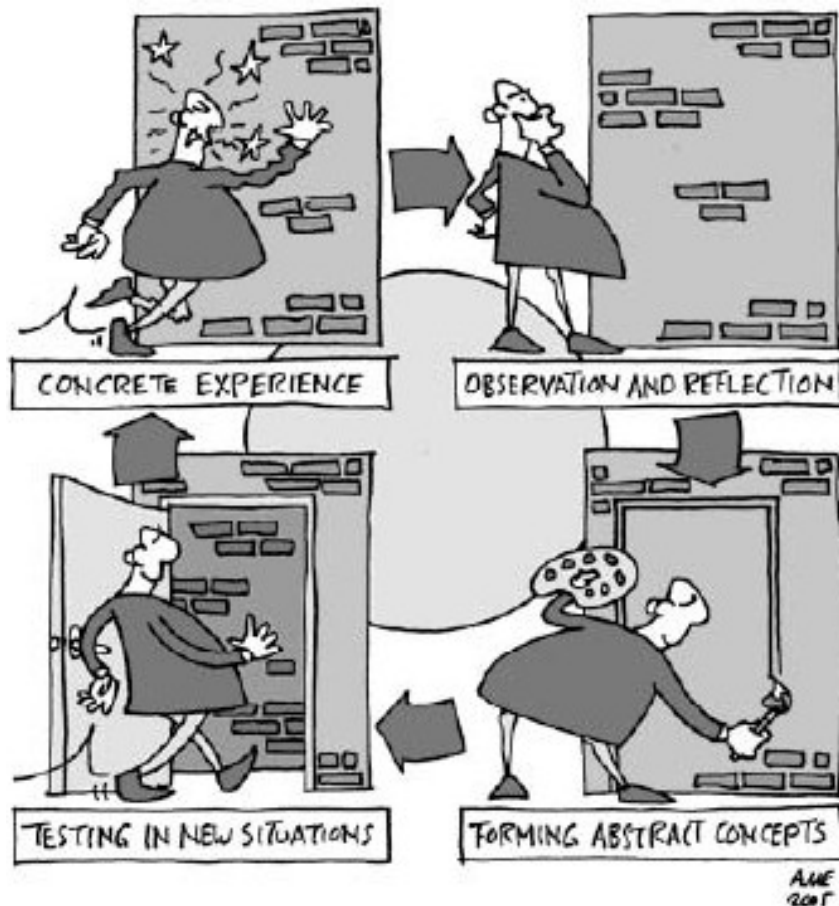


Figure 4.1: Kolb's individual learning cycle [118]

### 4.1.1 Individual learning

There is one thing all educators agree upon: Learning is not just the sharing of information. Ackhoff [2] illustrates this by developing a hierarchical system in which the extent of the use of cognition determines the hierarchy. Information stands at the bottom here, because it is only absorbed. Knowledge is remembered and therefore second. Comprehension and wisdom stand at the top, because it is about new insights and action.

Especially the word *new* is interesting in this regard; it points out that something that was not known before, now is. Synge [123] defines learning as the application of knowledge and experience in an improved action. He illustrates this with the example about someone who just read a book about cycling. It would be nonsense to say: *I just read a great book about cycling, now I have learned it!* Learning allows us to do something we could not do before.

A useful model for understanding how individuals improve their practice by learning from experience is Kolbs [70] experiential learning cycle (Figure 4.1). In this influential model, learning is depicted as a cycle. First, you do things. Then you observe what you have been doing and reflect on it. Next, you analyse these observations, linking them to theories or concepts while trying to understand them. Lastly, you decide what you will be doing differently and how (or set up an experiment), after which the cycle is repeated again. For learning (changed behaviour) to occur, people have to go through all phases of the learning cycle[70].

Where you start in the learning cycle is different for everyone and for every experience. Furthermore, most people have a preference for one of the phases in the learning cycle. Some prefer doing (activist learning style), some prefer reflecting (reflective learning style), some conceptualising or thinking (theoretical learning style), and some prefer to decide by trying out new ways of working (pragmatic or experimental learning style) [70].

### 4.1.2 Learning-by-Doing Methodology

*"For the things we have to learn before we can do them, we learn by doing them."* This quote from Aristotles "Nichomachean Ethics" succinctly summarizes the compelling intuition behind Learning-By-Doing (LBD) pedagogical methods. Most of us learn best on the job by trying things out and reflecting on our own experiences, even sharing our experiences with other people who may also learn from them. LBD enables us to consolidate our knowledge of domain-specific facts as well as practice and refine the skills necessary to accomplish the related tasks[20].

The LBD methodology is built on the constructionist approach and promotes a learner oriented learning environment. It fosters skill development and the learning of factual information through *hands-on implementation* of the associated concepts [108]. It thus sensitizes people to the use of the knowledge rather than acquiring knowledge for its own sake. In this methodology, mentors assist the students in their course work by "providing hints and not solutions" [63].

VWs and SL in particular, are emerging as a platform with huge potential for teaching and learning, in general, and LBD training, in particular. Many universities have established a presence in SL,at the same time, researchers and educators are grappling with a number of questions around the adoption of VWs for educational purposes. These questions range from how to best exploit this new technology, to how to adapt teaching pedagogy to a virtual classroom, to deciding what types of learners might benefit the most from learning what type of subject matter in them. Among the most important questions include developing new pedagogical theories and models of how students learn in VWs and corresponding methods for assessing the effectiveness of education in these worlds.

While the LBD methodology is not new, we have combined it with personalization and customization in our training program. In addition, we adapted from Kolbs experiential learning model [70], to designing our didactic experiments. In this learning experience, lesson/unit goals and expectations are set at the beginning, so learners understand what they are trying to achieve and the expected level of that achievement. Learners discuss multiple strategies of solving the problems in the SL environment, allowing the learners to understand the various ways in which they can solve the problems that they encounter. Feedback is given during learner interactions (through presentations and discussions) which allows the learners to revise their projects/artifacts. Also, an involvement with applications in the real world allows the learning process to take place in a more meaningful context.

### 4.1.3 The VirtualHOP Setting

In this section we present a SL environment, VirtualHOP (Virtual Help for Orthogonal Projections)[93], programmed as a specific setting for teaching technical drawing to first

level students. Our aim is to exploit the three dimensions of SL environments to improve the understanding of orthogonal projection drawing and of the relationships between the real 3D objects and their 2D representations. It is important to point out that we do not want to replicate professional drawing systems (i.e., CAD systems), since these offer better drawing capabilities, but require a more complicated interaction that does not fit student and didactic needs.

VirtualHOP supports students in the orthogonal projection drawing by involving them in a 3D guided experience aiming at improving their understanding of the basic principles of orthogonal projections. The proposed system, shown in Fig. 4.2, and the associated didactic experience drive students in constructing 3D objects starting from orthogonal views and exploiting the 3D VW environment to clarify the relation between the "concrete" artefact and its orthogonal projections.

It is important to mention that we use the "First angle projection" to represent the orthogonal views, which is the ISO standard primarily used in Europe. The 3D object is projected onto 2D drawing space as if the student were looking at it, as for an X-ray of the object: the top view is under the front view; the right view is at the left of the front view. This is different from the "Third angle projection" used in the United States and Canada, where it is the default projection system according to BS 8888:2006. Not only the left view is placed on the left and the top view on the top, but the projection direction is also reversed.

The proposed environment and didactic experience take advantage of all the visualization modalities of the hosting environment to highlight the interesting aspects of the experience and the capabilities of the 3D VW to develop the orienteering and synthesizing skills required to a technical drawer. Orthogonal projection technique may result difficult to learn because of the dimensional reduction required when moving from reality to the drawing plane. Since 3D-objects have edges and surfaces and they appear differently in various views, students may experience difficulties when they have to:

- Construct the 3D concretization of an orthogonal projection, considering that points perpendicularly project from one view to the adjacent ones, and object dimensions (height, width and depth) need to be consistent from each view to the others.
- Indicate surfaces and edges and their location in the appropriate view (i.e.: top, front or side).
- Construct Isometric sketches from Orthogonal views on isometric dot paper.

Another problem is finding the appropriate object orientation according to projecting directions. This means that, if the representation adopted is not the maximal six views one, the opaque surfaces have not to hide any meaningful part of the object. In our case, we propose simple objects for the didactic experience, but we also limited the adopted view to the common 3-views schema: top, front and side view. However, our students do not suffer this problem since objects are oriented following the optimal projection directions.

#### **4.1.3.1 VirtualHOP Architecture**

VirtualHOP system supports the creation of simple 3D objects starting from their orthogonal representation. The system drives the students in the dimensional shift required by

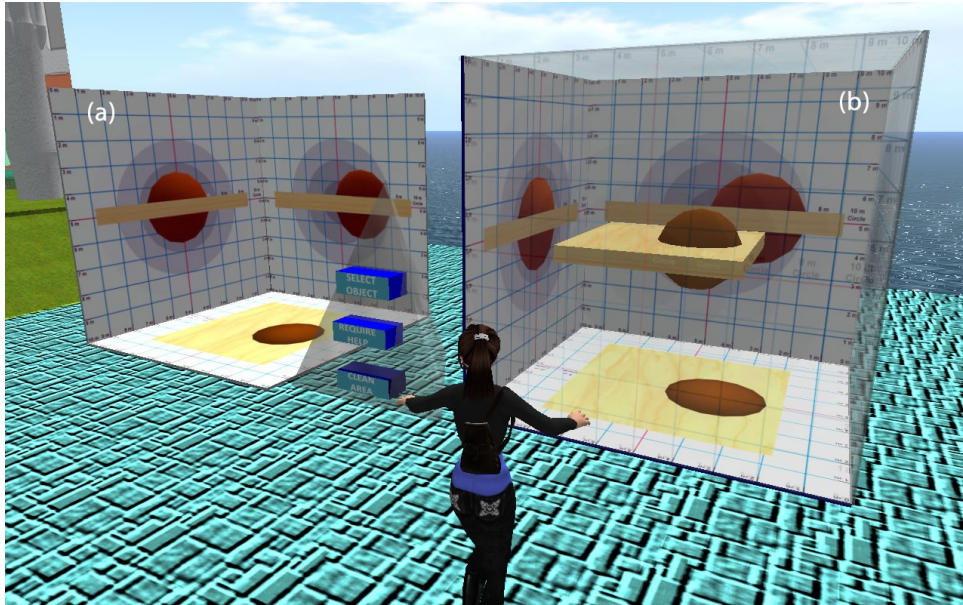


Figure 4.2: The VirtualHOP system in SL. From right to left: the Show Room (a), the Control Bar and the Build Room (b).

the drawing process by providing the 3D samples of objects and the relative orthogonal projections.

The proposed SL environment is composed by three main areas: the *Show Room* Fig.4.2 (b), the *Build Room*, shown in Fig.4.2 (a) and the *Control Bar*.

The *Show Room* is a display area where the required object is shown in its 3D form, using the technique and metaphor usually adopted to teach orthogonal projection: "*imagining object surrounded by a glass cube where surfaces are projected onto the faces*".

