An Empirical Evaluation of Technical Drawing Didactic in Virtual Worlds

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***Abstract*—This work proposes a 3D Virtual World environment and a didactic experience for training young students in an environment capable of supporting the engineering practices based on technical drawing. 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. An empirical evaluation, conducted as a controlled experiment, has provided enthusiastic results in terms of user performances and impressions.**

***Index Terms*—3D Simulation Environment, Distance Education, Technical Drawing, Virtual Worlds.**

I. INTRODUCTION

In this work we experiment a Second Life environment, *VirtualHOP* (Virtual Help for Orthogonal Projections), programmed as a specific setting for teaching technical drawing to first level students. Our aim is to exploit the three dimensions of Second Life 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.

This work presents *VirtualHOP*, a Second Life-based system, and an associated didactic activity that has been adopted as a case study for the evaluation of the experience.

The proposed Second Life (SL) environment is composed by a display that shows to students the orthogonal view of the object to build, a specific didactic module that demonstrates the resulting virtual 3D representation of the object, and a construction area where the students can exercise their building capabilities aiming at reproducing the proposed object.

The proposed didactic activity is organized in three phases:

1. The student selects the drawing he/her wants to work on and displays its orthogonal views
2. The system displays a 3D version of the selected object the student can examine and explore from various sides, moving in the environment
3. The student reconstructs in the 3D Virtual World the selected object.

The SL environment lets users build their constructions starting from primitive and simple components, such as cubes, pyramids, cones and so on. The main didactic value of the proposed experience is the need to understand the 3D form of the selected object from the orthogonal views and to resume it in terms of SL elementary components.

A preliminary evaluation conducted on the *VirtualHOP* system revealed general user satisfaction and encouraged us in continuing the experimentations. In this work we complement the subjective evaluation discussed in [1], with objective performance measures collected during practical sessions.

This paper is structured as follows: Section II discusses related work, while Section III presents the proposed system. The evaluation of the proposed approach is reported in Section IV. Section V, finally, concludes.

II. RELATED WORK

A. Virtual Worlds and Education

Virtual Worlds (VWs) are more and more diffusing as a genre of online communities that exploit computer-based simulated environments for supporting user interaction. VWs have been experimented as didactic settings for a wide range of didactic activities often strongly based on user collaboration.

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.

The capability to provide users with simulation and collaborative environments is at the base of the success of several VW environments, such as Active Worlds [2], Open Cobalt [3], Second Life (SL) [4] and its open source replica OpenSim [5] or openWonderland [6], that propose didactic environments ranging from replicas of real universities to other planets, or completely fantastic.

During his participation at the Dr. Dobb's Life 2.0 [7] Alem Theas (the virtual character of Grady Booch, best known for developing the Unified Modeling Language (UML) affirmed to currently use the SL platform for remote conferencing and collaboration. He said to see its application for "objects with high semantic density: in world (SL) there is so much more that you can do than with the 2D Web, you can put all artifacts in one space and manipulate them". In [8], Macedonia foresees, on the basis of the current web technological explosion trend, the fulfillment 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 [9], 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 Virtual Worlds 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.

3-D Virtual Worlds are typically characterized by three important features: the user perception of the 3-D space, the avatars that visually represent users and an interactive communication tool to let social connections be possible. In this work, we adopt a 3D VW for creating a bridge between the 3D reality of objects and their 2D projected representations, aiming at providing lower student with a didactic environment capable to let them explore the object and its representations (2 and 3D) empowering their comprehension about the orthogonal projective drawing technique. In our system we use SL environment as a VW, even if other environments such as OpenSim or Open Wonderland are equally capable of hosting similar didactic systems. However, SL is particularly suitable for didactic and remote simulations and activities.

The adoption of 3D representation has a significant advantage over virtual communities based on ''2D'' technology: the former induce a strong presence sensation, as shown in [10].

As a diffused example of connection between a traditional learning platform and the 3D Virtual World of SL, Kemp and Livingstone proposed Sloodle [11], a system integrating SL and Moodle [12], which uses ad-hoc SL objects to communicate with instances of the Moodle learning management system equipped with a specific Sloodle plug-in.

