Online Learning with Virtual Puppetry

Giuseppe Chiazzese, Maria Rita Laganà

Istituto per le Tecnologie Didattiche, Consiglio Nazionale delle Ricerche Palermo Italy
{giuseppe.chiazzese, mariarita.lagana}@itd.cnr.it

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The first part of this paper introduces learning environments built on virtual worlds with the idea that avatars match the characters from theatrical productions. An actor performing on the stage of these new virtual theatres must master the rules of the world he has entered and in so doing engages in "natural" experiential learning. Then, within this general framework, we describe a system developed for 9-10 year old children. In this environment actors in different localities are connected to the Internet and use puppets to act out a story, giving them voice and movement. The way the little puppeteers "move the strings" of their puppets allows them to experiment with and learn the first elements of programming. Our software has been tested in a classroom where the actors shared not only the virtual space of the stage but also the physical classroom in which they were located.

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1 Introduction

The idea that gave rise to this work stems from the consideration that there are strong analogies between entering a virtual world with an avatar and playing the role of a character in a theatre. Certainly the two contexts arouse very different emotions: in the virtual world participants are most interested in discovering what the system has to offer, while on the real stage they are motivated by a wish to communicate with an audience through their acting prowess. In both cases, however, participants are actors because interpret a role where they are fully immersed in a "here and now" imaginary world and "live" according to the time specified. Research shows the educational value of virtual worlds and the theatre. According to constructivism, virtual worlds are highly effective learning environments: they engage the learner in exploratory and experimental activities in an entirely voluntary and personal way (Chris, 2008).

Learning through playacting is rooted in the mists of time: the caves were the setting for theatrical performances (ritual dances, acting out tales of hunting) for Paleolithic man (Montello, 2004) and even today the theatre is a valid pedagogical tool. We cite studies concerned with the narrative development of young children (Fecica & O'Neill, 2010; Baumer *et al.*, 2005), the learning of sorting algorithms (Katai *et al.*, 2008; Katai & Toth, 2010) and computer architecture (Bodei *et al.*, 2008).The ancient graffiti used as a background to the performances of our ancestors have evolved into today's cinematic backdrops and it is natural that the theatre now takes on board new technologies like human computer interaction interfaces, 2D and 3D software simulations and internet technologies (Adam *et al*., 2010).

At this point a new educational perspective opens up which brings together the two approaches: the stage in a virtual world provides the young actor with a place where he can perform and at the same time engage in an experiential learning activity. The constraints imposed by the geographical and physical characteristics of the real world are removed and replaced by the logic of programming. Moreover, by choosing an avatar, and acting out a story in the virtual theatre, interacting with other characters and objects, means learning by doing. The rules governing the world which has been created will prevent an actor impersonating a red blood cell from winning the battle against bacteria, or closing the wound of the blood vessel in which it lives, and similarly the person who has chosen to be the big bad wolf will be forced to treat Little Red Riding Hood and her grandmother unkindly. All our knowledge, from the structure of the atom to the creation of the universe, from Alexander the Great's empire to Italian unification, from myth to science, everything can be "lived". This form of teaching almost seems to make Comenius's dream, "omnes omnia docere" come true. We give this vision the name of Virtual Theatrical Learning

(Chiazzese & Laganà, 2011).

2 Acting and learning

The theatre provides a unique learning environment, especially for the actors both on stage and behind the scenes. The reason for this seems to lie in the deep inter-correlation established between different pedagogical elements such as *narrative context*, *social-collaborative interaction*, *stage performance*, *multisensory language*.

The aptitude to invent and comprehend narrative is an important characteristic of the human species and is already activated in childhood (Barsalou, 2008; Matlock, 2004): children are able to mentally simulate a story, to assign temporal consequences to events, intentions and emotions to people and humanizing aspects to animals and objects. Through narrative they discover their identity, learn to talk about themselves and to listen to the narration of others (Bruner, 1966) thus establishing interpersonal relationships.

Socio-collaborative interaction is implicit in the relationship on the stage with other actors: a good performance depends on everybody's contribution; so all the actors must coordinate their roles constructively in relation to everybody else. This promotes self-control and self-regulation even though in the virtual world the emotion aroused by the presence of an audience is missing.

