Towards a classification of Narrative Learning Environments

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1. Introduction

Narrative, in the form of stories and narrations, is increasingly used in education. Not only is it a natural expressive form for people of any age and culture (Bruner, 1990), but also it is recognized as a privileged way to help develop cognitive abilities and organize knowledge (Schank 1995), as well as to work out a coherent meaning for our experiences (Bruner 1986, 1990, 2002). As a consequence, stories are increasingly used in a variety of subjects, not only intuitively related ones, like history, literature and language, but also in the scientific domain (Burton, 1999; Bruner, 2004).

Stories can be used in the educational field for different purposes, that is, to support learning, teaching and research (McEwan & Egan, 1995). In a narrative approach to learning, the focus and research effort is on finding meaningful ways for the students to make use of stories, either by being told or by creating them, so as to facilitate and improve learning. In a narrative approach to teaching, on the other hand, the attention is on creating and using suitable stories to incisively convey content knowledge and motivate people to learn, both in school (Jackson 1995) and in organizational contexts (James & Minnis, 2004). Finally, the use of narrative for research purposes, which is usually called “narrative research”, consists in using narrative as a way to collect data; it entails, therefore, the development of procedures to extract and interpret data from narrations (Lieblich et al., 1998). While there is clearly a relation between the study of narrative to support learning or teaching, narrative research differs from both of them as concerns its aim and operation, and actually is a separate research field.

This paper is focused on narrative learning, in particular within technology-enhanced learning environments. The interest of studying the synergy between narrative and technology for the creation of effective learning environments raises from the fact that ICT offers a variety of tools and techniques – from 3D graphics and animation to intelligent agents, from communication means to augmented reality – apt to exploit and even amplify the learning potential of narrative in different ways and for different purposes. This has given rise, in the past couple of decades, to the research and applicative field of Narrative Learning Environments (NLEs).

In the next sections we highlight why narrative can support learning, drawing from the literature. Then we describe what are NLEs, mentioning a few examples. We also discuss NLEs’ characterizing aspects - user role, technological means and educational approach - stressing their importance in determining the learning afforded by an environment. We conclude by pointing out what issues need to be tackled to advance the field.

2. Why narrative can support learning

Even though the concept of narrative might seem rather intuitive, defining it precisely is not trivial. This term is often improperly used in everyday talk to mean a wide range of expression types, thus voiding it of its meaning and possible usefulness in relation to learning (Thomas & Young, 2007). Relying on a loose characterization may be source of confusion and does not help to understand what determines the learning potential of narrative. For this reason, it is necessary to start our analysis with a meaningful definition, drawing from the large amount of characterizations given in the literature. Let us therefore compare the points of view of four scientists working in different non-literary fields and with different orientations.
Bruner (1990), whose work on cultural psychology represented a milestone for the development of many subsequent studies on the educational impact of narrative, defines it as:

“a unique sequence of events, mental states, happenings […] But these constituents do not have a life or meaning of their own. Their meaning is given by their place in the overall configuration of the sequence as a whole - its plot or fabula” (p. 43).

Wertsch (1998), who analyses narrative as a cultural artefact in his studies on mediated actions, points out its components:

“Narrative is organized around temporality, it has a central subject, a plot with a beginning, middle and end, and an identifiable narrative voice; it makes connections between events; it achieves a closure, a conclusion, a resolution” (p. 80),

and then adds:

“The cognitive function of narrative form is not just to relate a succession of events but to body forth an ensemble of relationships of many different kinds as a single whole” (p. 81).

Ricoeur (1981), considering narrative in his studies on hermeneutics and the human sciences, explains:

“The activity of narrating does not consist simply in adding episodes to one another; it constructs meaningful totalities out of scattered events. The art of narrating, as well as the corresponding art of following a story, therefore requires that we are able to extract a configuration from a sequence” (p. 278).

Herman (2003) in relation with cognitive science, claims:

“One of the hallmarks of narrative is its linking of phenomena into causal-chronological wholes” (p. 176).

It is clear that, beyond the different phrasing, these characterizations of narrative are essentially in agreement with each other. This is very important, since it points out that the word narrative is used in consistent way across different scholarly fields, so that when working on the use of narrative to support learning it is possible to rely on theoretical studies of different origins.

All the cited definitions highlight the presence of causal and temporal constraints among the elements of a story, which make them form a whole that gives meaning to its single parts (Bruner, 2004). This allows narrative users to infer more than it is explicitly reported, and hence leads people who receive or produce a narrative to engage in a meaning construction process. This makes narrative a powerful sense-making device and cognitive tool.