In our system, according to the previous metaphor, the object is shown in a cube, Fig.4.3, with three transparent surfaces that avatar can traverse to allow students to explore all sides of the demo object and their projections. The other three cubes faces show, in the space, the front, side and top views of the object as they would be in the 2D representation. This is what we previously called a bridge between 2D and 3D representations of the object that contributes to teach students how moving from the orthogonal view of the object to its real 3D shape and vice versa. The student can also explore the object inside the Show room and move him/herself around for a better visual comprehension and memorization of the shape.

The *Build Room* is the active area of the system. It's the construction area, where the students can exercise their building starting from the primitive simple components like cubes, pyramids, cones, etc. provided by the SL environment. This area is also surrounded by the orthogonal view of the object, aiming to train the student to mentally move between the 2D orthogonal views projected and the object being built, in terms of sizes, directions, rotations, and so on.

The *Control Bar* is the command interface with the user and exposes three main actions: SELECT OBJECT, REQUIRE HELP and CLEAR AREA. The SELECT OBJECT button enables us to choose the desired object for exercising. Once the object is chosen, a temporary 3D copy is shown in the display area and its Top, Front and Side orthogonal views are projected on the faces of both the Building and Show Rooms. After the disappearing of the temporary object, the projections persist in the rooms as an aid

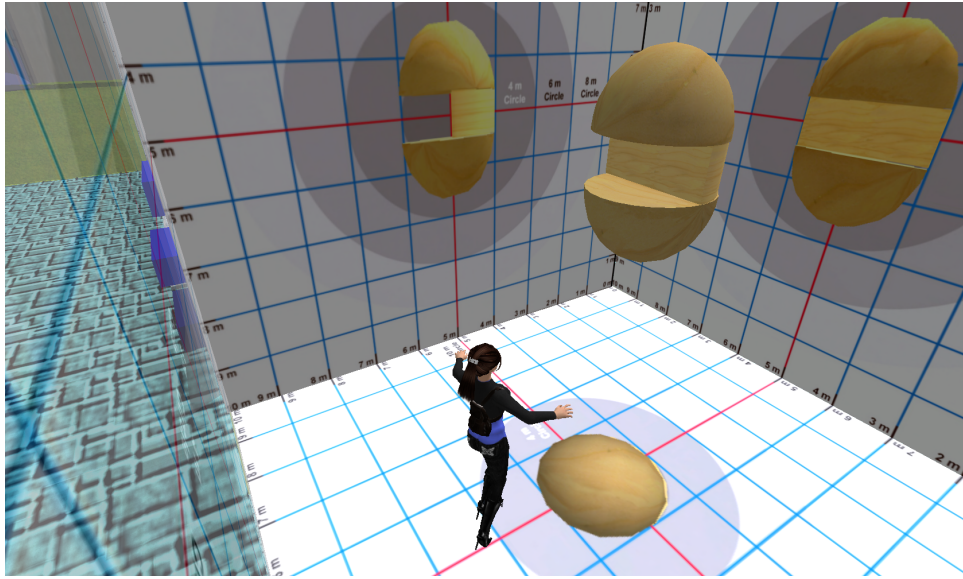


Figure 4.3: VirtualHOP Show Room.

for the building phases. If the user needs a new look on the 3D copy, he/she can press the button REQUIRE HELP and request of newly materializing the object in the Show Room with the help of its orthogonal projections.

#### 4.1.3.2 VirtualHOP Didactic Experience

The proposed didactic experience is centred on two types of system users: tutors and students. Before starting the experience, all users have been trained on SL environment to let them be familiar with the communication, moving, seeing, commands, with a particular emphasis on the building facilities. The following steps are proposed as a didactic experience to exploit the VirtualHOP system and as a first basis for the evaluation. The tutor activities are organized in the following steps:

1. To construct simple 3D objects for the student exercises using SL primitive components (prisms, cylinders, cones, etc.).
2. To obtain the orthogonal views of built objects by exploring the three sides of the object in SL and obtaining their snapshots.
3. To add the 3 views to the surfaces textures, and the object to the main system component.
4. To perform a training session on the SL building facilities and helps their comprehension by showing them how performing the suggested didactic construction experience.
5. To provide support during the SL experience.
6. To evaluate the student objects.

The student activities are explained in detail in the following:

1. The student selects the drawing he wants to work on by clicking on the button "SELECT OBJECT" button on the control area, stopping on the object to build.
2. The system displays a temporary 3D version of the selected object in the Show Room, and its orthogonal views on the surfaces of both Show and Building rooms.
3. The student examines the object from the various sides, moving the avatar and flying in the environment inside and outside the Show Room, before the temporary object disappears, as shown in Fig.4.3
4. The student moves to Building Room and reconstructs the selected object, using the available elementary SL building components.

With the proposed didactic experience, we do not intend to simply provide students with a way of practicing with orthogonal projections, but also to let them create a mental model of the concepts underlying the graphic technique. The Building Room reveals really effective in providing such a concrete model. As shown in Fig. 4.4 (a), we drive students to start from the top view surface with an elementary block and stretch his shape according to the Top projection of the object Fig. 4.4 (b). The object is then aligned with the Front and Side views, see Fig. 4.4 (c), and its shape is adapted to these two projections with a stretching operation as shown in Fig. 4.4 (d). Final details are added to complete the work, obtaining the final object shape and size, as shown in Fig. 4.4 (e) and (f).

5. If the student is satisfied with work, he uses the SL object exchange system to deliver the artefact to the tutor: he adds the built object to the avatar inventory and shares it with his teacher for evaluation.
6. The student is invited to manually draw the orthogonal projection of two objects: a cube laying on the centre of Top plane which faces are aligned with projection planes, and a square pyramid similarly placed, which basis borders form a 45 degrees angle with projection planes.

SL environment provides the builder with the ability of moving, rotating, scaling, colouring and linking the building components in order to obtain the desired object. Fig. 4.4 shows also some of the building facilities available in SL. In particular, frames (a), (c) and (e) show the interface to the moving controls, while pictures (b) and (d) display the scaling commands.

The environment also facilitates and enriches the student experience by providing different view modalities:

- The *Orbit camera* rotates the view around a selected point that can be an object or an avatar. Adopting this modality, the camera will move in a circular path centred on the selected object. We propose students to switch in this view modality when they are in Show Room or in the Building one. In this way the user attention is focused on the object but the rotation continuously underlines the relationship between the sample shown, or what is being built, and its projections.
- The *Pan camera* can be used for fine tuning the point of view on the SL scenes by moving the camera up, down, left, and right.



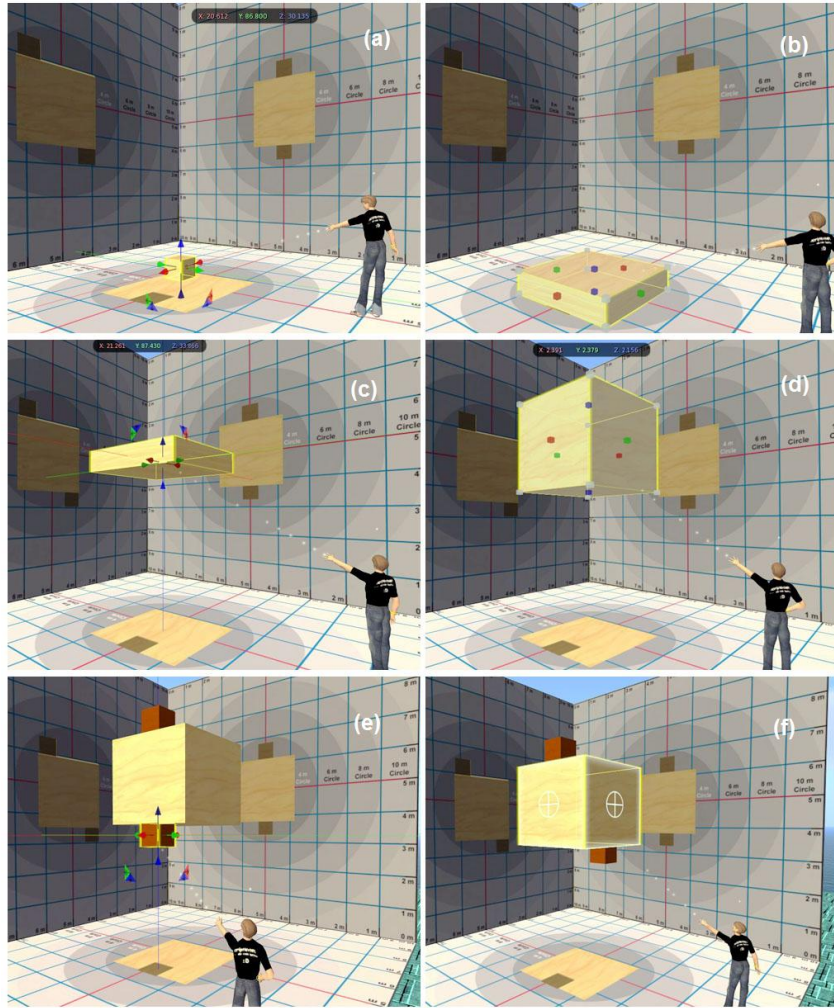


Figure 4.4: The construction steps for a simple object

- The *Free view* allows the user to freely move the camera with the keyboard and mouse controls. This is also called the first person look, where the user avatar is not shown and the VW appears as seen by user eyes. This view modality may lack in reference points, since the user avatar maybe useful during building to better understand the object dimensions. We reserve this view modality only for the more experienced users.

## 4.2 Virtual Assistant for SecondDMI

This Section presents the adoption of a Chatbot assistant, for helping the exploration of environments and fruition of distance didactic activities in SL. Aibot is a modified Chatbot controlled by an Artificial Intelligence engine that appears in SL as an avatar and assists the learners during their VW experiences. In this way, it adopts the same interaction style that all the users have when moving and communicating in VWs. Aibot insure the existence of at least one inhabitant in the Unisa Computer Science Island in SL, avoiding the "the lonely island" phenomenon, specially in the periods when there is no ongoing didactic activities.

The Section is organized as follow: Section 4.2.1 motivate the use of a Chatbot, Section 4.2.2 and 4.2.3 introduce the adopted A.L.I.C.E chatbot system. While Section 4.2.4 detail the proposed Albot assistant.

### 4.2.1 The Choice of Chatbot

The technology for negotiation of an open learner model requires the following characteristics [64]:

- Keeping the user on topic preventing them from deviating too long from the issue at hand
- Database connectivity to allow reading and writing of data to and from the learner model
- Capability to be event driven by database changes to allow the chatbot to initiate negotiation if there are conflicts in the learner model
- Web integration to allow easy deployment to maximum possible users
- An appropriate corpus of semantic reasoning knowledge.

The open source foundations of AIML [133] have provided an interesting and useful application for AI development. We believe that while the A.L.I.C.E. solution could be used to create this system, writing of AIML on this scale would be challenging for the non-developer, and that the richness of processing is limited in comparison to Lingubots<sup>1</sup>. Both Lingubots and AIML have a wide corpus, but Lingubots is more focussed on goal driven conversation. The Lingubot Creator editorial interface allows for more in-depth developmental objectives and facilitates the building of this complex system.

The Lingubot technology has generated a significant corpus of external scripts and applications, providing functionality relevant to conversations, such as abuse counters, theme metrics and directed conversational abilities, as well as integration with many web technologies. It has the capability to generate and manipulate variables and information regarding the conversation, and also for retrieving and posting information to other web enabled applications such as search engines and databases.

