The Child Behind the Character

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Abstract— **This paper presents a research approach for guidance and control of story characters by young children. We show that it is possible for a child to be at the same time an actor, performing a role in the story, and an engaged and empathic spectator of the overall story. To illustrate the approach we will describe *Teatrix* a collaborative virtual environment for story creation by young children. In *Teatrix* children control the actions of their story characters, which are implemented as intelligent agents in order to perform a certain chosen role (ex. a villain or an hero). During the acting, children control their characters at different levels: at motor level, by defining the navigation and movements their characters will perform; at behavioural level, by setting tasks to be achieved by their characters; at emotional level, by changing the emotional state of the character; and at reflection-level, by justifying the actions and decisions taken. In order to combine these different types of control we have introduced the concept of *time-freeze* in the story creation, combined with a tool for reflection, called *"Hot Seating"*. In this way, children are able to control their characters more deeply, while at the same time, feel part of the audience of a play.**

Keywords— **Social Agents in Virtual Worlds, Mixed-Control of Agents.**

I. Introduction

Stories and story telling are part of our lives since early childhood. They color our days, shaping who we are and how we relate with others and with the environment [1]. In the first three years of their lives, children play and try to make sense of the world that surrounds them. Through direct interaction and exploration they start to assign categories and concepts to the objects and events of the world. After having acquired their first notions and knowledge about the world, they begin to construct more decentralized plays and start to include the others in their make-believe world. Stories emerge in their plays. At this point they also start to use common objects in a way that they become magical and powerful props in their stories (for example, a stick that becomes a horse) [2]. Following Piaget's theory, this evolution of the make-believe activities allows children to perform different roles, gain control of the course of the action and acquire the skills to organise the sequence of a play and most important to project these experiences into the cognitive and social requirements of the real world.

Along with these findings about children enactment in make-believe worlds, there is also evidence that shows that when being part of the audience of a play, children develop empathy with the cast of the story [3]. When "acting" as audience, children enjoy taking sides, identifying themselves with a good character or being angry with a mean character. They become very emotional and emphatic about the characters and plot, and instead of keeping their thoughts to themselves they instantly demonstrate their feelings and automatically respond to a change in the flow of the story. Children can be in the audience of the same story over and over again.

By grounding our research not only on the benefits that children take from being actors in dramatic games but also on the children fulfillment that is provided by being in the audience, we have explored the different roles children may take in a virtual story creation environment. There, stories emerge from the actions and interactions that the characters perform in the virtual world, and those characters can be partially controlled by children. To that end, we will present a framework for distinguishing different ways by which such characters can be controlled by children. Further, to contextualize the use of such framework we will present *Teatrix*, a collaborative virtual environment for story creation. In *Teatrix*, the characters are the ones really acting the story out, but they can also be "partially" controlled by the children. Therefore, children are simultaneously the actors of the play - by means of their characters - and the audience of the same play - since they are not physically in the story world and they contribute to the agents own "acting" and to the story development at *creation-time*.

This approach lead us to the following research problem related with the control of agents by user: how can we combine different types of controls and intentions (coming from the user and from the internal state of the agent) without making the user feel some "lack of control"?

The remainder of this paper is organised as follows. First we will describe some related work. Then, we will present *Teatrix*, providing the context for the discussion to be done in the following section. There, the role of the user/child as controlling the social intelligent agents in virtual environments is addressed . Then, we will present some first results and describe what we call "deeper control" of a character. Finally we will present some results and elaborate on further developments.

II. Related Work

For the past decade a large number of virtual environments inhabited by intelligent agents, or avatars, were developed in many different applications areas. Interactive television, computer games, virtual training environments, or interactive story telling environments, are but a few of the application areas that pose major challenges for the development of such agents. One of these challenges concerns the role of the user, and consequently, the degree of autonomy of the agents in relation to that user.

On one extreme, embodied social agents can be seen as "fully" autonomous[1], and can interact with the user, through speech, facial expressions and gestures. They may

[1]See [4] for a discussion on different types of autonomy.

recognize and respond to verbal and nonverbal input. They can exhibit verbal and non verbal output, combined with turn taking and feedback, necessary in social interactions [5]. They nod, glance, jump, point , explain, etc. in reaction to the user. Examples of such agents are Rea [6], Steve [7], Cosmo [8], and others. In general, these agents are not controlled by the user and interact with the users in a similar way that a human would. They are the ones to decide autonomously what and how to perform their tasks. The user is interacting with a third person in an interactive environment.