SL, the Linden Labs environment, is the most popular Internet-based Virtual World, if measured by number of subscribers and money exchange and its popularity may increase the effects of the learning actions hosted on the Linden spaces. It is largely adopted for academic, social and business purposes. In particular, many Universities and other kind of organizations (IBM, Sun Microsystems, Toyota, Nissan, Dell, Reebok, Reuters, NBC, etc.) are already using the SL Grid to host distance learning [13] and [14], tutoring, marketing surveys, branding actions and so on.

De Lucia et al. proposed SLMeeting, a hybrid system hosted between SL and an external Moodle based web site [15] and [10]. SLMeeting is hosted in a SL Virtual Campus [16] which provides four distinct types of virtual spaces: a common student campus, collaborative zones, lecture rooms and recreational areas. SL environments and objects have been designed and programmed to support synchronous lectures and collaborative learning.

SLMeeting has been evaluated in a controlled experiment involving university students, aiming at evaluating SL synchronous distance lectures in the proposed learning environment. The evaluation has been carried out considering that, in a 3D multi-user Virtual Environment, learning is strongly related to the user perception of belonging to a learning community, as well as to the perception of awareness, presence and communication. The results of the evaluation are very positive since SL "Residents" reach an advanced level of social connection and perceived presence, as deeper as users are able to identify themselves with their avatars.

The evaluation presented in [17] completes the research suggesting that the proposed SLMeeting system, enriched by the verification that the SL third dimension does not introduce disruption elements respect to a textual chat based meeting environment.

In a previous work [18] we presented AIbot, an assistant system, resident on Unisa Computer Science Island, and adopted for helping users in the exploration and fruition of Virtual Worlds. The proposed guiding assistant, aiming at reaching a natural appearance and a usual interaction style, concretizes in an avatar, the typical character that usually represents users during their Virtual World experiences and utilizes an AIML engine to interact with users on the ordinary text chat channels. Results obtained in a controlled experiment were really good and highlighted how the Virtual World environment influences user perceptions of artificial intelligence.

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 [19].

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.

B. Technical Drawing Didactic

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 [20]. Our approach, according to its didactic goals, considers only simple objects characterized by a regular and homogeneous internal structure and we adopt three projection planes.

In general, technical drawing requires neophytes to thinking 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 [21], [22]. Field [23] 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 [24] 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.

Following these needs, we propose 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.

A strong contribute 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.

Really recently, Martin-Dorta et al.[25], proposed a mobile application for exploiting the pedagogical potential of mobile devices, designing a 3D construction mobile game for 3D spatial visualization training, with the aim of familiarizing users with a 3D environment and improving their understanding of the 2D-3D relationship. Their aim is similar to ours, even if the proposed drawing activity is limited to an object constrained on a prefixed matrix of 3x3 simple cubic blocks and the projections are never shown contemporarily to the 3D entity. In addition, the *VirtualHOP* system, exploiting the SL features, enables the student to move his/her avatar (and the relative point of view on the scene) around the 3D sample of the object to reconstruct, exploring the relationship with the three projections.

III. THE PROPOSED SYSTEM AND APPROACH

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. 1, 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.

A. *The proposed system*

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

The proposed Second Life environment is composed by three main areas: the *Show Room* Fig. 1 (b), the *Build Room*, shown in Fig.1 (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.2, with three transparent surfaces that avatar can traverse to allow students to ex-

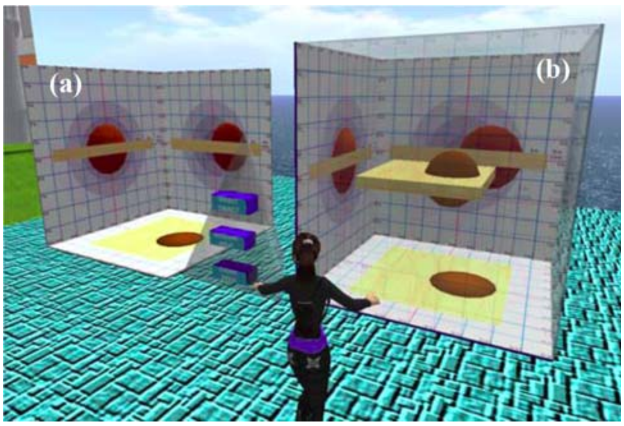

Figure 1. the *VirtualHOP* system in Second Life. From right to left, the Show Room (a), the Control Bar and the Build Room (b)