The commercial nature of the technology also ensures that it is well tested. Lingubot technology is the most appropriate AI technology for this development due to the ability for the human to remain in the loop due to its ease of update and open reporting structures. It also meets the requirements of a user centred experience, easy web integration and database connectivity.

By allowing the AI researcher to focus more on the delivery or outcomes of conversation, rather than the underlying pattern matching effectiveness we hope to build a bridge towards a more complex understanding of the dynamics of humans with machines.

### 4.2.2 The ALICE Chatbot System

A.L.I.C.E. (Artificial Intelligence Foundation, [113], [132] ) is the Artificial Linguistic Internet Computer Entity, which was first implemented by Wallace in 1995. Alices knowledge about English conversation patterns is stored in AIML files. AIML, or Artificial

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<sup>1</sup>Creative Virtual. Web site of UK Lingubot distributor:www.creativevirtual.com.



```

<aiml version="1.0">
  <topic name="the topic">
    <category>
      <pattern>PATTERN</pattern>
      <that>THAT</that>
      <template>Template</template>
    </category>
    ..
    ..
  </topic>
</aiml>

```

Figure 4.5: ALICE AIML format [114]

Intelligence Mark-up Language, is a derivative of Extensible Mark-up Language (XML). It was developed by Wallace and the Alicebot free software community from 1995 onwards to enable people to input dialogue pattern knowledge into chatbots based on the A.L.I.C.E. open-source software technology.

AIML consists of data objects called AIML objects, which are made up of units called topics and categories. The topic is an optional top-level element, has a name attribute and a set of categories related to that topic. Categories are the basic unit of knowledge in AIML. Each category is a rule for matching an input and converting to an output, and consists of a pattern, which matches against the user input, and a template, which is used in generating the ALICE chatbot answer. The format of AIML is as shown in figure4.5:

The `<that>` tag is optional and means that the current pattern depends on a previous chatbot output. The AIML pattern is simple, consisting only of words, spaces, and the wildcard symbols `_` and `.`. The words may consist of letters and numerals, but no other characters. Words are separated by a single space, and the wildcard characters function like words. The pattern language is case invariant. The idea of the pattern matching technique is based on finding the best, longest, pattern match [114].

### 4.2.3 ALICE Pattern Matching Algorithm

Before the matching process starts, a normalization process is applied for each input, to remove all punctuation; the input is split into two or more sentences if appropriate; and converted to uppercase. For example, if input is: I do not know. Do you, or will you, have a robots.txt file? Then after the normalization it will be: "DO YOU OR WILL YOU HAVE A ROBOTS DOT TXT FILE".

After the normalisation, the AIML interpreter tries to match word by word to obtain the longest pattern match, as we expect this normally to be the best one. This behaviour can be described in terms of the Graphmaster set of files and directories, which has a set of nodes called nodemappers and branches representing the first words of all patterns and wildcard symbols [132].

Assume the user input starts with word X and the root of this tree structure is a folder of the file system that contains all patterns and templates, the pattern matching algorithm uses depth first search techniques [114]:

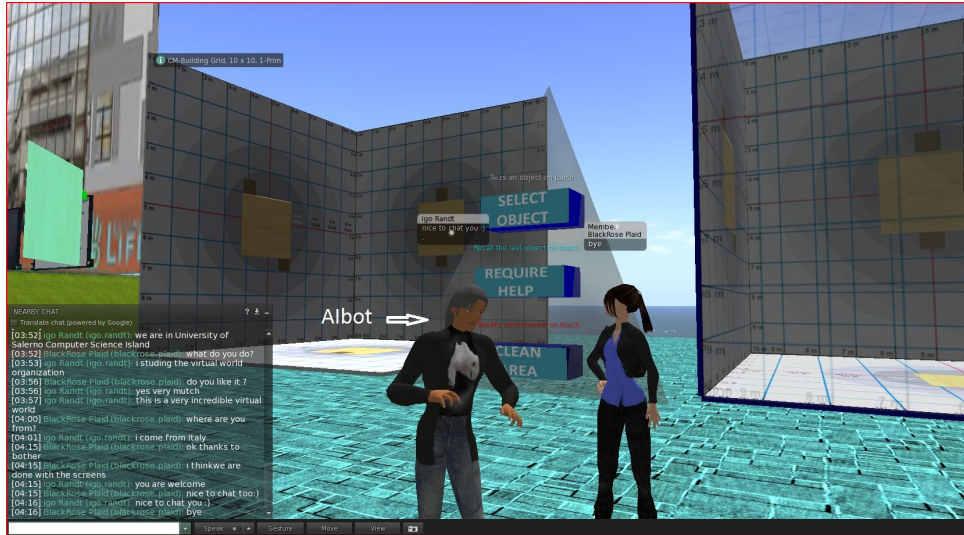


Figure 4.6: Albot, on the left, is chatting with a user

1. If the folder has a subfolder starts with underscore then turn to , ”\_/” , scan through it to match all words suffixed X, if no match then:
2. Go back to folder, try to find a subfolder start with word X, if so turn to ”X/” , scan for matching the tail of X. Patterns are matched. If no match then:
3. Go back to the folder, try to find a subfolder start with star notation, if so, turn to ”\*/” , try all remaining suffixes of input following X to see if one match. If no match was found, change directory back to the parent of this folder, and put X back on the head of the input.

When a match is found, the process stops, and the template that belongs to that category is processed by the interpreter to construct the output. There are more than 50,000 categories in the current public-domain ALICE brain, slowly built up over several years by the Botmaster, Richard Wallace, the researcher who maintained and edited the database of the original ALICE.

## 4.2.4 The AIbot System

AIbot (Artificial Intelligent bot) [41] is an automatic assistant adopted for providing information on SL e-learning activities and settings. It welcomes distance learners on the Unisa Computer Science Island in SL and aims at reaching a natural interaction style: as shown in Figure.4.6 it appears as an avatar and adopts the usual communication channels and behaviours. Because of its representation and conduct, when in the virtual setting, users perceive it just as another user, naturally asking information to it. Users seem more available to interact with AIbot respect to other forms of assistant (scripted objects or panels). In this section we describe the main features offered by the AIbot system and the details of its software architecture components.

### 4.2.4.1 AIbot Architecture

The deployment diagram of the AIbot system architecture is shown in Figure 4.7, depicting the main components of the system and their dependencies.

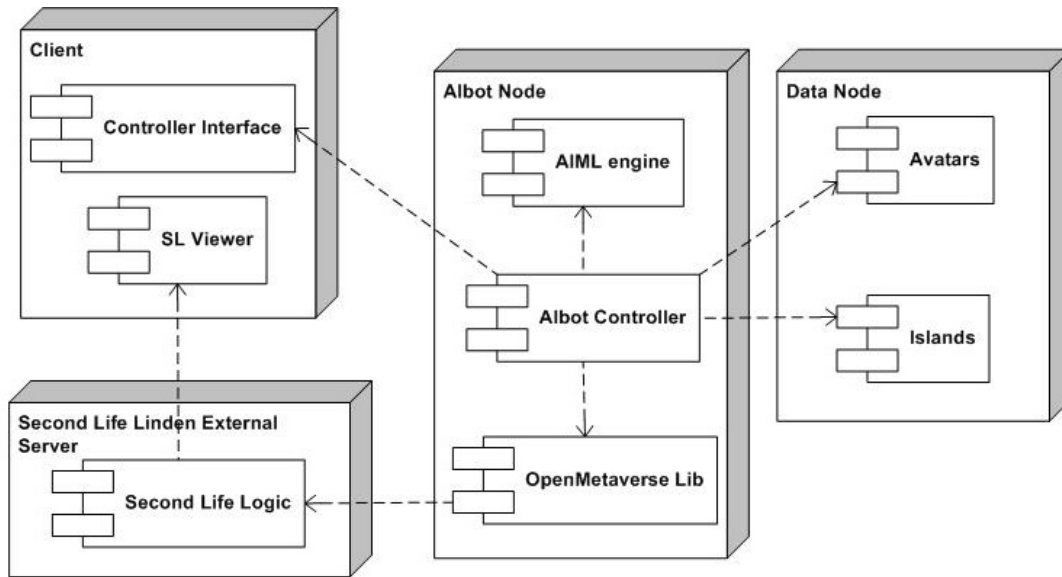


Figure 4.7: The AIbot system architecture

AIbot has been developed exploiting the features that SL offers for creating and controlling a character using the OpenMetaverse library<sup>2</sup>. We built an SL avatar bot, managed by the *AIbot Controller* component, a C#<sup>3</sup> application that uses the *OpenMetaverse Lib* for communicating with the Island Server. It also communicates with the *AIML Engine*, the Artificial Intelligence component, to get the answer to the student questions. A separate *Data Node* hosts the data related to the AIbot appearances and the SL destination that AIbot can reach. The Client screen displays the *AIbot Controller Interface*, which supports a user in the AIbot set-up and management, and the *Viewer* interface offered by SL to his inhabitants.

AIbot is able to participate to a conversation by answering to the user questions listened on the text chat channel. This is possible thanks to an artificial intelligence engine, which has been embedded in the system and controls the conversation. AIbot interprets the user questions and generates human like answers using the Artificial Intelligent Markup Language (AIML), an XML dialect for creating natural language software agents. AIML specifies pairs composed by a pattern and a template. When an utterance from a user matches a pattern in the pair, the agent returns the associated phrase template. In particular, we adopt the open source cross platform Rebecca AIML<sup>4</sup> from the Alice project described in the above subsection(4.2.2and 4.2.3). Rebecca AIML also comes with a set of tools that supports the C# programming language, adopted to develop AIbot.

Table 4.1 reports some excerpts from a chat conversation between AIbot and a human controlled avatar.

#### 4.2.4.2 The AIML Modification

To keep students engaged in the discussion for as long as possible and permit the maximum possible freedom on the discussion topic [38] [64] AIbot is required to discuss both

<sup>2</sup>LibOpenMetaverse: <http://www.openmetaverse.org/>

<sup>3</sup>Microsoft C#: <http://msdn.microsoft.com/en-us/vcsharp/aa336809>.

<sup>4</sup>Rebecca AIML :<http://rebecca-aiml.sourceforge.net/>

Table 4.1: Samples of Albot general conversations

The Human	Albot
do you like art	Yes I enjoy art very much, especially painting.
what kind of paintings	I can't decide. You choose.
how about abstracts	What is it to you.
i prefer using google	Have you tried a web search? Does it find what you are looking for?
usually, doesn't it find what you are looking for?	I think there might be a few exceptions.
Interesting comparison, like what exceptions. what does that have to do with exceptions	"Interesting comparison." What does it have to do with exceptions?
not sure	You're not sure of what?
i don't know	I am as good as it gets.
your as good as it gets in what?	Is that a fact.
do you like logic	I use it as often as possible.
thats nice	Me either.
just a bit actually	Not much, eh?
do you like television	Yes I love TV.
what is your favorite show	My favorite show is STAR TREK VOYAGER.
Nice	Are you getting bored?
i like your style	You like my style.
yes	Alright then.