On the other extreme, we have avatars, almost fully controlled by users that mimic, to the most detailed element, all the users' actions. Applications where avatars play important roles are: collaborative virtual games, distributed collaborative work, interactive inhabited tv, among others. In general the avatar is seen as a representation of the user in the world and therefore must follow the user and mimic all the movements he/she makes. For example, in the work by [9], some experiences were made in interactive tv where viewers become participants in a virtual play and were able to interact with the virtual environment and with other participants. Live broadcasting, like the one performed in "Out Of This World", allowed participants (the actors) to be immersed through a VR headset and tracked (head and hands) using electromagnetic trackers. Other users could also participate through the use of a standard PC joystick for motion control. Users could easily control their avatars that would respond to the direct motor commands given by the users.

Recently, however, we have witnessed the emergence of new types of control both in autonomous agents and in avatars, where some aspects related with the autonomy of the former are combined with some control of the later. Sengers at al. in [10] proposed the notion of semi-autonomous avatar, that is "agents/avatars that have their own behaviours and intentionality, but are intimately tied to the user's actions". Although this notion and its associated degrees of autonomy is quite important it still doesn't tell us how to define the control of autonomous agents that can be partially controlled by humans.

In [11] a multi-level control system for synthetic characters is proposed. In such system the control is divided into two main types: motor control and control over the behavioural system. This later one is further divided into motivational control (that is, changing the current motivation of the character) or task level control (that is, provide a high level directive and expect the agent to carry out the command). These levels of control map into the different components of the agent architecture proposed (its motor level engine and its behaviour generation module). However, this multi-level control system does not address directly the question: how to combine conflicting control requests, without making the user feel "without" control.

Another type of control was done in the system described by [12] where the users control/influence the emotional state of the agent through the use of a porcelain dolphin with emotional sensors. In such system, featuring two synthetic dolphins in a virtual environment, the user can touch such "emotional" sensors and influence the emotional state of one of the synthetic dolphins (Isolda). The change was then visible in differences of behaviour shown in a large screen for public exhibition. However, as reported in [13], for the user to feel in control of the dolphin and really "see" some effect of his/her actions, some shortcut had to be made for the dolphin to react immediately, even if internally the dolphin should perform a different action (like for example "breathing"). This solution for the problem of control was the best one found for that particular context (of a public exhibition).

Another interesting approach was used in Carmen's Bright IDEAS [14]. There, the user (a mother that is in a stressful situation) interacts in a drama by making choices for Carmen (one character-the mother in the drama). Such choices may, for example, involve the decision of which problem to work on, or the choice of Carmen's inner thoughts. The control is therefore on the level of decision making, rather than on motor control or even behaviour.

III. Application: *Teatrix*

In order to illustrate this new paradigm of characters control, we will present Teatrix[2], a virtual environment for story creation.

Teatrix is a collaborative virtual environment for story creation by young children (4-8 years old), which aims at providing effective support for children developing their notions of narrative through the dramatisation of different situations.

Teatrix is integrated in a new concept of classroom (CiC-Computer Integrated Classroom)[15] where the computers used by children "disappear" into the background of the classroom. Children interact with applications (such as *Teatrix*) through specialized devices and interfaces (a big interactive screen or interactive pen-based LC-displays) allowing them more friendly and less intrusive type of interactions. The *Teatrix* application was inspired by the environment and pedagogical approach followed by the Portuguese school "O Nosso Sonho" where the CiC classroom was installed. Not being a curricular school, "O Nosso Sonho" fosters creative activities, such as drama, painting, sculpture, etc. Thus, *Teatrix* was created as a support to the drama activities. As drama often relies on fantasy stories, *Teatrix*'s scenarios and actors were inspired by fairy tales. Fairy tales have a particular attraction to children as they appeal directly to their emotions. Further, fairy tales have, in general, simple and structured narratives, being therefore ideal plays to be tried and created in a virtual stage. In fact, our work relies on a "morphology" of folktales provided by Propp [16]. Finally, by acting out the play through the control of the characters, children can be given the opportunity to make a fairy tale their own, bringing their own associations into it [17].

[2] *Teatrix* is an application being developed under the Networked Interactive Media In Schools(NIMIS) project, a EU-funded project (n. 29301) under the Experimental School Environments (ESE) program.

Teatrix divides the creation of a virtual play in three major steps strongly related with the theatrical performances found in the school (see [18] for more details about the design of the application). In the first step, children must choose the scenes, the cast, the roles, the props and the initial situation for their play. Similarly to what happens in the backstage of a theater during the preparation of a play children create an initial "set-up".

For example, if a child wants to recreate the little red riding hood, he/she may choose a *forest in the day* scene and a *in-house scene*. The child can then choose a little girl (the little red riding hood), the grand-mother, a wolf and a hunter. Then, roles are assigned to each one of the characters (for example, the little girl will be the hero and the wolf the villain). For props, the child can add a basket, some food, etc. All these elements will be set (saved in a special file) as the ingredients for a play to start. Further, the child will also set up the initial situation for the story to come. Figures 1 and 2 show the preparation of a story with three linked scenes ("at home", "in the forest" and "at grandmother's home") and three characters (a little girl, a wolf and a grandmother).