On the other hand, all the given definitions do not put limits on the nature of the content or on the language employed. Hence, narrative includes both invented and true stories, as well as narrations of personal experiences. It can be expressed in a variety of different languages, such as spoken words, written texts, sequences of static or moving pictures and even body language and shadows, or a combination of all of them.

Starting from this essential characterization, many authors have deepened the analysis of narrative properties, spotting roles which are relevant for learning, such as (just to cite a few): external knowledge representation (Porter Abbott, 2002), cognitive process (Luckin et al, 2001; Scalise Sugiyama, 2001), context setting element (Aylett, 2006), organizational principle (Polkinghorne, 1988), way to structure human experience (Aylett, 2006), mediator of human action (Wertsch, 1998).

Moreover, the literature highlights that narrative can support not only cognition, but also motivation and emotions, which are equally important components of learning. As Bruner (2002) points out, “narrative in all its forms is a dialectic between what was expected and
what came to pass” (pg. 15), as well as “an invitation to problem finding, not a lesson in problem solving” (pg. 20). For this reason, the use of narrative in learning can result challenging and stimulate curiosity and fantasy, which are major components of intrinsic motivation according to the taxonomy proposed by Malone and Leppers (Rowe et al, 2007). The support to emotions raises from the fact that stories are based on an interplay between characters and causation (Aylett, 2006), which leads the user to highlight aspects of personality, emotional state and social standing, as well as the motives and intentions which underlie the characters’ actions.

3. What are Narrative Learning Environments

The expression *Narrative Learning Environments* was created in the 90s within the field of Artificial Intelligence (AI), to indicate learning environments where some stories, created by the interaction between user and system, had a central role to facilitate learning. In recent years, however, due to the widespread interest raised by the educational potential of narrative, this expression has started being used in connection with learning environments originated within other contexts and developed with other kinds of technological tools and techniques. Such environments share with the original NLEs the characteristic to be based on ICT-mediated learning activities where stories related to the task at hand play a central role. They differ from the original NLEs, however, in a relevant way. AI-based NLEs are technological constructions, with all the necessary component packaged in them, i.e., they include the assignment of relevant narrative activities, a pedagogical approach to guide them and a selection of technological tools supporting them. NLEs originated in other research fields, on the other hand, are conceptual construction making use of some technological tools that can more or less facilitate a relevant narrative activity and require an amount of human labour to set up narrative tasks and define a pedagogical approach apt to favour task completion and the achievement of the expected learning.

It is important to note that not any learning environment including a story can properly be considered narrative. There are environments where a story is given as an appealing background to problem solving, without a conceptual integration between the assigned tasks and the narrative fruition. In this case, the back-story simply aims to provide a generic, extrinsic motivation to work in the environment. This may result strategic in disciplines (like mathematics) that are scarcely appealing for many students, as a way to sweeten an unpleasant pill (Aylett, 2006), but it does not characterize those environments as NLEs.

Besides AI, the fields that have most influenced the creation of NLEs are Multimedia and Educational Design. Also the increasing diffusion of web 2.0 technology is providing technological tools that can well be used to set-up NLEs centred on role-playing. Hence, at present, we can devise four main groups of them, which resort to different kinds of technology and entail a varying amount of human involvement to set up stimulating tasks and control the development of a narrative activity. Table 4-1 summarizes them, highlighting what kind of technology is used in each group. The four groups are described in the section below, together with some examples. More examples of NLEs and tools supporting their construction can be found on http://nle.noe-kaleidoscope.org.

As concerns content learning that can be acquired working with NLEs, in some cases it may be the development of narrative competence, which is a relevant task in itself, especially for children and teenagers. In other cases, narrative is used to stimulate learning in a variety of curriculum subjects, (such as linguistic expression in mother or foreign language, history, science, etc.) or to develop social competence and soft skills (such as relational behaviour in critical conditions, decision making, etc.). These two possibilities - learning to tell stories and
learning by telling stories - are not in alternative with each other, in that using narrative to foster subject or skill learning obviously also influences narrative competence, while practicing story telling necessarily involves some other competence like the use of language or of some other expressive codes. This should not be surprising, in that narrative is a cultural artefact used in NLEs to mediate learners’ action, and it is typical of mediated action to have multiple simultaneous goals (Wertsch, 1998, p. 25).