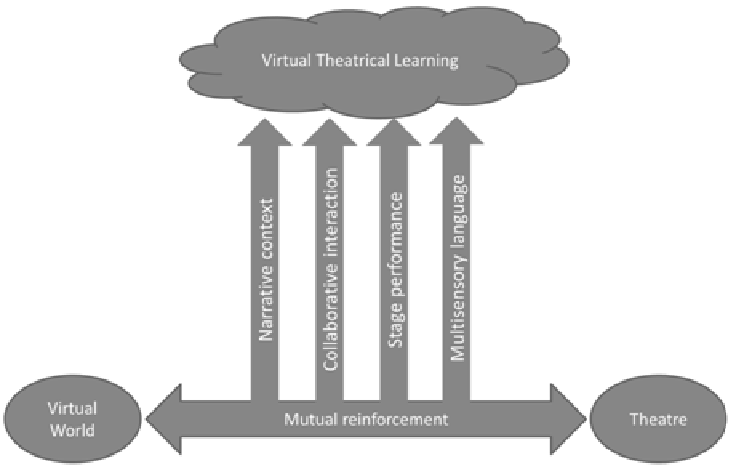

Fig.1 - Virtual Theatrical Learning vision

The actor has to adapt his behaviour to suit the physical dimensions of the theatre. Moreover the relationship between actors and their movements on stage will further affect his behaviour. When children perform they make spontaneous movements and demonstrate expressive skills (Ebbeck & Pannerselvam, 2004). They invent strategies for impersonating characters: they choose appropriate clothes, gestures, facial expressions and tones of voice and use the multi-sensory capabilities of the brain to express themselves and make themselves intelligible to others.

There are examples inspired by the pedagogy of drama (Lindqvist, 1995) where classrooms are transformed into real stages with sets built from paper and cardboard, and everyone (teacher and children) performs. This practice has been tested successfully in different educational experiences conducted in northern Europe (Rain, 2008; Hakkarainen, 2006).

The multi-sensory language of the theatre is complete (using the body, the scene, music, etc.), enhances the usual verbal language, promotes simple but ample communication, and an immediate and powerful emotional response. It is this component that represents the most profound difference between traditional and virtual environments. There are obvious physical constraints related to a real stage-which, moreover, have led to the famous rule "unité de temps, de lieu et d'action" - and the movements of an actor on the stage. Without these constraints in the virtual world we can pass into the bloodstream as a fictional embodiment of a red blood cell, drive a spacecraft beyond the solar system, live through the tragedy of an atomic explosion, jump over the rings of Saturn or onto the planet of the Little Prince.

All this can be accompanied by the sound track of an orchestra, the voices of the forest or the backyard, or even the roar of planes. But while the scenic effects may be heightened in this way, the expressive power of body language may be diminished and when projected onto an avatar movements and interactions may not reflect natural behaviour. From this point of view we are in a situation similar to a puppet theatre where the movements of the puppets are determined by the movements of the strings or fingers. However, it is important to note that recent technological innovations related to 3D simulations, virtual immersion, multi-sensory interactions, and the Internet allow us to create highly realistic virtual environments. In particular haptic interfaces provide tactile sensation of objects and are already in use in medical robotic applications (Westwood *et al*., 2002), olfactory interfaces applied as feedback tools in VR learning environments (Richard *et al*., 2006) enhance the multi-sensory perception.

The high level of definition of computer graphics and monitor technologies provides 3D representations of scenes and avatars. This allows full immersion in a virtual world where interactions, body movements, social presence, verbal and nonverbal expressions etc. are extremely realistic. Faster network communication and multi-user architectures make live events on a large scale possible.

For example, (Yang *et al*., 2006) using a virtual environment, remote dancers can take part in a virtual collaborative performance. 3D cameras fixed to a TV monitor film the dancers who are able to control their avatars in real time and reproduce their movements. We would therefore like to think that in the not too distant future it may be possible to use body language naturally, something which Montessori considers to be of great importance.

Figure 1 summarizes our vision of the Virtual Theatrical Learning.

3 Te@trino

To recreate the opportunities for "natural" learning provided by the theatre, we have developed a virtual environment for children aged 9-10, inspired by the tradition of Sicilian puppets. Just as in the real world, the actor is like a traditional "puppeteer" who manipulates a puppet; this choice of design means there is no need for any particular immersive interface for body language and physical interactions between characters. In any case the learning mechanisms described above still apply. The puppets perform on an online shared virtual stage and the children give the puppets a voice and move them in a synchronous mode, each child controlling one puppet in each scene. A director manages the staging of the show; he chooses the script, the characters, the backdrops and stage props. He also decides when to start and end a play by raising or lowering the curtain. Actors, the director and spectators perform on the Internet. Children move the puppets by using a rudimentary computer programming language.

The prototype system (Lorenzini, 2008) is based on Flash Communication Server technology (Lesser *et al.*, 2005) and client/server architecture and includes three types of client: actor, spectator, director. Each client has specific functionalities and different privileges for the virtual theatrical learning environment. The server is the heart of the virtual theatre. It manages audio communication between different clients, scene synchronization, the stage, events, sets, puppets, props. This is described in the script managed by an XML file.

The client spectator can only watch the show and intervene with brief vocal comments and applause.

The client director provides features to manage the stage performance. The start-up phase allows the director to select the show and the actors, who receive an invitation to perform. Subsequently, the presence of actors on the stage appears in a text field. An actor can only perform when permitted to do so by the director.

The client actor is the child's acting tool: it manages his online access, the selection of the character and his entry on stage. It provides commands for running language instructions creating and saving procedures for moving the puppet.