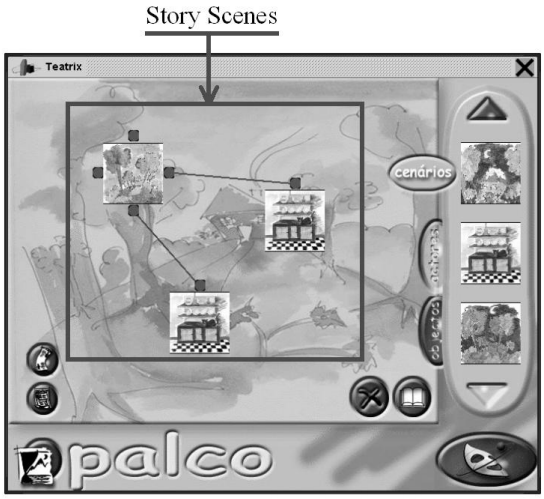

Fig. 1. *Teatrix*: Backstage Option- Scenes setup

Once children have decided what elements to use in the story, the play can start. In general, children see this phase as a game. The acting is done by means of each child's character, which he/she commands throughout the story creation process (we will discuss this process in detail later). Since *Teatrix* is a collaborative environment, each child participating in a play must select the character he/she wants to control. All characters that are not chosen by the group of children will automatically become system-controlled characters.

From the story creation process a "film/play"-like object is created. Such object allows the children to analyze and even to reconstruct in future performances.

Finally, the third step is based on the artifact produced from the story creation process. In there, children can watch their previous performances (as being the audience

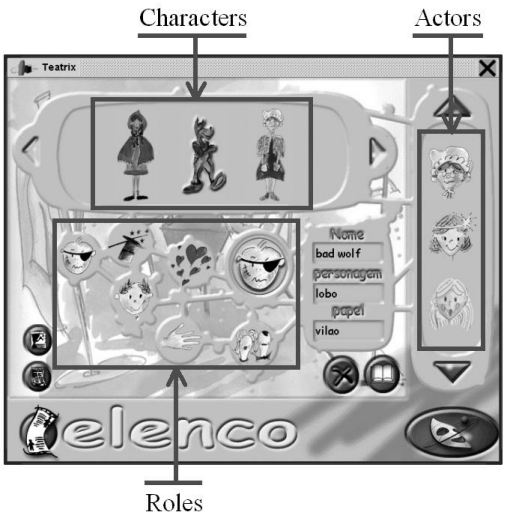

Fig. 2. *Teatrix*: Backstage Option- Roles and Actors

Fig. 3. *Teatrix*: On Stage Option

or the public in the theatre). In this option the children have also the possibility to write about the stories previously performed. With this part we want to provide the children with the opportunity of watching and discussing what they've produced. By supporting the discussion of the story we aim to promote a better understanding of the characters interactions, and maybe to encourage the reflection of the children about the emotional and intellectual parts of the story [19].

IV. Social Characters in *Teatrix*

When the curtain is raised, the play begins. A collaborative 3D featuring the scenes chosen by the children becomes a virtual stage (see Figure 3). In this phase, the virtual environment offers a rich setting for the development of interactions between humans and agents. As the virtual worlds of *Teatrix* are populated by characters, children can interact with each other through the use of props as well as through direct relations between the controlled characters (see Figure 4).

The main goal of this phase is to build a coherent story.

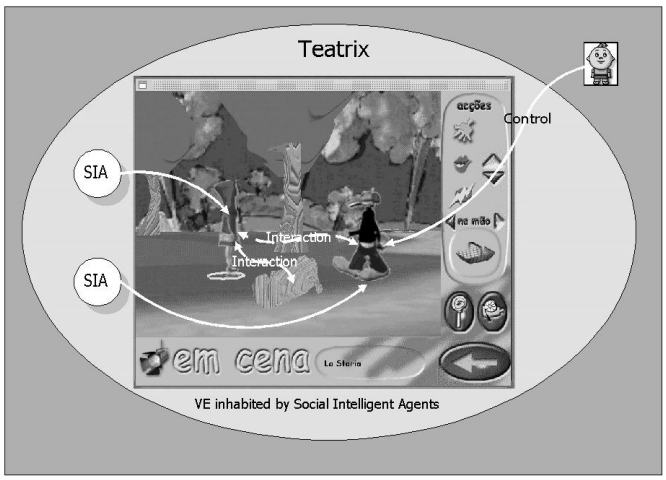

Fig. 4. Control of Social Characters in *Teatrix*

Since the characters are the ones that are going to "act" in the story, they must display a believable behaviour to engage the children in a fulfilling experience, which would help them to understand the real world by means of the stories [19].