Table 1. Classification of NLE types according to the technology used

<table>
<thead>
<tr>
<th>Interactive NLEs, based on AI technology</th>
<th>Focus on story creation</th>
<th>Focus on story fruition</th>
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<tr>
<td>(control of the activity is in large measure embedded in the environment; teacher intervention is necessary in limited measure)</td>
<td>Stories emerge from collaboration among users and environments. Parts of narrative are automatically created by means of intelligent agents. <em>Example</em>: Teatritx</td>
<td>The user is proposed a narrative that can help him/her understand a problem situation and possibly learn to cope with it. The narrative is mainly produced by the environment, but the user can influence the story development. Partially new stories are produced at each use. <em>Examples</em>: FearNot!, Crystal Island.</td>
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| NLEs based on multimedia technology | Environment based on narrative editors, i.e. multimedia editors oriented to the creation of stories in the form of cartoon strips or animations. *Examples*: StoryMakerII, MediaStage, Kart2ouche, ZimmerTwins | Multimedia environments where the user is given a narrative helping him/her understand a problem situation by relating the data describing it. The narrative is predefined, the user has only freedom of navigation. *Example*: Ecolandia. |

| NLEs based on web 2.0 technology | Intrinsically collaborative, mainly based on role play. Participating in story creation, users receive part of a narrative from the other participants and produce their own part by complying with rules and adapting to story’s global development. *Example*: Revolution |

| NLEs based on general purpose technology and on educational design and theories | 1) Environments where some relevant narrative activity is assigned within an articulated learning task. General purpose technology is usually employed. *Examples*: Dolk & Den Hertog (2006), De Vries (2006), Makrì (2006), Walker (2006). 2) POGO, a virtual story world, accessible through a number of interactive tools distributed in the physical environment. | No examples known at the moment. This is the field of interest of Narrative Teaching. |

4. A classification of NLES

4.1 Interactive NLEs

The group of NLEs originated from AI research includes mainly environments produced within research projects; they are, hence, well documented by research reports but not commercially available. This group consists of *interactive* NLEs, that is, technological environments in which the users interact in non trivial way with the system to generate consistent narrative, thanks to *intelligent* (*e.g.* autonomous and conversational) *agents* and other AI procedures.

Implementing this kind of environments entails working out a solution to a number of technological and conceptual issues. A major one concerns making computers automatically
generate consistent and believable narratives. To this end, researchers derive formalisms for story generation by drawing from narrative theories formulated within narratology studies (Cavazza & Pizzi 2006). Another important issue concerns realizing interactivity between human and computer in narrative construction. This entails addressing a number of questions to balance user’s freedom and system’s intended aims. Research in this field has given rise to a number of different approaches (Paiva, 2005), leading to a variety of solutions for the creation of emergent narrative, that is, consistent stories collaboratively created by human-computer interaction (Aylett, 1999).

Though always involving the user, to some extent, as participant in story creation, interactive NLEs may be more focused on narrative construction or on narrative fruition. An environment in which the focus is on story construction is Teatrix, a virtual stage where pupils can build and play stories in collaboration with other users and with synthetic characters. Moreover, AI functions provided in the environment help the users check the consistence of their stories and of characters’ behaviour.

As concerns interactive NLEs focused on narrative fruition, what characterizes them with respect to non-interactive NLEs of the same kind is the fact that here the stories proposed are not pre-determined but are generated, with some variant, every time the environment is used, and the user can influence their development by making choices on the story’s content. For instance, in FearNot!, an environment aiming to help pupils to understand what is bullying and to cope with it, the stories generated realize the suggestions given by the user to the main character, a child who is being bullied in school and asks suggestions to stop it. The environment aims to raise empathy in the users and make them become aware of the negative side of bullying, as well as understanding if their suggestions can be effective by seeing them played on the screen.

Also Crystal Island (Rowe et al, 2007), an environment for middle-school students, supporting inquiry-based learning in microbiology and genetics, gives more space to story fruition. Here the student is invited to identify with one of the characters of the back story, the child of a member of a scientific expedition who needs to solve a genetic problem to stop an epidemic disease that is ailing the research group. In this case, the backstory provided has the role of a container to highlight the elements to take into consideration when solving microbiology and genetics problems; it help the user relate data with each other in a meaning-creation process which is functional to the construction of a solution. The student navigates the environment and, interacting with the characters, gets information on the object of study and suggestions to work out a solution. The characters are animated by semi-autonomous agents, which means that (partially) new dialogues are generated each time a character interacts with the students.