Table 4.2: Samples of Albot customized conversation

The Human	Albot
What is this setting?	This is the Orthogonal Projection Lab
What is used for?	It is used for learning how to draw Orthogonal Projection
What does it mean?	A two-dimensional graphic representation of a 3D object
Do you think it is nice?	Yes, it is. Try it

on general topics and on specific ones related to the learning environments. To this aim, the AIML engine of Albot has been properly customized in such a way to be able to carry out both general conversations and, as a student assistant, answering questions on the island as well as on the VirtualHOP setting. Table 4.2 reports an example of conversation on a customized topic.

The modifications were simply adding a new file category to the ALICE database files, named "Orthogonal Projection" that contains sub files with the detailed information needed in our didactic experiment using the VirtualHOP setting. The changes made to the Albot assistant, allows his to answers questions related to:

- General information about Orthogonal Projections: definition, use and techniques.
- How to use SL building facilities, such as moving, scaling, rotating, coloring and linking the building components in order to obtain the desired object.
- How to use VirtualHOP setting, Albot explains:
  1. How to start from the top view surface with an elementary block and stretch the shape according to the Top projection of the object, how to align the object with the Front and Side views and how to adapt the object shape to these two projections with a stretching operation.
  2. What to do in case of mistakes, i.e., reset the Rooms, delete the object, etc..

3. How to add to the avatar inventory the built object and share it with the teacher.

#### 4.2.4.3 The AIBot Controller

The Controller Interface is a Graphical User Interface useful to manage the AIBot avatar in SL. It is the interface of the AIBot Controller, a C# component that uses the Open-Metaverse library for connecting to SL and controlling the avatar behaviour. It supports the user in letting the avatar appear or disappear in SL and moving it as desired. As shown in Figure 4.8, the Controller Interface is organized in two main areas, which aggregate related commands:

- The Simulation Control Area, shown in the higher part of Figure 4.8, which groups commands for connecting and disconnecting the bot from the SL environment and changing the active SL avatar. Acting on this interface, it is possible to retrieve the avatar position and to display its status respect to the logging operations.
- The Avatar Movement Area, shown in the lower part of Figure 4.8, which enables to move the avatar in the required place of the island. In particular, simple avatar behaviors, like following another character, sitting, flying and changing the character status (i.e., present or away) are managed. Also basic avatar movements may be requested by acting on the four buttons related to the N, E, S and W directions, and by specifying the distance to walk in a numeric text box.

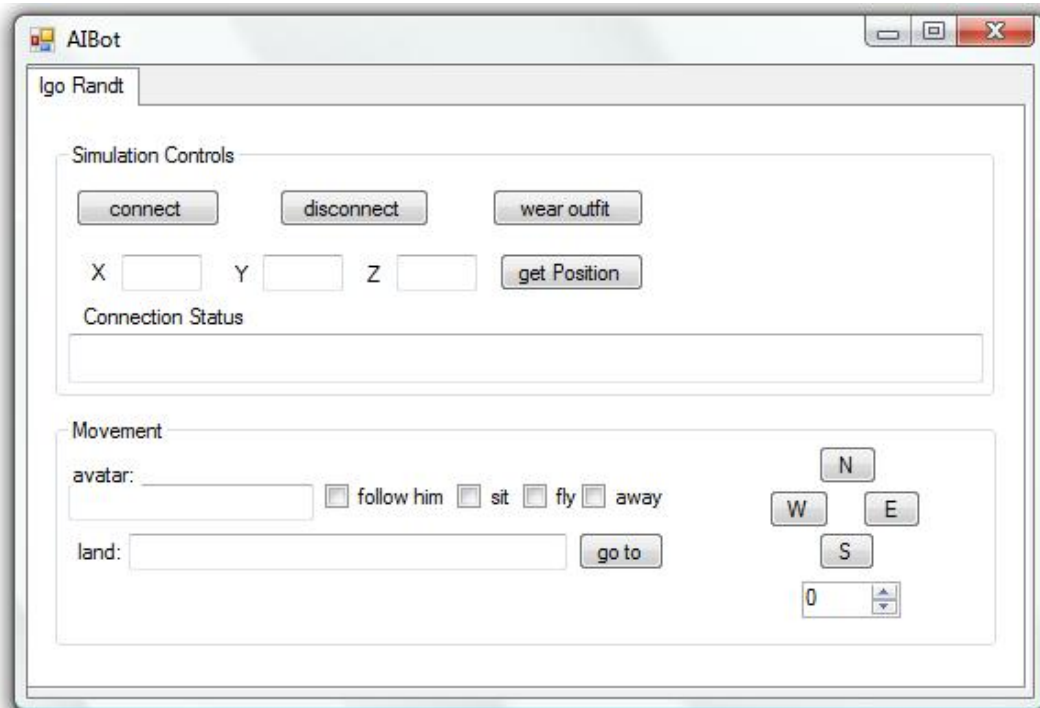


Figure 4.8: The AIBot Controller Interface

The AIBot Controller listens to the chat channel, invokes the AIML engine service to generate the answer and sends it back to SL, following the usual chatting interaction metaphors. AIBot has been programmed in such a way that when the engine is parsing a

chat and producing the answer, it appears digitizing the chat messages on an imaginary keyboard with a simulated thinking delay, following the expected behaviour of any SL character.



# Chapter 5

## Evaluation

A research method or tool has more chances to be transferred to practitioners if its usefulness is investigated through empirical user studies [100]. In order to evaluate the usefulness of the research presented in this thesis the following research question has been previously reported:

**RQ** *Do Virtual Worlds satisfactorily and effectively support individual learning activities?*

The evaluation plan aims at assessing the effectiveness and the user satisfaction when performing an individual activity in VirtualHOP, in addition to the user satisfaction on the support provided by AIBot during an individual learning activity. To this goal the following sub-research questions have been derived from the analysis of the research question defined above:

### **Learning Setting evaluation:**

- *RQ<sub>1,1</sub>: Does VirtualHOP satisfactorily support individual learning activities on Orthogonal Projection in SL?*
- *RQ<sub>1,2</sub>: Does VirtualHOP enhance the learning outcomes practising technical drawing in VW?*

### **Virtual assistant evaluation:**

- *RQ<sub>2,1</sub>: Do VWs strengthen the credibility of an Artificial Intelligence virtual assistant?*
- *RQ<sub>2,2</sub>: Does AIBot satisfactorily support individual didactic activities in SL?*

This first section 5.1 objectively investigates the didactic value of the proposed virtual lab (RQ<sub>1,2</sub>), as long as the user opinion and impression toward the experience (RQ<sub>1,1</sub>). While Section 5.2 presents the AIBot evaluation. In particular Section 5.2.1 answer to assess the credibility of an automatic ChatBot tutor in a 3D virtual learning environment performing a modified version of the Turing Test (RQ<sub>2,1</sub>), while Section 5.2.2 examine the perceived benefits related to the adoption of AIBot as a virtual assistant during an individual learning activity (RQ<sub>2,2</sub>).



## 5.1 VirtualHOP Evaluation

In this section we evaluate the practical didactic value of the presented virtual lab VirtualHOP in learning technical drawing in a VW. The main difficulty of technical drawing consists in representing a 3D object on a 2D medium. This restriction imposes to human mind to be able to summarize the spatial properties of objects on the paper.

In this Section we investigate both the benefits of the nature of the VW as 3D environment aiding the student in learning Orthogonal Projection, as long as the user perception toward the proposed system and the design of learning experience.

The next sub-section 5.1.1 and 5.1.2 answer the question RQ<sub>1,1</sub> and RQ<sub>1,2</sub>, respectively.

### 5.1.1 Subjective Evaluation

Although it seems likely that virtual worlds will have a large impact on the future Web [126], and, in particular, in teaching and learning, there is still a limited comprehension of the effect of their usage for didactic purposes. Virtual Worlds have been largely adopted as a learning environment, as discussed in Chapter 2 and Chapter 3. However, there are still some unresolved issues such as difficulties in navigation or in using 3D interfaces [142]. As discussed in the State of the Art, there is still the need of evaluating the didactic value of the experience.

#### *Experiment organization*

We collected the opinions of 14 young students, from 11 to 13 years old after involving them in the didactic experience described in previous section. Before starting, a training lecture has been provided them in a four hand computer session (both tutor and student at the same computer): the tutor individually follows each student ensuring good average SL moving and building skills.

After the individual training phase, the students were trained on Orthogonal Projections with a one hour lecture. The questionnaire contains a control section aiming at evaluating user skills that can influence the evaluation with the following questions aggregated in three factors, PC Knowledge (PCK), 3D Environments and Games (3DG) and Drawing (DW).

1. I am practiced in computer usage PCK
2. I am practiced in Internet usage PCK
3. I am practiced in the usage of Video-games 3DG
4. I am practiced in the usage of Virtual Environments 3DG
5. I am practiced in the Second Life usage 3DG
6. I often play Video Games (at least one time at week) 3DG
7. I like drawing (DW)
8. I'm practiced in Orthogonal Projections (DW)

The part specific for evaluating the experience has been composed by the following questions:

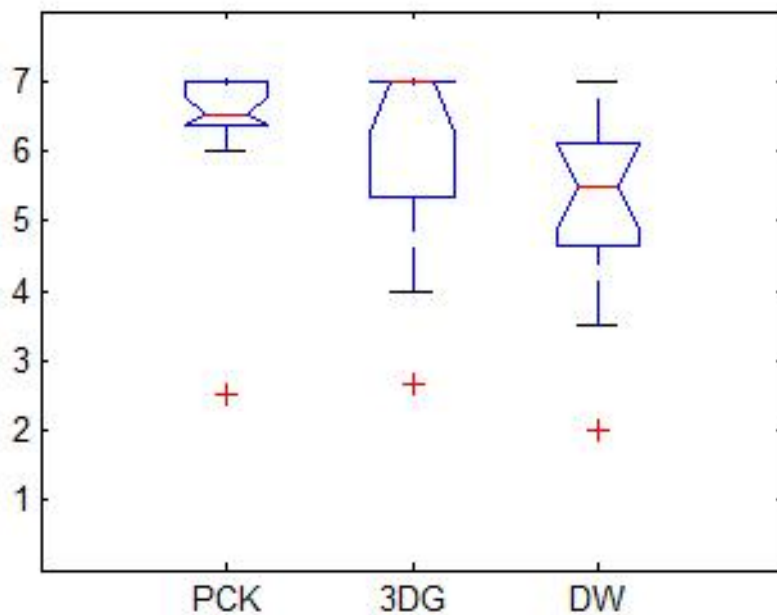


Figure 5.1: The Control Questionnaire Results

9. The training session was well taught
10. The lecture was well taught
11. Moving in SL was easy
12. Building in SL was easy
13. It was easy moving around the sample object to examine it
14. The technologies performed satisfactorily
15. The Help command was useful
16. The teaching staff gave me helpful feedback
17. The online teaching and resources in this unit enhanced my learning experience
18. The paper drawing session was easy
19. The workload in this unit was manageable
20. I'm globally satisfied of the experience

The answers to the questions of the two survey questionnaires have been scored on the seven-point Likert scale: from 1 (strongly disagree) to 7 (strongly agree). We report the questionnaire results by depicting three box-plots. In this way, it is possible not only to highlight the point values for results, but also their overall distribution.