In *Teatrix*, the story characters can be seen as the conjunction of two different concepts: the *actor* and the *role*. An *actor* is the physical representation or appearance of a character (examples: a witch, a boy, a girl, etc.). In *Teatrix*, children have a set of 7 actors to chose from, which will make their cast[3]. A *role* is the definition of a set behaviours that are known to both the characters and the audience [20]. In *Teatrix*, the roles definition was based on the work done by Propp [16] on one hundred Russian folktales (see [**?**] for more details on the characters definition). The roles are:

Villain the role of the villain is to disturb the peace of the happy family, to cause misfortune, damage or harm. Its main function is therefore the "villainy".

Hero/Heroine Introduced by his/her name indicating his/her status. There are two types of heroes: seeker heroes, which go in search of a loved element (this is an usual type of hero in computer games); and the victimized heroes, whom are themselves the victim of the villain.

Helper It has special functions in the story and has the function of helping the hero.

Beloved one and Family Usually described in the initial situation, and is often subject to harm by the villain.

Donor or the provider It is from the character playing this role that the hero obtains something (sometimes magical) which allows the hero to eliminate the misfortune.

These roles establish the functional behaviour of an agent/character, by means of the specification of the actions and goals for that agent. They are therefore used to fill the agent's mind setting up its initial goals and plans and therefore guiding its behaviour (see [22] for further details on the agents's architecture).

[3]Note that they can choose how many instances of one actor as they want. For example, they can choose two girls, give them different names and be controlled by different children.

A. Architecture of the Characters

In *Teatrix* the social characters were built as autonomous agents using the architecture shown in Figure 5. This software architecture is used to generate and execute the appropriate actions of the characters in the 3D world.

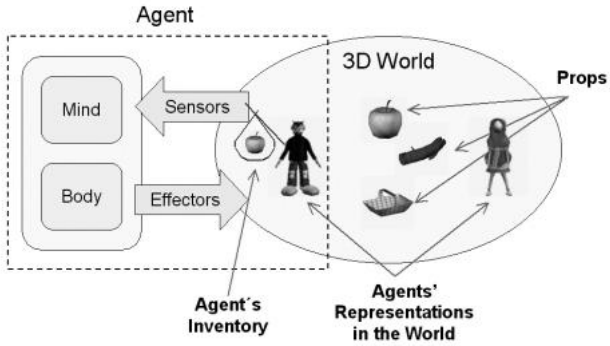

Fig. 5. Architecture of the Social Characters in *Teatrix*

In this architecture there is a clear separation between the *body* and the *mind* of the characters. The *mind* is responsible for all the decision making associated with behaviour generation whereas the *body* controls the agent's representation in the virtual world. The interface of these two components with the 3D virtual world is made through the character's *sensors* and *effectors*. A short description of all these elements is given bellow.

1. *sensors* - are responsible for capturing information from the world, the 3D world where the stories develop, and translate it into perceptions which will be given to the character's mind.
2. *effectors* - allow the agent to execute actions in the world. These actions include: walk, get item, drop item, use item and talk.
3. *body* - module that controls the agent's representation in the virtual world. (e.g. what the agent looks like to the others, its position and its movement).
4. *mind* - responsible for the action planning of the agent. It is also responsible for keeping and updating the information about what is happening in the world.

Further, the architecture also shows an *Inventory* component which keeps the set of items (props) the agent has collected from the world. The agent may use any of them when needed.

In more detail, the *mind* is composed of several components that as a whole generate the behaviour of the character. The *mind* stores the last *perceptions* received from the *sensors*, the current *world model* (which contains what the agent believes), the *actions* that it knows it can perform, its current *goals* and *emotional state*.

All the changes in the environment arrive to the agent through its *sensors*. The *mind* of the character keeps a *world model* where information about the 3D world is stored (about other characters and about props). If a perception of a "world change" reaches the mind, an *world*

model update component will change the content of the *world model*.

Characters also keep their *Goals* which are pre-generated according to the role they play in the story. For example, if the character is a villain it will have the goal of "harm the hero". From these goals, sequences of actions are generated that are then executed through the effectors of that character. However, such *Goals* may dynamically change in the agent's mind if something in the world changes (e.g. the agent wants to pick an item, so he wants to be near it; however, if someone has already picked it up, the goal is not achievable anymore and it will be removed).

Finally, the mind of the characters also contains an *emotional reaction* component that is responsible for all the changes the *emotional state* of that character. Such changes depend on the changes in the world and in the current *goals* (e.g. the agent may become sad if a friend is hurt or become happy if it just achieved a desired *goal*).