Across the two groups lies SAM, that both encourages and carries out storytelling. In this environment, which aims to help children become fluent in storytelling, a virtual child, projected on a wall, invites the user to engage in a game of telling stories to each other, taking turns. In this case, stories creation is made individually by both the real and the virtual child, but the system selects some keywords in the stories of the user to guide the generation of the next story told by the virtual child, so as to give the impression of a kind of dialogic activity.

4.2 NLEs based on multimedia technology

The second group of NLEs, which sprang from research in multimedia, includes hypermedia environments where some narrative is given to guide the exploration of a problem or complex situation, as well as environments that facilitate the creation of stories, based on narrative editors, that is, multimedia editors explicitly oriented to the creation of narratives in the form of cartoon strips or animations (Earp & Giannetti, 2006).
As concerns hypermedia products presenting a narrative, they can properly be considered NLEs only if the given story leads the users to build a global picture of the variety of elements involved in the considered problem situation, helping them to work out a solution strategy, analogously to what takes place in the Crystal Island environment mentioned above. This data-highlighting role is not trivial nor irrelevant in relation to learning, in that some research studies underline that problem solving is more often hindered by an incomplete or inaccurate analysis of the data involved than by the lack of a suitable solution strategy (Sutherland, 2002). In this group we find examples like Ecolandia (Dettori & Giannetti 2006), an environment that aims to foster reasoning on environmental issues, showing the need to integrate information from different sources. Here the student plays the role of an expert who is sent to work out a solution for the garbage disposal problem of three neighbor cities, and gathers the data necessary to tackle the task by talking with public administrators, citizens and experts. This back-story is strictly functional to help the student build a global picture of the problem situation and guide him/her to understand that often in complex problems there is not a single solution but it is necessary to chose among a range of possibilities what suits better to the considered situation. Unlike Crystal Island, environments of this groups are only based on multimedia technology, without intelligent agents, which means that the student is free to move in the environment as he/she wishes, but the possible interactions with the characters are all pre-defined.

As concerns multimedia NLEs for story creation, they can be set up with the use of narrative editors. The currently available ones include both commercial software, like Kar2ouche Composer\textsuperscript{v}, MediaStage\textsuperscript{vi}, StoryMaker II\textsuperscript{vi}, and freeware, like Zimmer Twins\textsuperscript{vii}. These differ from each other as concerns the graphics used (2D or 3D), the kind of animation allowed, the scene and dialogue complexity supported. Plain multimedia editors (like Textease\textsuperscript{viii}) can also be used (see e.g. Faux (2006)), as well as programs that allow one to assemble pictures into movies (e.g., Kynigos et al, (2006) use Camtasia Studio\textsuperscript{ix}; Arnedillo & Tangney (2006) use Microsoft MovieMaker with images and sounds collected with mobile devices). Multimedia editors usually offer analogous facilities for multimedia composition than narrative editors, and sometimes even better ones, but do not provide choices of characters and story-like backgrounds, as it is the case with narrative editors; hence they require some labour to collect and import the necessary story elements. Both narrative and multimedia editors offer facilities for story construction but do not provide functions to check story consistence nor built-in tasks or learning approach that could guide the narrative activity; they require therefore some attention of the users (teachers or mentors or even the learners themselves) to shape and control the narrative learning activity, as well as to check the consistency of the stories/mental configurations constructed and to reason on causal constraints.

4.3 NLEs based on web 2.0 technology

The multimedia communication technology of web 2.0 applications can also give rise to collaborative environments which can be used for narrative learning. Being intrinsically collaborative, these environments lead the users to take the role of participants in story creation, more than any other kind. This influences the cognitive activity implied, as argued in the next section.

A web 2.0 environment that was expressly designed for learning is the educational game Revolution\textsuperscript{x}, a multi-user role-play on the American revolution designed to be played by a group of learners in a networked environment, in 45-minute sessions. The users become part of the unfolding narrative actions by taking one of 7 different social perspectives, hence experiencing the social, economic and cultural daily life of the period. A story is built by the
participants’ actions, starting from a given back-story. The historical context given constrains the participants’ actions and connects them to learning. Knowledge is built by interacting and discussing with peers. As for all role playing, a suitable preparation is necessary to make consistent narrative be generated by the game and give educational meaning to the experience. Moreover, also online multi-player games with a narrative background, like WoW\textsuperscript{xi} or even role-playing environments without predefined back-story, like Second Life\textsuperscript{xii} or Upstage\textsuperscript{xiii}, are raising some interest in the educational field and could be used as technological engine for setting up NLEs. In order to build NLEs using them, however, it is necessary to design meaningful narrative activities with a chosen learning approach, making clear the learning aims of the activity and its relation with the narrative created by the role-playing.

