Computers in Human Behavior 31 (2014) 620–637

Contents lists available at SciVerse ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

A methodology and an authoring tool for creating Complex Learning Objects to support interactive storytelling

Matteo Gaeta [a], Vincenzo Loia [b], Giuseppina Rita Mangione [c], Francesco Orciuoli [a], Pierluigi Ritrovato [a,*], Saverio Salerno [a]

[a] DIEM – Dipartimento di Ingegneria Informatica, Ingegneria Elettrica e Matematica Applicata, University of Salerno, Fisciano (SA), Italy
[b] DI – Dipartimento di Informatica, University of Salerno, Fisciano (SA), Italy
[c] MOMA SpA, Baronissi (SA), Italy

ARTICLE INFO

Article history:
Available online 24 August 2013

Keywords:
Narrative learning
Risk education
Authoring tool
Digital storytelling
Adaptive learning
Intelligent tutoring system

ABSTRACT

Knowledge of appropriate behavior during an earthquake is crucial for the prevention and mitigation of natural disaster. Several studies confirm that disaster-risk education should be part of the national primary and secondary school curricula. The school plays an important role in developing a positive attitude towards safety as well as in increasing young people's social responsibility. This can especially be achieved by "active educational methods based on real situations". Narrative learning, according to this pedagogical vision, is seen as an educational approach mostly suitable for the development of cognitive abilities and knowledge in action, supporting processes of meaning construction through risk education contexts. In this paper, we present a methodology to design digital storytelling, a "media rich" strategy able to support the learning process in a civil emergency context and an authoring tool for creating Storytelling Complex Learning Objects (SCLOs), as a complex learning resource characterized by an adaptive mechanism that exploits a *template-based approach*, which is focused on the design of *teaching situations* suitable for achieving specific learning goals. The integration of this new kind of learning object with an advanced e-learning platform, namely Intelligent Web Teacher (IWT), that allowed us to carry out a full experimentation of the overall learning process, from content creation, to learning path packaging and adaptive delivery. The experimentation results demonstrate the effectiveness of both SCLO and authoring tool from a pedagogical and usability point of view.

1. Introduction

By accepting the idea of overcoming educational models that can reproduce receptive educational architectures and which are based on a static condition of roles, tasks and environments, the ALICE Project (ALICE, 2010) defines a Storytelling Design Model aiming at developing the Storytelling Complex Learning Object, (SCLO). The SCLO is an *intensive resource* characterized by its capability to support learning in a specific emergency context, combining direct experience and *reflection in action* (Mc Drury, & Alterio, 2003) and making use of elements like dramaturgy, suspense and immersion to intervene and maximize the engagement level (Mangione, Orciuoli, Pierri, Ritrovato, & Rosciano, 2011).

Relying on the increasing relevance of Storytelling in risk education the research (Mangione, Capuano, Orciuoli, & Ritrovato, 2013) focuses the attention on the content creation, in order to overcome the lack of instruments that cater for the enabling organization and structuring of stories and support the design of authoring tools in the definition of specific object behaviors and interactivity mode that help learner's engagement and key concept understanding.

The paper is organized as follows: the next section provides an overview of the state of the art of both narrative and storytelling models, and the existing narrative learning solution (platforms/tools). The third section presents the model defined for creating the Storytelling Complex Learning Object (SCLO in short) and the related authoring tool. This section also presents advanced features of the IWT– Intelligent Web Teacher (Albano, Gaeta, & Ritrovato, 2007) as enabling technologies and explains how the SCLO has been used within IWT, providing examples of the Amusement Park SCLO opportunely created for the experimentation. The fourth section shows the results of the experimentation carried out within the two high schools. Finally, the last section concludes and describes directions for future works.

1.1. Background knowledge

Disaster education, field of study embraced by the more general risk education, has become a main subject of interest in teaching

* Corresponding author. Tel.: +39 089964289.
E-mail addresses: mgaeta@unisa.it (M. Gaeta), loia@unisa.it (V. Loia), mangione@momanet.it (G.R. Mangione), forciuoli@unisa.it (F. Orciuoli), pritrovato@unisa.it (P. Ritrovato), salerno@unisa.it (S. Salerno).

0747-5632/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.chb.2013.07.011

and learning science (Selby & Kagawa, 2012) also due to the apparent increase in natural disasters occurred over the last century (Mangione et al., 2013). As asserted by Kuhlicke et al. (2010) "*Risk education is a capacity building strategy of promotion of safety that encourages positive behavior, leading to modification of societal and individual risk states and behaviors that prevent people from living a safe life*".

The disaster education concerns "*building students' understanding of the causes, nature and effects of hazards (e.g. earthquake) while also fostering a range of knowledge and skills to enable them to proactively contribute to prevention and mitigation of disaster effects*" (Mangione et al., 2013).

Disaster education should be included in mainstream school curricula and it should aim to assist learners in forming positive attitudes and practices (Cardona, 2004). "*School children are excellent emissaries between home and school for information and mitigation practices relative to natural hazards and they can contribute significantly to raising awareness and public understanding of disaster vulnerability and issues*" (Kuhlicke et al., 2010).