V. The Child Behind the Character

Each child directs her character by using mainly the actions the character can perform. The actions are selected from a set of possible actions associated not only with the character that he/she is controlling but with the props that the character owns (see Figure 6 for a view of the icons used in the description of the actions).

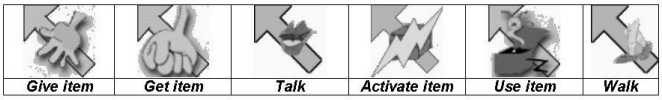

Fig. 6. Actions for controlling the characters

For example, "bewitch the hero" can only be achieved by the *girl* if she has in her possession a magical object with such powers. These actions can be picked from a list present in the *Acting Screen* - see Figure 3.

Therefore, the child can control the actions his/her character will perform, even if against the goals established by its role. For example, a child controlling the villain may decide not to harm or pursuit the hero.

The story will be achieved through the interactions of the different characters of the cast, which can be controlled by children or system controlled characters. In the later case, the characters behave in accordance to the roles that they play in the story.

A. First Result on the Control of the Characters

Teatrix is already installed in a Portuguese school, "O Nosso Sonho", and we have been testing it since the middle of March 2000. Since the the first version, children showed great enthusiasm to use it and their comments are quite positive:

- "It's funny, instead of doing the drawings to use in the story we can pick them from a list of characters, things and scenes and in the end we build the story."
- "It's a fantasy of heroes and princesses. It's entertainment in the computer!"
- "*Teatrix* is a like a theatre, where we can play together. What I like most is the feeling of being inside the characters. In *Teatrix* we can do things that all others can watch, and that is very important because by this way everybody can participate in the stories."

This first prototype, which included the described control of the characters, was the target of a first empirical study. In this first empirical study we followed an informal evaluation approach, which was mainly based on direct observation of children using the system, and also on some data collected from children and teachers' diaries. The study group was small - only 12 children - and they interacted with the system for one month and a half. The interaction sessions did not have any limited duration, but usually lasted for about one hour each, three days a week. The results from such empirical study revealed positive and negative aspects of *Teatrix*. These first experiences showed that children understood the meaning of the defined roles and that, at acting time, they were able to direct their character in order to meet their goals and display a coherent behaviour. However, and despite the encouraging initial results, some very important problems were brought to light. Perhaps the most important of such problems was the fact that when children were acting the story, they were a little frustrated because the set of character actions did not provide them with the means to develop their characters' performances as deep as in the play. Their major complains were: they did not have the props they needed, the characters were not very expressive, and they could not control the minds of the characters. This problems lead to difficulties in achieving a collaborative task as such, and more often children would play (the game, as they call it) by themselves. To overcome such problems we decided to:

- increase the number of actions and props available in the system;
- allow for children to add their own props by scanning images that they can embed in the story as a new prop;
- improve the character's emotional expression;
- allow children to reflect and respond to the current state of the story.

The first two tasks were easily done. The last two were more difficult since it involved a structural change in order to allow for a deeper control of the characters by the children.

B. A New Type of Control

The results above showed that children expect better and deeper control of their characters. They also want to know how and why their characters acted in a certain way. They want their characters to perform as they decide even if against the roles they are performing (a wolf villain may not harm a little girl heroine). To address this problem we had to develop a different type of control of the characters that would engage children in reflecting over the actions performed by the character and its associated role. To do that, we have extended the multi-level control proposed by

[11] by introducing a new dimension. The idea is simple: there are two main dimensions of control. The first one is real-time control which includes motion control, behaviour control (as defined in [11]) and emotional control (like the one used in [13]). The second dimension of control is a meta-level control and involves the reflection on the control performed in real-time. This dimension implies a time freeze on the "story time" line.

This meta-level of control has its inspiration in studies on acting in classroom drama by Dorothy Heathcote [23], where children are asked to go to the *"Hot Seating"* and justify their acting. "Meta-level control" is performed out of real-time time, and the actions of the characters are justified and agreed upon. The idea is that when a child is "seated" on the "Hot Seating", he/she is asked to freeze his/her character's actions. By stepping out of the characters motor skill control, the child can explain and reflect upon the meaning of his/her character's current behaviour. At each reflection time we seek answers to the following questions:

Character **x** *has performed action* **z**
Because <motive>
Therefore <what are the expected outcomes>
Or
Character **x** *is* **sad**
Because <motive>
Therefore <what are the expected outcomes>