4.4 NLEs based on general-purpose technological tools

The literature reports a number of environments that can properly be considered NLEs, based on general purpose technology, not strictly oriented to the production of stories. Such environments are strongly human-centred and envisage some narrative task within the overall design of a learning activity. For instance, De Vries (2006) makes pupils create narrations of school by e-mail, with the aim to stimulate the learners to reflect on what they are learning. Dolk & Den Hertog (2006) challenge trainee teachers to collaboratively develop narratives of paradigmatic classroom situations in mathematics education, with the help of a software to show videos. Makri (2006), makes trainee teachers exchange narrations of learning experiences by means of blogs. Walker supports the creation of narrative trails in museums (2006a) and in botanical gardens (2006b) by means of mobile technology.

Such environments are characterized by a strong human component, even more than the two previously mentioned NLE groups, since the technology they rely on is neutral with respect to narrative handling, and hence designing and organizing narrative activities completely relies on human intervention. The presence of some technological tool, however, serves to amplify the impact of the narrative activity. Such NLEs are not built around a particular ICT tool, but are essentially shaped by the educational design. Since they are not supported by the presence of narrative-oriented technological tools, some knowledge of narrative learning and of educational theories are necessary to plan meaningful and consistent narrative activities, articulated with the overall learning plan. Their use requires care and attention by mentors, to make sure that the learners are actually involved in a narrative activity, since relying on other types of discourse would obviously have a different impact on learning.

Ascribable to this group of NLEs is also POGO\textsuperscript{xiv}, an environment produced within a research project, that is very different from all the previously mentioned ones. POGO, that aims to facilitate primary school children’s collaborative creation of stories, is conceived as a virtual story world, accessible through a number of interactive tools distributed in the physical environment, which allow children to create and manipulate the story elements in a physical way. This leads to mix the physical (scanned drawings and objects, videos of themselves performing) and the virtual (digital elaborations) in story creation. Unlike the others NLEs in this group, POGO has a technological core. The technology used, however, even though developed on purpose so as to result child appealing, appears possibly suitable to a wide range of operations. Moreover, its use entails a good amount of pedagogical planning, which assimilates it more to the environments of this group than to those of the others.
5. Characterizing aspects of NLEs

Even though NLEs show such a variety of different forms, all of them can be characterized in terms of three aspects which together contribute to determine the learning affordance of the environments. They are:

- the learning approach;
- the role of the student;
- the technological means.

While it is obvious that the approach to learning and educational strategies underlying the activities that can be carried out within an environment have an influence on the learning taking place in it, the other two aspects require some comments.

5.1 Role of the student

The student can be given a narrative or can produce a narrative. Story production, in turn, includes creation, telling and participation. Each of such activities puts into play different abilities. When creating a story, the learner invents it and makes a (usually external) representation of it in some format afforded by the tools available. On the other hand, when carrying out a storytelling activity, the learner tells a (more or less well known) story created by somebody else. In story creation, fantasy is stimulated, while storytelling puts more into play memory and the ability to personalize the narration yet preserving consistency with the original story. In both cases, the activity can be carried out individually or in cooperation with some (human or virtual) agents, which entails negotiating the overall development of the story.

If in joint story creation each agent involved handles his/her/its own characters, and hence the narrative raises from the actions individually decided by each of the agents, then we speak of participation in story construction. This entails a different kind of negotiation than the cooperation mentioned above: here, the consistence checks are made more complex by the need to control one’s character(s) in an overall framework that depends on integrating the ideas and actions of all the participants. Role-playing is a case of story participation.

Finally, also receiving a story created and told by others implies a cognitive activity, consisting in the elaboration of a mental representation of the facts narrated apt to explicit the causal and temporal connections among them.

5.2 Technological means

Among the variety of technological means that are used in NLEs, some influence the appearance of the environment and user interaction mode, while others determine its structure and the kind of experience afforded. The first group includes 2D and 3D graphics, animations, sound, tactile interface. Intelligent agents, natural language processing, multimedia editors, web 2.0 technology and general purpose tools belong to the second group.