Fig. 5.1 reports the preliminary questionnaire results aggregated in the three constructs: PCK, 3DG and DW. Confirming what claimed in <sup>1</sup>, the PC skills and experience

<sup>1</sup>Technology Power Users, Available: <http://powerusers.edc.org/aboutpu.htm>

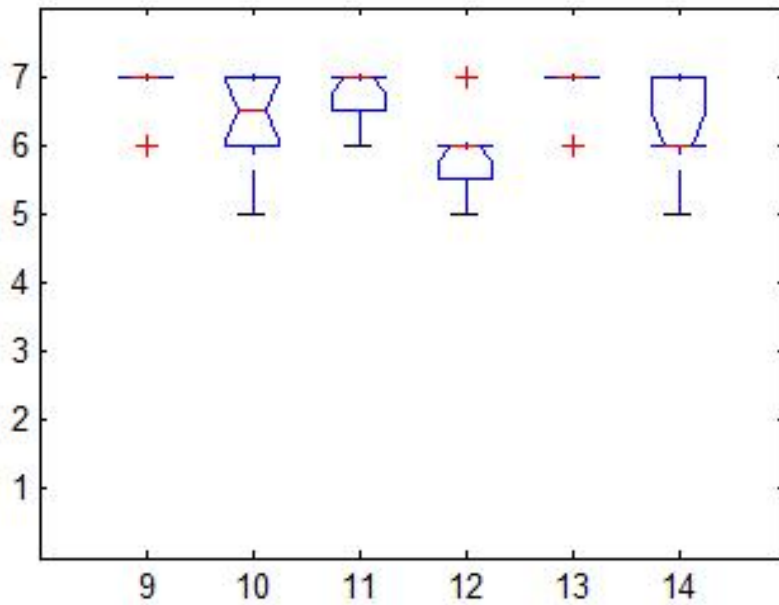


Figure 5.2: The Evaluation Questions from 9<sup>th</sup> to 14<sup>th</sup>

are really high in the adopted sample, just little lower scores have been reached by the 3D specific gaming addiction and practice, while the technical drawing capabilities scored near the medium.

Fig. 5.2 organizes the answer to the first six evaluation questions while the remaining part is depicted in Fig. 5.3. As shown in Fig. 5.2, students were really satisfied of the training session, since almost all of them scored the maximum value. Some differences in opinion manifest for question 10, since the subjects were expressing a positive opinion, but with a bigger degree of variability. Moving (question 11) building (question 12) and changing point of view around an object (question 13) in SL were perceived as easy, but students found the building activities harder. Question 14 reveals that the experience did not suffer from any technological troubles due to the system.

The functionality of recalling a demo 3D object has been appreciated by students that award it with a high score for question 15. Subject also exploited teaching support, evaluated by question 16, and considered it really important. Questions 17 and 19 are specific to evaluate how well the experience has been organized in terms of materials and difficulty of tasks and obtained scores do not reveal any concerns. Question 18 is specific for evaluating the post experience practical drawing session, while the last question is specific for assessing the overall didactic experience and proves a diffuse enthusiasm among participants.

It is important to point out observing the evaluation results how the proposed experience had been capable of influencing the subject perception of the drawing activities. If we compare the results obtained by construct DW (combining questions 7 and 8, with median 5.5) with the score obtained by question 18 (median 7), it seems that the proposed experience has had a good effect on student drawing attitudes.

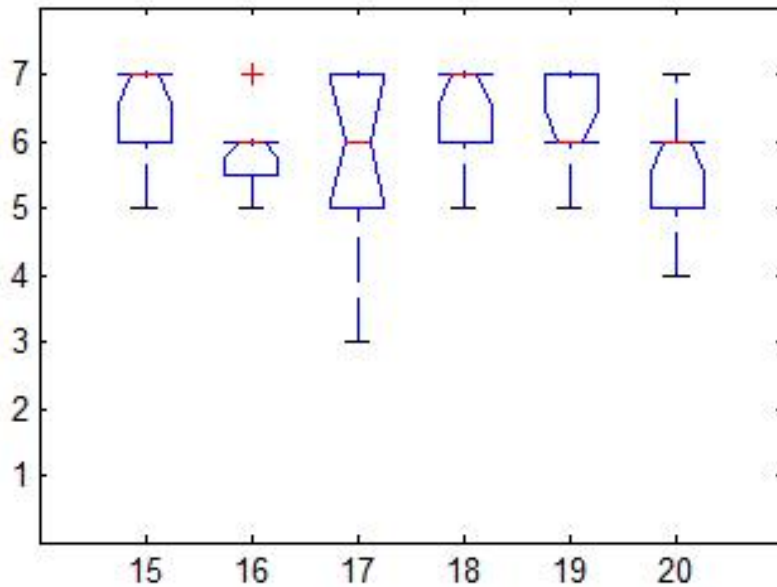


Figure 5.3: The Evaluation Questions from 15<sup>th</sup> to 20<sup>th</sup>

### 5.1.2 Objective Evaluation

The subjective perceptions, collected with the proposed questionnaire, have been complemented with objective performance measures obtained during three practical drawing sessions. At this aim, we organized a controlled experiment for evaluating if the adoption of VirtualHOP increases user comprehension and improves the orthogonal projections didactic.

According to [138], we designed a randomized experiment in which users were randomly assigned to one of the two treatments. Indeed, we selected two second year intermediate degree classes followed by the same technical drawing teacher. The classes were composed by 24 and 21 students aged between 11 and 13 years, as the subjective part of the experiment. We submitted to the classrooms the pre-experiment questionnaires for assessing their skills in technical drawing, 3D virtual Worlds and Personal Computer. Basing on the skill results, we excluded from the subject population the individuals obtaining best and worst results and obtained two samples each composed of 14 students. After that, aiming at avoiding unpredictable effects due to differences among classes, our subject groups were composed each with seven subjects for each class.

The two groups, Group1 (CL) and Group2 (SL) correspond to the two treatments of *Technical Drawing Teaching Modality*, the single factor we were considering: the Traditional didactic and the VirtualHOP one.

In particular Group1 was trained only using the classical laboratory and classroom didactic, while Group2 was additionally trained in the VirtualHOP environment. Both student groups were finally involved in an evaluative classical Orthogonal Projection Session which results have been evaluated by the teacher. The drawing session was based on the realization of three orthogonal projections by each subject. The geometric entities to depict were progressively increasing in complexity and no time limit was indicated. At the end of the task, the teacher was correcting the deliverables and assigning a grade in the range 1-10.

Table 5.1: Sample Statistics For Group1(CL) And Group2(SL)

	N	Mean	StDev	SE Mean
Group1(CL)	42	6.67	1.52	0.24
Group2(SL)	42	7.29	1.53	0.24

The proposed experiment supported two statistical hypotheses:

- **H<sub>0</sub>**: VirtualHOP does not support technical draw didactic differently than classical approach.

against:

- **H<sub>1</sub>**: VirtualHOP supports technical draw didactic better than classical approach.

Table 5.1 reports some statistics on the obtained results and shows that performances differ in terms of sample means. The dispersion of data around the means is almost the same for both samples (see column StDev).

The two hypotheses have been evaluated with a two samples T-Test [27]. As prescribed by the chosen test, we verified the distribution of our results with a preliminary check on data normality, performed as Anderson Darling test [3] performed at an  $\alpha = 0.10$ . For both samples, the p-values provided by the test (0.008 for VirtualHOP didactic and 0.01 for the classical one) were really lower than  $\alpha$  and assured that the obtained results respect the sample distribution requirement. The second requirement for T-Tests prescribes that the samples must be characterized by the same variances: this is verified at sample level, as shown in Table 5.1.

The performed T-test, with a p-value 0.034 did not give us enough statistical evidence to accept  $H_0$  against  $H_1$  and the estimate for difference between the performances of the two groups (Classical Vs VirtualHOP) is in (-1.283, 0.045) at a 95% degree of confidence. In practice, also in objective terms, VirtualHOP seems to be effective in improving user performances and a valid help in teaching technical drawing.

In addition to enthusiastic feedback from subjects, the proposed environment seems providing them with a synthetic view of space and objects that helps students during successive hand writing sessions. SL allows them to move in a 3D space exploring the demo objects and the relationship with their orthogonal projections, but it also provides the Building room metaphor that constitutes an easy way of schematizing the reality. This has also been verified by the objective evaluation phase performed. Moreover, students were pleased to carry out their tasks also in a cooperative manner. They felt that the tutor help or some interventions of colleagues were really useful in coping with first difficulties due to the novelty of the environment. Also the perceived sense of presence and immersion have been important ingredients for the success of the entire experience.

## 5.2 AIBot Evaluation

In this section we evaluate the contribution of a virtual assistant like AIBot to an individual didactic experience conducted in a VW. To this aim, we formulated the following research questions:

- *RQ<sub>2,1</sub>*: Do VWs strengthen the credibility of an Artificial Intelligence virtual assistant?

- *RQ<sub>2,2</sub>: Does AIBot satisfactorily support individual didactic activities in SL?*

We designed two evaluations in one of our SL educational settings. The first is inspired by the classic Turing Test that is used to evaluate ChatBots, while the second assesses the AIBot usefulness in assisting students when an individual activity is performed in a Virtual Lab.

## 5.2.1 Virtual Worlds and the credibility of Artificial Intelligence

In this section we answer RQ<sub>2,1</sub> to assess the credibility of an automatic ChatBot tutor in a 3D virtual learning environment performing a modified version of the Turing Test.

The Turing Test (TT) is a test on the machine’s ability to demonstrate intelligence [128]. It is also presented as an imitation game in which the machine mimics a human behaviour. A human judge converses with a human and a machine in natural language. He does not know the real nature of its interlocutors that both try to appear human. The machine passes the test if the judge cannot reliably distinguish between the two interlocutors.

In general, the purpose of TT is not specifically to determine whether a computer is able to fool a human interlocutor convincing him that he is speaking with a human being, but rather whether a programmed intelligence could imitate a human. Indeed, to this day, no machine has passed this test. In this paper, we exploit the Turing idea evaluating whether an AIML ChatBot seems to be a more ”credible” human being when adopts an avatar appearance and is immersed in a Virtual World.

### 5.2.1.1 The Modified Turing Test

Several versions of the TT have been proposed [101], aiming at testing the intelligence of programs or at modifying them according to the context in which the intelligence has to be verified.

The Ultimate TT<sup>2</sup>, introduced by David Barberi, is a virtual TT with a comprehensive environment of sight, sound and body, allowing the judge to base his decision not only on written words, but also on spoken speech, non-verbal cues, and body movements.

Neumann *et al.* [95] suggested variations of the standard interpretation of the TT for the challenges arising from new technologies such as internet and virtual reality systems. They also underline the need of such tests in view of massively multiuser online role-playing games (MMORPGs) and virtual reality systems like Second Life.

Philip Hingston [55] describes a new design for a TT for game bots. He tries to reach a more natural evaluation method, where the judges are simply game players and their opinion is an indicator of the game success.