C. The "Reflection Tool" of Teatrix

To include this new type of control in *Teatrix*, we had to design a reflection tool called-*"Hot Seating"* which aims at giving the child the deeper control just discussed. In *Teatrix* such tool not only allows children to make justifications for the character's actions but also provides information about the role, previous actions, emotional state and goals of the character. It discloses the character's mind (see [24]), which has similarities with what is called "a window into the agent's mind" by B. Hayes Roth [25]. In *Teatrix* however, the *"Hot Seating"* not only allows changes in the mind but also provides a way for these reflection statements to be shared among all the children involved in the story creation activity. This need of sharing arises from the fact that every child needs an audience during their pretend plays and also when acting as part of the audience of a play. To achieve this, we developed two different modes for the reflection tool:

- *for the child's own character*: in this mode the child has available the information about the character that is controlling in the story. Through this interface the child has the opportunity to: (1) introduce some motivation for her character's behaviour; (2) induce some change in the characters emotional state and justify such change; (3) or, consult her character's role in the story. This reflection mode can be explicitly invoked by the child that is controlling the character when he/she wants. It can also be implicitly triggered by the system when the child commands go against the character's role. Further, it is through the *"Hot Seating"*, that a child can enter the emotional world of the character and at the same time justify its emotional state.
- *for others children character*: this mode is particularly useful for the children to inspect the minds of their peers' characters and see the results of the reflection done by the others.

D. Interaction Example

In order to understand the role of the *"Hot Seating"*in *Teatrix* let us describe an example where two children control two characters: a *girl* (hero) and a *wolf* (villain).

The *girl* finds a path in the forest and decides to follow it. Meanwhile the *wolf* is just wandering in the *forest at night*. The path taken by the *girl* leads her to the same scene as the *wolf*. As the *girl* sees the *wolf*, she walks towards him and asks: *"Hello! What's your name?"*. Since the *wolf* does nothing (although the wolf is a villain) the *"Hot Seating"* is activated.

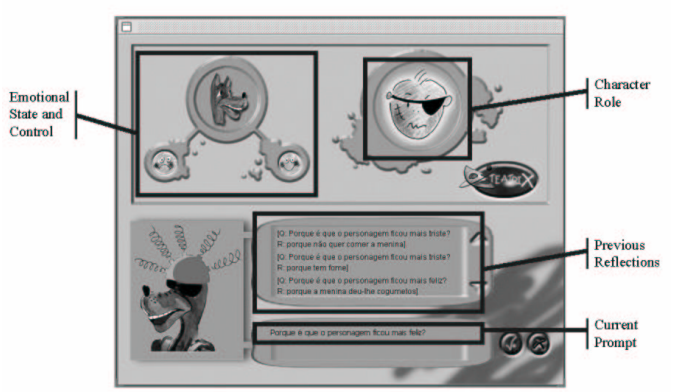

Fig. 7. The reflection tool

The window shown in figure 7 appears to the child controlling the wolf[4]. On that window the child can see his/her character's emotional state (which is currently shown as "normal", that is no emotion triggered), its role, the set of previous reflections, and the reflection currently prompted. In our example, the reflection prompted is: *"Why don't you pick up the stick and use it on "Linda"?"* (Linda is the name of the *girl* actor in the story[5]). As the answer provided is *"ok."*, the control returns to the 3D world. There, the *wolf* picks the *stick* but does not use it on the other character. After a while (given a certain timeout), the *"Hot Seating"* tool becomes active again. A similar question is then generated: *"Why don't you use the stick on Linda?"*. At this stage the girl controlling the wolf answers: *"I don't want to hurt her. The wolf just wants to eat."*. Due to fact that the goals of the villain are not being achieved, the emotional state of the *wolf* becomes sad. Finally, as the *girl-Linda* drops some *mushrooms* that the character has in its inventory, the *wolf* is lead to pick them

[4]Note that the child is not forced to go into the *"Hot Seating"* and may choose not to.
[5]When choosing the *cast* children can also assign names to each character.

up. Then, the child changes explicitly the emotional state of her character to happy (since the *wolf* finally ate!).

Note that the system activates the *"Hot Seating"* whenever there is a conflict between the internally generated goals of the character and the control provided by the child. For example, in the scene just described, when the *girl* named Linda goes to *forest at night*, the scene where the *wolf* is, the *wolf* agent's *sensors* will capture the information that another agent is in the same scene. Such information will be send to the *mind* of the agent. Thus, as the *perceptions* contents change, an *emotional reaction* and a *goal update* will be done. Because the *wolf* is a *villain* it has the *goal* (set by its role) of harm the *hero* and "harm Linda" is produced. As a new *goal* emerges, and since the agent has the information about the presence of a *stick* in the *forest at night* (from a previous *perception*) and that the *stick* can harm another agent (this knowledge is associated with the *stick* and its use) the *wolf* should therefore use that *stick*. And, since the child does not control the character to achieve the goal internally generated, the *"Hot Seating"* becomes active. Note that this approach is only possible because we keep the agent's internal state still running in spite of it being controlled by the child.