4 The language

The language used to program the puppets was inspired by Logo and is based on a body syntonic approach. While in Papert's language the child's body movements it the whole robot or turtle, in our language the child's movements correspond to different body parts of the puppet. To simplify the programming and the work of the graphic designer, only three parts are used, the head, trunk and arms, even though a larger number of body parts would make the movement of the puppet more realistic.

Instructions like "bodypart.action" adopt the object-oriented programming dot notation. Some of them are parameterized according to the speed of execution, number of steps and degrees of rotation. Another difference between Logo and Te@trino is that with the latter it is possible to compose sequential and parallel instructions: ";" between two statements specifies sequential execution, while "+" indicates parallel execution. So the "armrt.up; armlt.up" action is visually different from "armrt.up + armlt.up " even if the final result is the same. Instructions can be grouped in procedures. The characters on the stage assume four views (front, left side, right side, back) and two levels of depth: (back and front). The movements of characters are performed according to these constraints. Children are able to observe the execution of commands and so understand their semantics better.

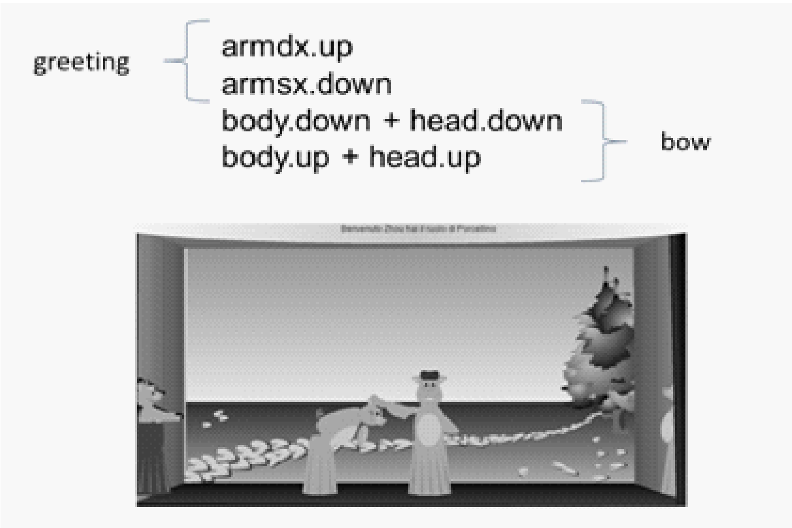

Fig. 2 - Final scene of greeting and bowing

Fig 2 shows an example of instruction composition and the final execution where we can see an interesting effect: Jimmy touches Tymmy's hat.

5 Testing the system

We tested our initial prototype at the elementary school Zerboglio in Pisa with a group of 9-10 year old children who were delighted at the idea of being Internet actors. Initially, the teacher invited them to invent or rewrite a story to be performed on the stage. The first phase of writing the script took place in the classroom using paper and pencil. The fact that there were few characters in the system limited the imaginative scope of the children. Our young authors chose to provide their version of "The Three Little Pigs." They completely transformed the traditional fairy tale and produced a new version where the pigs had to try to learn to be wolves... with tragic consequences for themselves! At this point we introduced Te@trino to the children and explained the charactieristics of the environment and the characteristics of the avatar.

All the activities were carried out in a collaborative way and the children were free to decide which role they wanted to play. Then we moved to the testing stage in which the children become familiar with the system and with the programming features: they could build the movements of their characters, time their execution to match the cues in the script, and coordinate their performance with that of the other puppets.

We report the comment of a child "*[...] I think that Te@trino is fantastic because I was very impressed by the movements of the characters [...]" and the teacher [...] Te@trino was certainly very attractive because it involved pupils, stimulating their curiosity and their active participation.... It brought home to children the importance of planning and cooperation [...]*".

Conclusion

Recent studies (Robinson, 2011) advocate combining science and arts in the educational curriculum to enhance learning opportunities. The main didactic strength of Te@trino is that it combines the two aspects, allowing the child to experience the learning process in an aesthetic context. Our approach promotes social and collaborative interaction, creativity, analysis of the puppets' movements, and algorithmic thinking. In this regard it is important to point out that the child can self-evaluate the results of his activities immediately and check whether the movement that he programmed corresponds to his intentions as he has instant feedback. We have also noted that at the moment there are too few characters in the system and in addition it is not possible to interact with objects (Jimmy cannot take a stick to threaten the wolf). Our system does not aim to develop children's computer skills since they are digital natives and have few problems with these aspects. We prefer instead to shift their interest from being computer users to programmers, introducing them to algorithmic thinking and to the rules of programming. A possible evaluation of te@trino could be made by carrying out a further experiment to follow the test presented in this paper, and applying the directions in (Stolee & Fristoe, 2011) specifying the elementary learning modules: the semantics of instructions, language syntax, sequential or parallel instructions, the breakdown of a problem into sub-problems with the definition of procedures.

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