In [6] Arroyo *et al.* explore the possibilities of adopting metabots, which make conversations and move like human avatars in a 3D VW. They also propose the concept of the extended TT to assess the anthropomorphism of the programmed characters respect to their interaction with the metaverse elements. In their work, they mainly focus on the social behaviour of the avatars, and evaluate the use cases by calculating the number of conversation lines exchanged by users and the bots. In [16], Burden presents architecture for immersing ChatBot avatars in SL. The paper considers the challenges related to the adoption of AI in a 3D VW, and designs a possible application of the TT. With respect

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<sup>2</sup>The Ultimate Turing Test :<http://david.barberi.com/papers/ultimate.turing.test>

to the last two papers, we perform a deep evaluation based on a running prototype of a virtual assistant.

The test we propose is characterized by the presence of two judges: an internal judge, inside SL, that chats with a human tutor and AIBot, and an external judge, that passively assists to the conversations. Both judges are required to guess the nature of participants. This change in the test mechanism adds a new challenge to the experience: the learning environment ability to strengthen the naturalness of the bot is tested by a direct performance comparison. If it is possible to observe statistically significant differences it will be possible to argue that VWs positively impact on the learner credibility of AIML ChatBots.

### 5.2.1.2 TT Design

The proposed evaluation has been organized as a modified TT, based on both objective and subjective evaluations of the AIBot performances. All participants were trained on basic SL commands and communication ways in a collective session performed before the test started. A group of 24 students of the first level degree in Computer Science of the University of Salerno voluntarily took part to the evaluation, physically conducted in the SE4eL (Software Engineering for e-Learning) laboratory of the University of Salerno and virtually performed inside the VirtualHop setting of the Unisa Computer Science Island, described in Section 4.1.

In particular, the test was organized in 12 comparison sessions and each one lasted less than one hour, involving the following actors:

- *The AIBot Avatar*, the virtual tutor that automatically answered to the chat messages using the AIML engine.
- *The SL Avatar*, connected and controlled in SL by a human tutor expert of the virtual setting.
- *The SL Judge Avatar*, a participant that performed a conversation, chatting with both AIBot and the SL avatar inside the SL environment.
- *The External Judge*, a participant that, behind the scene (i.e., outside the SL environment), evaluated the two chat conversations generated by the SL Judge Avatar with the SL and the AIBot avatars.

The communication among the participants was centered on the SL chat, accessed by the SL Judge Avatar inside SL and observed from outside by the External Judge (Figure 5.4). The SL Judge Avatar can propose both general questions and questions concerning the VirtualHop learning activities. In particular, the test proposed the following two tasks to the participants:

- *T1. Conversation with the AIBot Avatar*  
AIBot controlled the avatar and answered to the SL Judge Avatar.
- *T2. Conversation with the SL Avatar*  
A human tutor controlled a regular SL Avatar acting on the standard SL client and chatted with the SL Judge avatar.

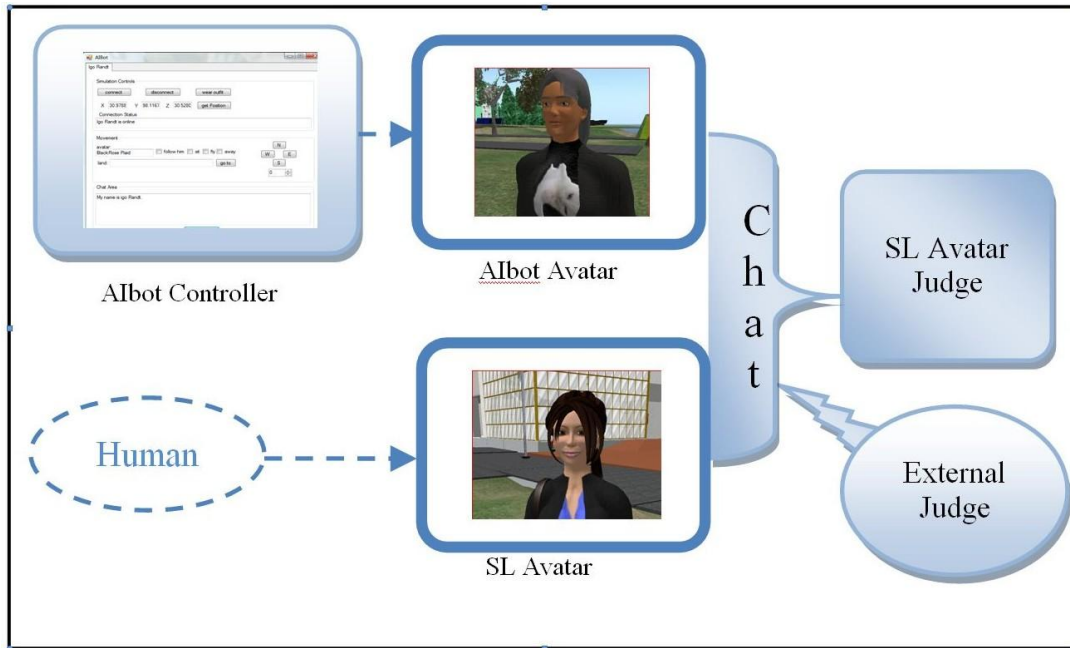


Figure 5.4: The Turing Test Organization

It is important to point out that we adopted a balanced design [139] to minimize the effect of the order in which the participants performed the tasks on the experiment results. The design is characterized by the same number of participants starting with the first task and the same number of participants starting with the second.

The SL Judge Avatar and the External Judge were the actors involved in the collection of the evaluation measures. Each participant was randomly assigned to one of the two roles and took the same role in both the two tasks.

The External Judge observed in real time the conversation from outside SL and evaluated the nature of the interlocutors without being influenced by the VW environment. When the SL Judge Avatar was sure about the nature of his interlocutor, he just signaled that he reached a decision and continued the conversation until the External Judge also communicated to the test conductor he was ready to take a decision. The number of participant messages required to take the decisions was adopted as a performance metric of the objective assessment for empirically evaluating the following null hypothesis:

- $H_{0,AI}$ : A 3D virtual environment does not affect the AI tutor credibility when it appears as an avatar ( $AIbotSL = AIbotEXT$ ).

The corresponding alternative hypothesis is:

- $H_{1,AI}$ : A 3D virtual environment improves the AI tutor credibility when it appears as an avatar ( $AIbotSL > AIbotEXT$ ).

We also executed the analogous verification on the effects on the judgments on human conversations inside and outside SL formulating the following hypothesis:

- $H_{0,H}$ : A 3D virtual environment does not affect the human tutor identification when it appears as an avatar ( $HumanSL = HumanExt$ ).

Against the alternative hypothesis:



- $H_{1,H}$ : A 3D virtual environment improves the human tutor identification when it appears as an avatar ( $HumanSL > HumanExt$ ).

This second test aims at investigating if the effects retrieved by the AI hypotheses could be due mainly to the environment influence and not to the Avatar added value to AI. As an example, the environment could distract the SL judges in both tasks, and, as a consequence, it could impact on all the conversations independently from having an AI or a human interlocutor.

After the test, both the judges answered the first three questions reported in Table 5.2, in order to collect information concerning the perception of the experience of the participants. The remaining questions were answered only by the SL Judge Avatar.

Table 5.2: The proposed TT questionnaire.

ID	Question
Q1	Which of the two conversations you had was with a human?
Q2	Was easy to decide which interlocutor was a human?
Q3	How much were you convinced of your decision?
Q4	Do you think that SL Avatars are a good representation of humans?
Q5	Even if synthetic, do you think that the SL avatar appearance enhances the bot with respect to a simple chatbot?
Q6	How much did the environment distract you ?
Q7	How much did the environment involve you ?

The first question has only a control nature, since until now, AIML bots have always been recognized and we do not trust being able to alter user perception so much to win the undefeated Turing Challenge. The following two questions aim at evaluating the credibility of the AIbot experience investigating the qualities of the user judgement. In particular, question Q2 aims at quantifying how easily the participant takes her/his decision, while question Q3 aims at assessing the belief level on the final decision, which is further verified by analyzing the number of user messages. Question Q4 was proposed to assess the SL Judge Avatar perception of the SL avatars representativeness of humans being, while question Q5 was specifically formulated for evaluating the perception of the effects of the avatar appearance on the credibility of a ChatBot. The last two questions aimed at assessing whether the attention of the SL Judge Avatar has been affected by the SL environment. Indeed, there is the possibility that the user concentrates his attention on other features offered by the environment (Q6), and this aspect should be considered when examining the assessment results in terms of the number of participant messages. On the contrary, a positive well known effect of VWs is a deep presence perception and, in particular, a high involvement attitude (Q7). The more a user is involved and not distracted by the environment, the more her/his attitude to learning will be positive. Indeed, too many or too few stimuli can cause distraction and can reduce the learner involvement [137].

All the questions, except question Q1, have been evaluated on a five point Likert scale [99] ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

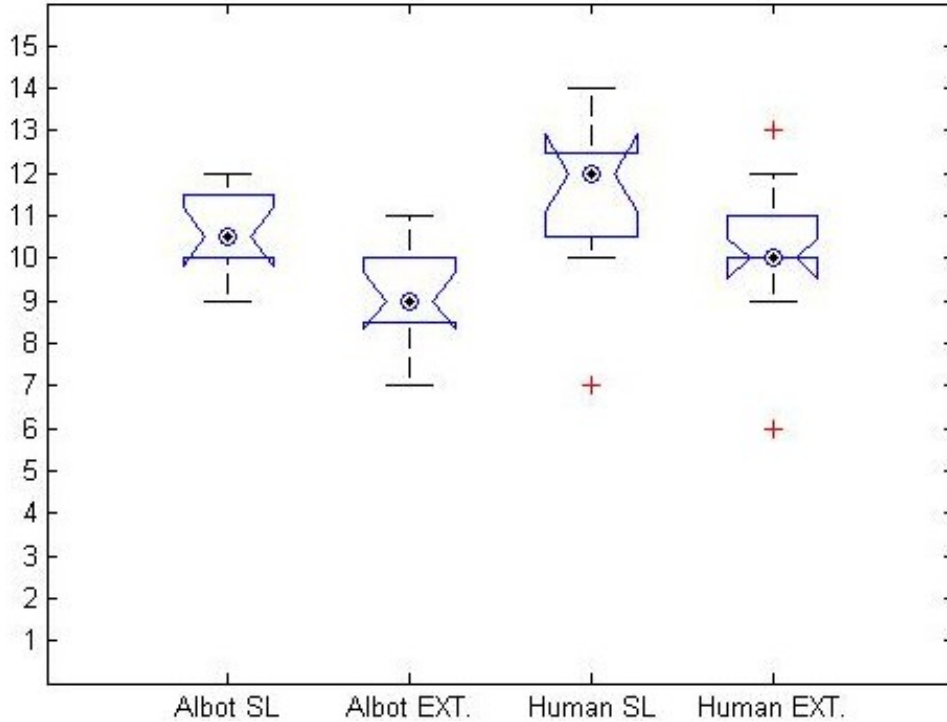


Figure 5.5: Number of participant messages

### 5.2.1.3 TT Results

The evaluation concerned both objective (performance metric) and subjective (questionnaire answers) results.