E. Further Evaluation

The *"Hot Seating"* has already been included in *Teatrix* and we have conducted a new set of experiments in order to find answers about the influences of the new method in controlling the story characters. In these new experiments we had two different goals:

- to evaluate the use of the reflection tool;
- to identify any reflection patterns that could be used to refine the *"Hot Seating"*.

In this second period of evaluation, the target population was divided in two different groups: the control and test groups. The control group - which was composed of six children - was asked to perform and produce written stories that had the same themes and characters present in *Teatrix*. The test group - which was composed of 24 children - was asked to interact and use *Teatrix* to create new stories by acting and also to write about them in the end.

The test and control groups carried out their story-telling activities (on paper or on *Teatrix*) on a daily basis and each session lasted for one hour. The evaluation lasted for one month. All children in both conditions were given equivalent guidelines. The control group was asked to write some stories and they were told that they had to include some of the *Teatrix*'s story elements - a table with pictures of such elements was provided. The control group could also bring their written stories into the drama room and perform them. The teacher of that room was asked to trigger some reflection moments when a child was not acting in character. These performances where recorded on video.

The test group had already had some understanding as to using *Teatrix* and the only instructions they were given was on the need to produce a written story from their story performances - done in the third phase of application - the *Audience* phase.

To analyze the data collected from both groups, we decided to conduct a qualitative assessment. This decision was based on two different reasons: (1) the experiment conditions for both groups were not completely the same; (2) and, the lack of a method that could help us to evaluate in a quantitative way the reflection moments triggered in both evaluation conditions. In this qualitative assessment, we did not have a well-defined and measurable hypothesis but only a list of questions to analyse and study. Such questions were:

- *In what kind of situations do children reflect upon her characters' behaviour?*
- *Are children interested in other characters' thoughts?*
- *Do children justify their characters behaviour when asked to do it?*
- *What type of justifications do they usually give?*

As qualitative research involves the search for reasons and liaisons and allows the researchers to have their own perspective and involvement with the study, the results presented here should be seen as particular to this test population and should not be understood or interpreted as global or even generalised to all children of this age group. Nevertheless, the results can be seen as an indication of how children in similar conditions could behave and respond.

The results that we have so far show that:

- the control group -

1. in their written stories children sometimes used some reflection voices to describe their characters' thought. For example: *"By this time Joana was really scared by the witch's magic spell."*;
2. during the performances of their written stories and when asked to reflect upon one character's behaviour, children usually engage on a discussion between themselves in order to justify and explain their different point of views;
3. in their stories children used a rich set of actions.

- the test group -

1. in the first two weeks of interaction with the application, children tended to ignore the reflection moments (even if triggered by the system);
2. in the last couple of weeks children, started to use more often the reflection tool to justify their character's behaviour; its use became easily understood;
3. at the same time, children started to consult each other reflection statements and to relate their future reflection moments with those statements;
4. after the use of the *"Hot Seating"* children seemed to be more in control of their characters, as they knew why certain actions were performed.

The results that we have so far are inconclusive and do not allow us yet to determine any reflection pattern. However, they show that children can and do use the *"Hot Seating"* to justify their characters' behaviours. Further, they take those justifications into account in their future character's actions and behaviour. So far, there hasn't been any correlation with the quality of the produced stories and the use of the *"Hot Seating"*. We hope however, that these results may be enriched with new data that is now being collected.

VI. Implementation details

Most *Teatrix* modules were built in Java, namely the user interface and the core of the agent architecture. The 3D engine of the 'On Stage' and 'The Audience' modules was built using the Java 3D library from Sun MicroSystems. All 3D scenegraphs (e.g. story scenes and items) were modelled in 3DStudio Max and exported to VRML , our elected 3D data format. The mind modules of the agent architecture are in JESS, which is a Java implementation of CLIPS. The representation of the agents in the 3D world is accomplished by showing some animations on 3D sprites which were created using CharacterStudio. *Teatrix* data productions (e.g. story setups, plays and writings) are stored in XML format, VRML and JESS format.

VII. Final Remarks

In this paper we have introduced a new approach for characters' control in virtual environments. To illustrate this new approach, we have described *Teatrix*, a collaborative virtual environment for story creation by young children. We have shown how children control the characters in *Teatrix* and the problems they faced when they wanted to have deeper control of such characters. We have then introduced a new type of control that has been implemented as a "Reflection tool" in *Teatrix*. The evaluation already performed shows that the use of the reflection tool is well understood and children easily justify their control of the characters.

Acknowledgments

We would like to thank all the elements of the *Teatrix*'s development team in particular (Andreia Garcia, Fernando Rebelo, Fatima Neves, Carlos Martinho), the children of the school "O Nosso Sonho", and our NIMIS partners.