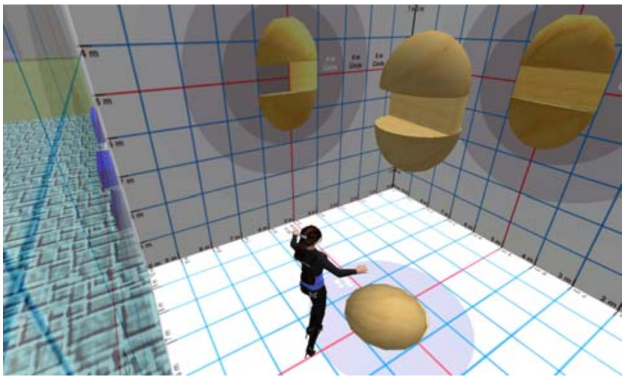

Figure 2. The *VirtualHOP* Show Room

plore 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 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.

B. *The 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. 2.
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. 3 (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. 3 (b). The object is then aligned with the Front and Side views, see Fig. 3 (c), and its shape is adapted to these two projections with a stretching operation as shown in Fig. 3 (d). Final details are added to complete the work, obtaining the final object shape and size, as shown in Fig. 3 (e) and (f).

1. 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.
2. 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. 3 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.

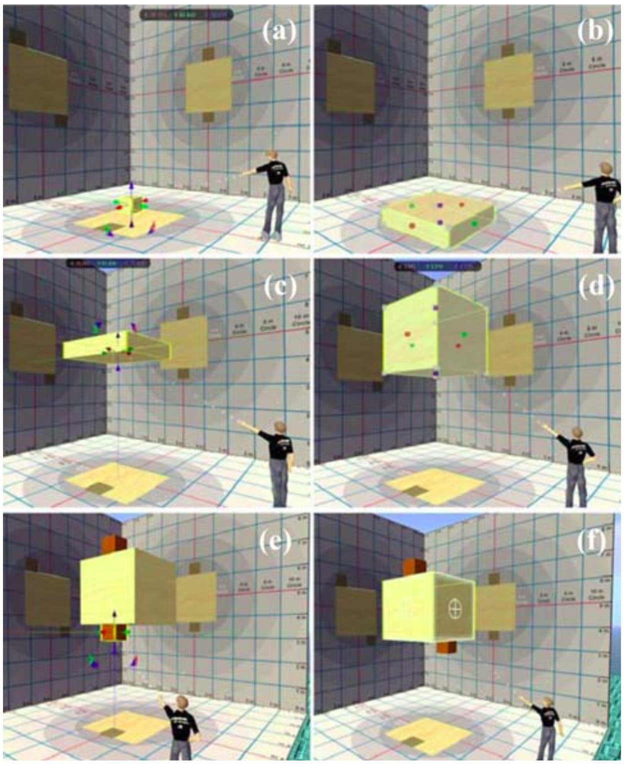

Figure 3. The construction steps for a simple object

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.
- 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.

IV. EVALUATION

A. Subjective Evaluation

In [10], [15] and [17] we performed several controlled experiments aiming at evaluating SL as a didactic environment under different perspectives. As reported in Related Work section, SL has proven to be effective for synchronous distance lectures, for distance collaboration and, after little starting difficulties with the moving and building controls, it does not seem to introduce further distraction elements in didactic activities.

As the state of the art, what remains to evaluate is the didactic value of the experience.

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:

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 camera around the sample object
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. 4 reports the preliminary questionnaire results aggregated in the three constructs: PCK, 3DG and DW. Confirming what claimed in [19], the PC skills and experience 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 organizes the answer to the first six evaluation questions while the remaining part is depicted in Fig. 6.