Before performing the hypothesis tests we checked the normality requirement of compared results via Anderson-Darling test. Results revealed a normal distribution for AIbot SL and AIbot EXT data (p-value = 0.133 and p-value = 0.370, respectively) and let us to choose a paired T test for hypotheses verification. On the contrary, in the case of the human identification results, the normality tests failed (Human SL p-value = 0.033 and Human EXT p-value = 0.019), requiring the adoption of a non-parametric test, the Mann-Whitney test [36].

Figure 5.5 reports the box-plots of the objective performance metric defined as: *the number of messages of the participant before being able to understand if he/she is interacting with a human or an automatic assistant*. The longer it takes, the more human-like the conversation should appear. The results are organized respect to the judge typology. In particular, the AIbot SL and AIbot EXT box-plots represent, respectively, the performances for recognizing AI obtained by the SL Judge Avatar and by the External Judge.

Results revealed that the external Judges required less questions to take a decision about the interlocutor nature. Indeed, basing on AIbot SL and AIbot EXT results, it is possible to confute, via a paired T test, the null hypothesis  $H_{0,AI}$ . With p-value=0.019, at a significance level  $\alpha = 0.05$  we can reject  $H_{0,AI}$  (i.e., AIbot SL requires more messages respect to AIbot EXT). Indeed, it is also possible to quantify at 90% confidence that the true difference between AIbot SL and AIbot EXT is between 0.31 and 2.35. This range confirms that the recognition of an SL AIbot tutor requires, on average, one more question inside SL than outside.

A trend similar to the one related to AI identification is graphically shown in the right-hand side of the box-plots of Figure 5.5. This figure depicts the recognition performances of a human assistant performed by the SL Judge Avatar and by the External Judge, respectively. At a first sight, the SL environment seems to improve the performances also in the case of human recognition. Despite this first impression, the Mann-Whitney test confirms  $H_{0,H}$  as the more likable hypothesis (p-value=0.128). This suggests that there is no statistical meaningful difference when the interlocutor is human, both inside and outside the SL environment. This confirms us that the SL environment affects only the user perception about AI, but not affects conversations in general.

Observing Figure 5.5, let us note that the human recognition happens slowly than in the case of AIbot conversation both inside and outside SL. This is probably due to the nature of this test. Indeed, a recognition of the interlocutor type can rely on unnatural behaviors, which can likely happen in the case of AIbot conversation. In the case of conversation with a human, more messages are required, since it is harder to find a clear evidence of such behaviors.

Concerning the subjective evaluation, Figure 5.6 reports the box-plots of the scores obtained by each question of the questionnaire. In particular, the left-hand side of Figure 5.6 reports results for the questions Q2 and Q3, respectively, for in-world (SL) and out-world (EXT) judges. The right hand side of the picture aggregates questions Q4, Q5, Q6 and Q7. As it is possible to see, respect to questions Q2 and Q3, the SL environment gives the internal and external judges a comparable easiness in recognizing the interlocutor type. A lower belief level on the AIbot recognition is reached in case of SL Judge Avatars respect to the outside observers. The scores obtained by questions Q4 and Q5 revealed that the participants perceived the SL avatars as a good representation of humans ( $\tilde{x}(Q4) = 4$ , where  $\tilde{x}$  denoted the median value) and that they prefer a ChatBot with an SL avatar appearance ( $\tilde{x}(Q5) = 4$ ).

The last two questions, Q6 and Q7 in Figure 5.6, investigate the SL Judge Avatar perceptions on his/her concentration during the experience performed, by examining the influence of the environment on the Distraction and Involvement perception. Indeed, a slower recognition could be due to a Distraction factor and could invalidate this result. Most SL Judge Avatars perceived a high engagement in the experience ( $\tilde{x}(Q7) = 4$ ), with low distraction from the VW environment ( $\tilde{x}(Q6) = 2$ ). In particular, 3 subjects scored 4 for Q6, confirming the danger of being distracted by the richness of a VW. On the other side, the results concerning the Involvement perception are very relevant, because the deeper is the involvement, the better is the presence perception that strongly affect the learning results. [106].

Concerning the Distraction effects on the objective results, a deeper analysis revealed that only 1 of the 3 subjects that considered the environment highly distracting required a high number of participant messages to detect the bot (12 messages). Thus, the Distraction effect should not have a dramatic impact on performances, while there is a positive influence of Involvement. In addition, the analysis of the chat log between SL Judge and AIbot revealed that the number of the participant messages related to the virtual environment and the activity there performed was characterized by  $\mu = 7.21$ , while the average number of messages of the entire conversation was  $\mu = 10.58$ . Thus, in average, few messages were dedicated to general conversation.

Resuming, there is no statistical difference in the recognition performances of a human interlocutor from inside and outside SL. On the contrary, SL enhances the AIbot perfor-

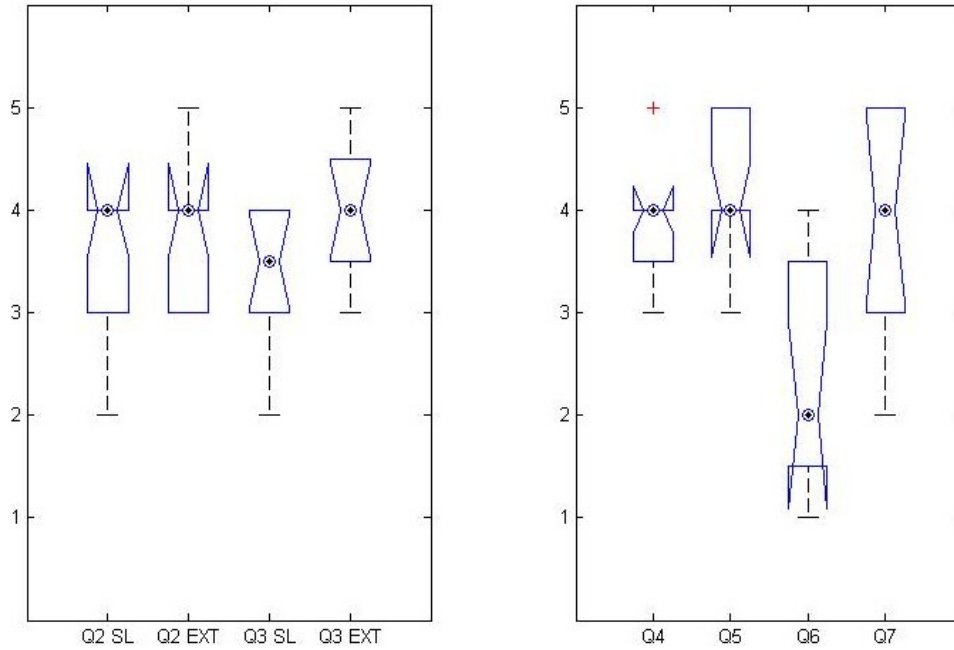


Figure 5.6: The questionnaire results

mances providing a setting that affects the learner perception of AI, since it statistically requires more messages to discover its machine nature when it appears as an avatar.

## 5.2.2 Evaluating the AIBot support to individual learning activities

In this section, we answer RQ<sub>2,2</sub> with an evaluation session assessing the perceived benefits related to the adoption of AIBot as a virtual assistant during an individual learning activity.

Also this study was conducted in the SE4eL laboratory of the University of Salerno and, virtually, in the VirtualHOP setting. Data for the study have been collected considering a group of 24 volunteers belonging to a secondary school classroom with a focus on science.

The participants were required to accomplish a building task in the VirtualHOP Lab, composed of the following steps:

1. select the drawing to copy;
2. observe the temporary 3D version of the selected object displayed in the Show Room and its orthogonal views on the surfaces of both Show and Building rooms. Examine the object from the various sides, moving the avatar and flying in the environment inside and outside the Show Room, before the temporary object disappeared;
3. move to the Building Room and reconstruct the selected object, using the available elementary SL building components;
4. use the SL object exchange system to deliver the artefact to the teacher.

Before starting, a training lecture was provided to the students in a four-hand computer session (both tutor and student at the same computer): the tutor individually

followed each student ensuring good average SL moving and building skills. During their training, the students were instructed to chat with an avatar called "igo Randt", the avatar in which our AIbot system was embedded, for receiving help. Obviously, we did not expose the fact that it was a bot, aiming at avoiding prejudices from students. After the individual training phase, the students were trained about orthogonal projections with a one hour lecture.

During the VirtualHOP practical session, which lasted up to 30 minutes, we registered the messages exchanged between the learner and AIbot, for further analysis. At the end of the session, we collected the opinion of the 24 participating students by proposing the questionnaire reported in Table 5.3.

Question Q1 is related to the user perception of usefulness of discussing with AIbot, while Q2 aims at evaluating the level of credibility of AIbot in this context. Questions Q3, Q4, Q5 and Q6 were specifically formulated for evaluating the degree and the level of support provided by AIbot to the students. In this direction, question Q3 is focused on understanding the support to the comprehension of the overall experience, i.e., the comprehension of the learning objectives, the steps to follow to accomplish the task, etc. Question Q4 is more specific and aims at evaluating the degree of practical aid provided to perform a single step of the task, i.e., how to display a sample object in the Show Room. Question Q5 is specifically formulated for assessing the perceived degree of being able to control the conversation and evaluates the participant perception of the negotiation process (negotiations are elements of conversations where a topic is introduced, discussed and resolved). Q6 and Q7 try to collect the easiness degree perceived by users: question Q6 is focused on how easily the users drive the generic AIbot conversation towards the required information, while question Q7 assesses the general easiness of the interaction. Question Q8 assesses the user enjoyment in practicing with the system and question Q9 evaluates the perceived comfort in communicating with AIbot as compared to the interaction with a real tutor or teacher. A user can find AIBot easy to use, useful, etc., but at the end he does not use it. Thus, it is relevant to determine his actual intention to use the system in the future (Q10).

Also the answers to these questions have been assigned on the five point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) [99].

Table 5.3: The Individual Learning Questionnaire.

ID	Question
Q1	The chat discussion was an effective aid.
Q2	I quickly realized that I was chatting with a bot.
Q3	I used AIbot to help me to comprehend my task (learning objectives, the steps to follow to accomplish it).
Q4	AIbot helped me in performing the single steps of my task.
Q5	I was able to achieve the negotiation tasks I wished with the AIbot.
Q6	AIbot made the access to the helping system easy.
Q7	It was easy to interact with AIbot.
Q8	I enjoyed interacting with AIbot.
Q9	I felt more free to interact with AIbot respect to speaking with human controlled characters (tutor/teacher).
Q10	I would like to use AIbot in the future.