References

[1] S. Engel, *The Stories Children Tell*, W. Freeman and Company, 1999.

[2] D. Singer and J. Singer, *The House of Make-Believe*, Harvard University Press, 1990.

[3] D. Wood and J. Grant, *Theatre for Children - A Guide to Writing, Adapting, Directing and Acting*, Faber and Faber, 1997.

[4] Cristiano Castelfranchi, "Guarantees of autonomy in cognitive agent architecture," in *Intelligent Agents*, Mike Wooldridge and Nick Jennings, Eds. 1995, Springer-Verlag.

[5] J. Cassell, "Nudge nudge wink wink: Elements of face-to-face conversation for embodied conversational agents," in *Embodied Conversational Agents*, et al. J. Cassell, Ed. 1999, MIT Press, Cambridge, MA.

[6] J. Cassell, T. Bickmore, L. Campbell, H. Vilhjalmsson, and H. Yan, "Conversation as a system framework: Designing embodied conversational agents," in *Embodied Conversational Agents*, et al. J. Cassell, Ed. 1999, MIT Press, Cambridge, MA.

[7] Rickel J. and Johnson L., "Integrating pedagogical capabilities in a virtual environment agent," in *Autonomous Agent '97*, Lewis Johnson and Barbara Hayes-Roth, Eds. 1997, ACM Press.

[8] Lester J., Towns S., Callaway C, Voerman J., and FitzGerald P., "Deictic and emotive communication in animated pedagogical agents," in *Embodied Conversational Agents*, Cassell J., Prevost S., and Sullivan J., Eds., Cambridge, USA, 2000, MIT Press.

[9] Mike Craven, Ian Taylor, Adam Drozd, Jim Purbrick, Chris Greenhalgh, Steve Benford, Mike Fraser, John Bowers, Kai-Mikael Jaa-Aro, Bernd Lintermann, and Michael Hoch, "Exploiting interactivity, influence, space and time to explore non-linear drama in virtual worlds," 2000.

[10] P. Sengers, S. Penny, and J. Smith, "Semi-autonomous avatars," 2000.

[11] Blumberg B. and Galyean T., "Multi-level direction of autonomous creatures for real-time virtual environments," in *Proceedings of SIGGRAPH 95*. 1995, ACM Press.

[12] C. Martinho and A. Paiva, "Pathematic agents," in *Proceedings of Autonomous Agents'99 Conference*, Seattle, USA, 1999, ACM Press.

[13] C. Martinho and A. Paiva, "Underwater love: Building tristao and isolda's personalities," in *Artificial Intelligence Today*, Michael Wooldridge and Manuela Veloso, Eds. 1999, Springer.

[14] Marsella S., Johnson L., and LaBore C., "Interactive pedagogical drama," in *Autonomous Agents '2000*. 2000, ACM Press.

[15] Hoppe U., Lingnau A., Machado I., Paiva A., Prada R., and Tewissen F., "Supporting collaborative activities in computer integrated classrooms- the nimis approach," in *CRIWG 2000*. 2000, IEEE Press.

[16] V. Propp, *Morphology of the folktale*, Austin: University of Texas Press, 1968.

[17] B. Bettelheim, *The uses of enchantment: the meaning and importance of fairy tales*, Harmondsworth, Penguin, 1978.

[18] I. Machado, R. Prada, and A. Paiva, "Bringing drama to a virtual stage," in *Proceedings of Collaborative Virtual Environments Conference*. 2000, ACM Press.

[19] K. Dautenhahn, "Story-telling in virtual environments," in *Working Notes Intelligent Virtual Environments*, 1998.

[20] B. Hayes-Roth, "Acting in character," in *Creating Personalities for Synthetic Actors*, R. Trappl and P. Petta, Eds. 1997, Springer Verlag.

[21] I. Machado and A. Paiva, "Heroes, villains, magicians,...:believable characters in a story creation environment," in *Proceeding of the AIED workshop on Life-like Pedagogical Agents*, 1999.

[22] A. Paiva, I. Machado, and R. Prada, "Heroes, villains, magicians,...:dramatis personae in a virtual story creation environment (forthcoming).," in *Proceedings of the Intelligent User Interfaces Conference*. 2001, ACM Press.

[23] G. Bolton, *Acting in classroom drama : a critical analysis*, Stoke-on-Trent : Trentham, 1998.

[24] I. Machado, R. Prada, and A. Paiva, "Is the wolf angry or just hungry: Inspecting, disclosing and modifying characters' minds," 2001.

[25] Barbara Hayes-Roth and Robert van Gent, "Story-making with inprovisational puppets," in *Autonomous Agents'97*, Lewis Johnson and Barbara Hayes-Roth, Eds. 1997, ACM Press.