As shown in Fig. 5, students were really satisfied of the training session, since almost all of them scored the maxi-

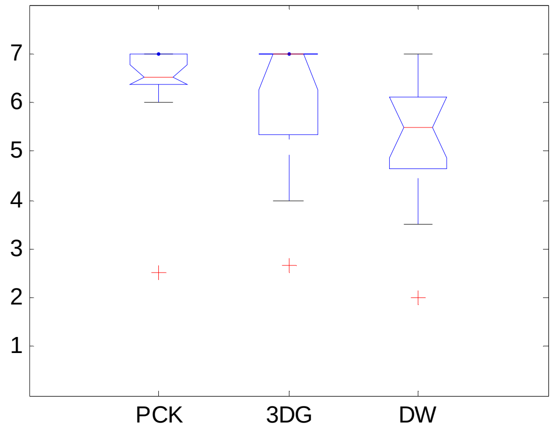

Figure 4. The Control Questionnaire

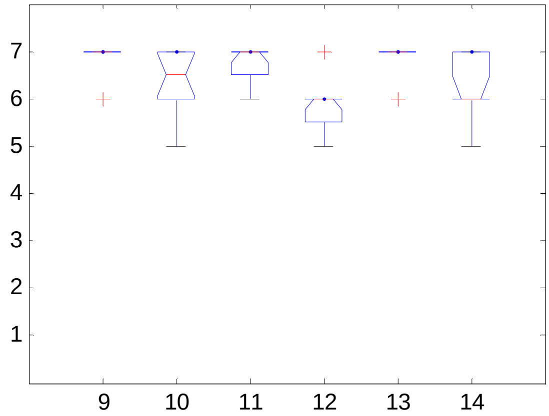

Figure 5. The Evaluation Questions from 9th to 14th

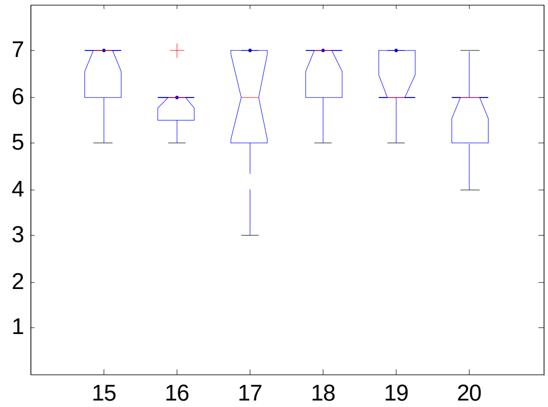

Figure 6. The Evaluation Questions from 15th to 20th

mum value. Somme 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 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.

B. *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 [26], 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 classrooms, followed by the same technical drawing teacher, composed by 24 and 21 students aged, as the subjective part of the experiment, between 11 and 13 years. 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 classroom.

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 I. reports some statistics on the obtained results and shows that performances differ in terms of sample means.

TABLE I.
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 dispersion of data around the means is almost the same for both samples (see column StDev).

The proposed experiment supported two statistical hypotheses:

$\mathbf{H_0}$: *VirtualHOP* does not support technical draw didactic differently than classical approach;

against

$\mathbf{H_1}$: *VirtualHOP* supports technical draw didactic better than classical approach.

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 [28] performed at an α=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 α 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 I.

The performed T-test, with a p-value 0.034 did not give us enough statistical evidence to accept $\mathbf{H_0}$ against $\mathbf{H_1}$ 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 really effective in improving user performances and a valid help in teaching technical drawing.

C. Advantages of VirtualHOP

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.

V. CONCLUSION

In this paper we presented and evaluated the didactic support provided by *VirtualHOP*, a SL environment programmed for helping young students in technical drawing. With the system, we introduce also a didactic experience that presents the concepts behind orthogonal projection by naturally exploiting the SL third dimension.

The more promising and interesting result obtained is that the proposed environment 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.

In general, SL environment lets users activate their constructions by programming their behaviours: as a future work, 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.

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