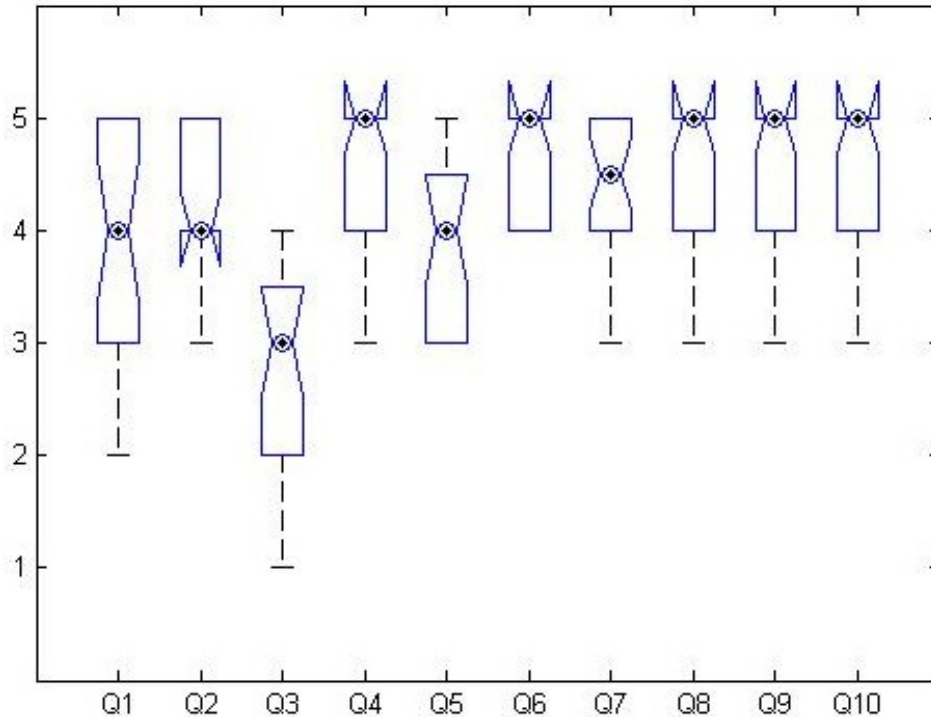


Figure 5.7: Individual learning perception results.

### 5.2.2.1 Individual Learning Results

In this section we discuss the results of the subjective evaluation of the proposed individual learning activity. In Figure 5.7 the results collected with the Individual Learning Questionnaire are shown, providing a boxplot for each question.

As shown in Figure 5.7, half of the participants was very satisfied of the support provided by the discussion ( $\tilde{x}(Q1) = 4$ ), 25% provides a score  $x \leq 3$  and two subjects scored 2. They quickly understood of being involved in a conversation with an AI controlled entity. Indeed, the 74% of them scored 4 for Q2 ( $\tilde{x}(Q2) = 4$ , which also represents the lower bound of the second quartile). This aspect should have had a positive effect on student availability to make questions. Indeed, the synthetic nature of subject interlocutor avoided them to feel under exam by a human tutor or teacher (Q9). In terms of provided support, less effective was the aid on the comprehension of the overall experience, related to the learning objectives and to the steps to follow to accomplish the task,  $\tilde{x}(Q3) = 3$ . On the contrary, question Q4 assessed a very good degree of perceived support obtained respect to the single actions the users were required to perform during the experience, i.e., obtaining the object preview, building, etc. (only 3 participants scored 3).

The negotiation process with AIbot has been perceived as easy for 63% of the users, while the others were neutral (Q5). This means that the discussion was easily directed towards their objectives. Continuing with the easiness perceptions, Q6 results report really good user opinions concerning the easiness to access the support information provided by AIbot ( $\tilde{x}(Q6) = 5$  and the lower value was 4). Question Q7 also states a positive degree of easiness in the interaction with the system ( $\tilde{x}(Q7) = 4.50$ , only two subjects were neutral). This result accords to the ones related to question Q5.

The last three questions results (Q8, Q9 and Q10) are very positive, with median equal to 5. A detailed analysis of the data revealed that all the students except one that was

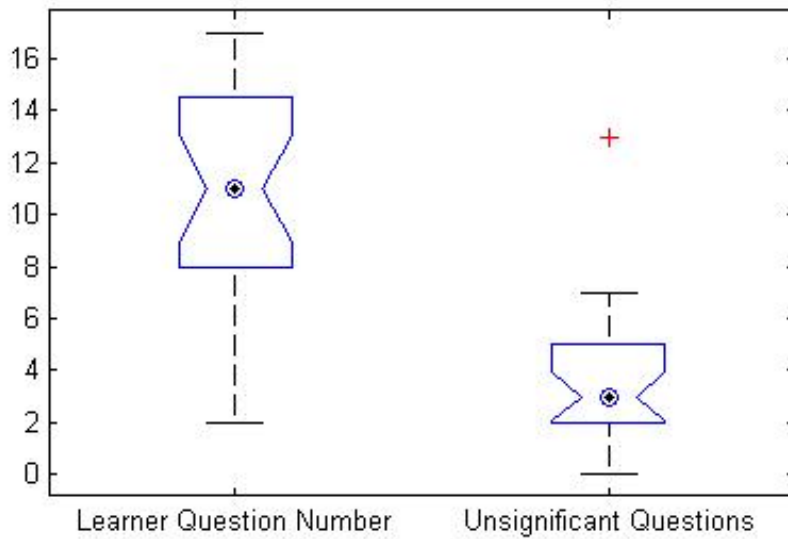


Figure 5.8: Number of participant messages.

neutral enjoyed the experience (Q8), 88% of them were deeply stimulated by the artificial nature of AIbot to formulate questions and find more comfortable communicate with it respect to a real tutor (Q9). Only 3 were neutral. This means that AIbot makes easy the opportunity for asking help and also for conversing. Most important result is their positive intention to use AIbot in the future (21 students expressed a positive intention, the others were neutral).

We also examined the chat log to determine the number of questions the learners proposed to AIbot, summarized in Figure 5.8. This analysis is useful to better understand whether the positive satisfaction results were supported by an effective usage of the AIbot help. In particular, the leftmost boxplot of Figure 5.8 shows a considerable usage of the AIbot support: the average number of questions is  $\mu=10.83$  with  $\sigma=3.79$ . The rightmost boxplot represents the data concerning the number of questions that are not strictly related to the learning experience. We can see that the number of questions falling in this category has  $\mu= 4.15$  and  $\sigma=2.7$  and that the participants mainly used AIbot for its intended learning purpose in average for the 61% of the questions. Generally, the questions non related to the learning experience were addressed at the beginning of the conversation. After this initial phase, the messages were mainly focused on the activity to perform. Participants were not aware that their chat was registered.

# Chapter 6

## Conclusion

### 6.1 Final Remarks

In this thesis we proposed new learning approaches in which learning in a VW presents added value with respect to traditional education and that effectively exploit the third dimension to conduct learning activities. In particular, we presented the didactic support provided by VirtualHOP, a SL environment programmed for helping young students in technical drawing. With this system, we also introduced a didactic experience that presented the concepts behind Orthogonal Projection by naturally exploiting the SL third dimension. Secondly, we objectively and subjectively evaluated the learning effectiveness of this environment and of the didactic approach. The more promising and interesting result obtained is that VirtualHOP seems providing students with a synthetic view of space and objects that helps them during successive hand writing sessions as a good mental model: students referred to adopt the "Show room" model each time they need to imagine the object in the space and that the experience helped them in creating this model and practicing with it.

However, VWs training actions are not limited to class time: the teaching resources are available 24 hours, 7 days a week and it is almost impossible to provide a tutor for assisting the students whenever they access the didactic world. For this reason, we developed AIbot, a virtual assistant for helping the e-learning community that meets on the Unisa Computer Science Island, in SL. It adopts an AIML engine and an interaction modality very usual in SL, the ordinary text chat channels. AIbot appears as an avatar and exploits the presence and awareness perceptions offered by the environment to address students towards the different didactic activities hosted on the Unisa Computer Science Island, and to provide assistance during individual learning activities conducted in a virtual lab, VirtualHOP.

In this thesis we evaluated the perception and the satisfaction concerning the interaction with AIbot considering two different points of views: first, we organized a modified version of the Turing Test, collecting objective and subjective performance measures to establish whether the SL environment influences the learner perceptions of an Artificial Intelligence tutor. In particular, during the test, in SL, a user avatar randomly interacted with a human tutor controlled avatar and with the AIbot tutor aiming at understanding whether the interlocutor is human or programmed. Simultaneously, an external judge observed in real time the conversation, without being in SL. The evaluation revealed that SL enhances AIbot performances, providing a setting that affects learner perception of Artificial Intelligence, since it statistically requires more messages to discover the pro-



grammatic nature of AIML conversations. This is probably due to a high involvement perception, which is a positive result, because involvement increases the presence perception, a factor relevant for obtaining a positive participation level to learning activities.

The result obtained in this first evaluation phase motivated a further investigation aiming at assessing the user perception of the didactic support offered by AIbot during individual learning activities. Student opinions have confirmed the impression we had during the Turing Test and stated that the experience and the users enjoy in using the aiding system, which was perceived as useful and easy to use and control. They also find very comfortable to communicate with it respect to asking question to a real teacher.

## 6.2 Future Research Directions

There are a number of research directions to extend the work described in this thesis. In general, SL environment lets users activate their constructions by programming their behaviours: as a future work to broaden the VirtualHOP system, we are preparing objects to transmit a specific behaviour to SL constructions. In this way, the proposed didactic system will be enhanced adding to the technical drawing didactic capabilities a more complete laboratory, where students will experiment not only with shapes, but also with movements and actions. In addition, we can verify if a collaborative use of VirtualHOP enhances learning outcomes when compared with individual use.

In a second direction, we are investigating how to extend AIbot to provide a richer multimodal interaction with the avatar, by including voice and emotional expressions. It will be interesting to evaluate whether these features provide a more effective human-like communication and increase the sense of presence and the learner positive attitude towards this kind of VW chatbots. In the meanwhile, we are also collecting the results on the use of AIbot in different learning settings for better understanding the amount and the quality of the conversations performed, their topics and the appropriateness of the bot answers. A preliminary analysis of the chat log reveals that the conversation topics are generally appropriate and the learners exploit AIbot for suggestions when there is an assigned homework for students, such as a 3D artefact to show to the teacher. In this case, less than 30 % of messages are not focused or inappropriate. Conversely, when the experience has not a fixed topic and is performed by occasional users, a general conversation on the activities proposed by the environment is mainly performed and denotes a higher interest respect to a conversation on a specific learning activity.

# Appendix

## A Publications

- Journals
  - [41] R. Francese, **S. Murad**, I. Passero and G. Tortora. On the adoption of a Chat-Bot Assistant in a 3D Learning Virtual World. *Journal of Computer & Education*. Submitted, 2012.
  - [92] **S. Murad**, I. Passero, R. Francese and G. Tortora, An Empirical Evaluation of Technical Drawing Didactic in Virtual Worlds. *International Journal of Online Engineering (iJOE)*,7(S1):23–30, 2011.
- Book Chapter
  - [91] **S. Murad**, I. Passero and R. Francese, Metric Pictures: Source Code Images for Visualization, Analysis and Elaboration. *Information Technology and Innovation Trends in Organizations* ,pages 279-287, Springer 2011.
- Conferences
  - [26] S. Cuccurullo, R. Francese, **S. Murad**, I. Passero and M. Tucci . A gestural approach to presentation exploiting motion capture metaphors. In *Proceedings of the International Working Conference on Advanced Visual Interfaces*, Capri Island, Italy, 2012. ACM Press.
  - [93] **S. Murad**, I.Passero, R. Francese and G.Tortora. VirtualHoP: Virtual Worlds for experimentation and concretization of technical drawing. In *Proceedings of the Global Engineering Education Conference (EDUCON)*, Amman,Jordan, 2011. IEEE Press.
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