Are NLE always based on ICT? In principle the answer should be no, since we can think of realizing meaningful narrative activities with traditional educational technology and means (e.g. drawing, dramatization, books, etc.). The use of ICT, however, allows the construction of more articulated and ductile NLEs, where the user can move with a good amount of freedom to carry out a variety of narrative activities. It also allows easy creation and use of multimedia-narratives, hence leading the students to become familiar with multiple representational modes within an activity – the interaction with stories - which is naturally appealing and not too difficult to understand. Non-verbal narratives, or with a very limited amount of verbal language, can also be easily constructed in technology-based environments,
hence allowing people with disabilities related to language to carry out educational activities exploiting the learning potential of narrative (e.g., Faux, 2006).

Since both narrative and ICT-based learning environments have an educational potential, one wonders whether their combination produces a positive synergy. An ever increasing number of studies on technology-enhanced narrative environments highlights that the use of different media (Fusai et al, 2003) and technological tools (Aylett, 2006) affects the environment’s learning affordance, so that the use of one or the other ICT tool influences the cognitive activities that can be carried out in a narrative environment, and hence the learning expected to take place in it.

In order to illustrate the possible influence on learning of technology, let us see how much can differ in this respect two environments that an inexperienced user might consider similar in that both aiming to help the creation of stories, namely the use of a narrative editor, StoryMakerII, and an interactive environment, Teatrix (Dettori & Giannetti, 2006). In these two cases, the experience of story creation is structured and developed in different ways. In Teatrix, the types of character available to build a story are in limited number, but are completed by a description which constrains their possible behaviour. Hence, constructing a narrative in this environment actually results in a role-play activity. The environment includes an intelligent function (the hot-seating) which aims to detect inconsistencies in characters’ behaviour and monitor the overall consistency of the story, thus encouraging the conception of an intentional dimension for the characters. This environment, therefore, strongly supports the development of a narrative competence, in particular as concerns causal reasoning.

StoryMakerII, on the other hand, is a tool orienting the user’s activity towards the development of communication skills. It pays attention to dialogues formulation, providing multimedia facilities, like the possibility to record people speaking or produce spoken sentences by means of a text-to-speech tool. It offers a library of backgrounds, props and characters which is much richer than that provided by Teatrix, with more complex animations and a more refined graphics. These features can not only support the creation of more articulated and fancy stories, but also favour the acquisition of a technological literacy in relation with multimedia expressive capabilities; these are not irrelevant skills in the current cultural context influenced by an ever increasing diffusion of powerful technological tools.

In both cases, visual elements (backgrounds, props and characters) are provided, which encourages fantasy and make story creation more concrete and faster than it would be possible in traditional classroom work (i.e. by drawing or dramatization), where often time constraints strongly limit the good development of such activities.

6. Research directions and open issues

The fields of NLEs can be considered an emerging one, since its taxonomy is still object of study, its diffusion limited and many conceptual and practical issues need to be addressed. Attention to the use of narrative to support learning is rapidly increasing, though, and we can therefore expect a rapid development of the research in this field and diffusion of its applications.

The field needs to be further developed in several ways:
• From the conceptual point of view, different possible cases of NLE should be explored, so as to define more precisely the boundaries and structure of the field.
• From the technical point of view, work should be done on building more effective, efficient and interactive environments, and also to integrate the different groups of NLEs described above. Good suggestions in this respect can come from narrative computer games, especially as concerns the realization of effective interaction engines.
• From the pedagogical point of view, the impact of applying NLEs in different disciplines should be analyzed more in depth, and their educational potential further explored. Moreover, attention should be given to two important issues that are transversal across the conceptual, the technical and the pedagogical, that is, evaluation and diffusion of NLE. Evaluation is crucial to fully understand how to build better NLEs and suitably exploit them in the educational practice. This is a complex task in that there are many aspects involved and thus obviously there can not be a single way of evaluating (Decortis & Rizzo, 2005). Aspects to consider should include technical features and ease of use, activities carried out in the environment, as concerns both outcomes and process, support to improve user’s learning ability, and also the emotional and motivational impact and enjoyment they produce in the user.

As concerns diffusion of applications, Aylett (2006) spots with great precision the roots of the scarce diffusion of interactive NLEs:

“Taking some of the innovative ideas and systems from research prototypes through to delivered systems is what is needed in order to make NLEs a real educational option. This is of course non-trivial since it depends not only on the maturity of the technology but also on the business case convincing educational software producers to move in this direction”.

As concerns the kinds groups of NLEs, which are based on the use of widely available technological tools but entail an amount of pedagogical planning, it would be crucial to prepare educators to their informed and conscious use. It would also be necessary to share within the scientific and educational communities reports of experiences of use and analyses of case studies, so as to inspire and guide the development of such environments and their application in formal and informal learning.

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