The research report "European risk education landscape" (Kuhlicke et al., 2010) is far from uniformity and several questions about suitability of different educational methods to adopt in order to teach risk and disaster management in school are still open (Selby & Kagawa, 2012).

Students are at present no longer seen as passive recipients of information but rather as active learners that should be involved in the development of their learning activities. These students, identified as *Digital Natives* (Thompson, 2013) were born in a multi-windows multi-devices society (screen/finger generation) and interact with many of these screens from an early age through a new language. Among the various researches, Prensky (2006) comes to conclude that this new language, associated with a new way of organizing thinking, is based on: multitasking, hypertext and interactivity.

In (Black, & Gen, 2010) the author observes that digital native students express a need for more varied forms of communication and claim to become easily bored with traditional learning methods. Because students' lives today are saturated with digital media at a time when their brains are still developing, many popular press authors claim that this generation of students thinks and learns differently than any generation that has come before, but the evidence to support these claims is scarce. The digital native needs self-directed learning opportunities, as well as interactive environments, multiple forms of peer feedback and assignment choices that use different resources to create personally meaningful learning experiences (Barnes, Marateo, & Ferris, 2007). Digital native learners wish to construct their knowledge by themselves. They expect to be immediately engaged in the learning process. As the higher education paradigm shifts from teacher-centered to learning-centered classrooms, the educators' need is that to provide environments and educational mechanisms for teaching, using a variety of instructional delivery methods and activities conceived to engage students within their own learning process (Prensky, 2006).

How can educators reach the digital natives and provide a productive and engaging learning experience that will help students acquire earthquake related knowledge?

The educators are asked to provide a variety of instructional methods and activities (*do, connect, play, share*) (Berk, 2009) to engage digital natives in a risk education process (Mangione et al., 2013) basing on learning technologies as an important driver of the pedagogical change (Black & Gen, 2010).

If the educational *message* (whose objective is to mitigate the risk of disaster) is that students should be made ready to actively engage in pre-empting and facing potential disaster, then the *medium* through which they learn should be one of an active engagement type (Shaw, Kobayashi, & Kobayashi, 2004). A pedagogy that brings knowledge to life, practices skills, challenges attitudes and scrutinizes values is a pedagogy that is active, interactive, experiential, able to "*...stimulate responsibility and guide the comprehension of correct behavior*" to adopt in the face of a natural disaster. "*Perceived responsibility plays an unimportant role in the (flood) preparedness decisions...*" (Terpstra, 2009). The school plays an important role in developing a positive attitude towards safety as well as in increasing young people's social responsibility (Selby & Kagawa, 2012).

This can especially be achieved by "active education methods based on real situations" (Kuhlicke et al., 2010).

One of such methods that has the potential to be effective in children emergency preparedness is teaching through story (Robbins, 2012).

The narrative, in this view, is a privileged instrument that can help develop cognitive skills and organize the knowledge, a powerful cognitive tool whose potential can support the learner in the process of meaning construction. As observed by Bruner (2002), the narrative, in all its forms, is a dialectic between expectations and events and a call for problems, not a lesson on how to solve them. The narrative is a privileged educational strategy for developing cognitive skills and organizing the knowledge, it is a powerful cognitive tool whose potential can support the learner in theprocess of meaning construction (Herman, 2007). The use of narrative in learning can be exciting and can stimulate curiosity and imagination, which are essential components of intrinsic motivation according to the taxonomy proposed in Malone and Lepper (1987).

Storytelling is expression of a *realist approach* in risk education (Wachinger, & Renn, 2010, Selby D. & Kagawa F., 2012) that assumes that there is an objective world with risks that we can recognize and acknowledge, in order to apply this to similar situations – this process is known as *transfer* (Kuhlicke et al., 2010). The researchers argue the possibility to achieve significant learning outcomes when the storytelling is used in reflective, thoughtful and formalized ways (Mc Drury & Alterio, 2003).

The "new media generation" has fostered the mode of intervening and rethinking of teaching activities, specifically recalling the concept of narrative learning in the digital context (Thompson, 2013). The *digital storytelling* can be utilized in order to support the development of individual's expressive skills (Wan Chi Wan Chi Wu, 2008) and in particular as regards to childhood, promoting at the same time the development of critical faculty, perception of others, and problem solving (Mc Drury & Alterio, 2003; Ohler, 2008). "Media rich" environments have contributed to revise the possibility offered by the linear narration, introducing in the *digital storytelling* not only elements of dynamicity but mainly of reticular construction, adaptivity and interactivity that simulate and, in some way, approximate the cognitive thought encouraging the understanding of self and others in the world (*external representation*) (Lieblich et al., 1998).

In fact the storytelling owns a huge potential as a narrative methodology that meets the ways in which adolescents act applying bridging (build bridges) and linking (build linking) approaches, and helps digital natives develop effective and selective attention and improve their reasoning skills.

The challenge that digital storytelling in risk education poses is how to harness the massive potential of the story form, with its possibilities to inspire, engage, transform, through a process that will endow it with opportunity for reflection, critical thinking and problem solving (Ohler, 2008).

Storytelling, addressing "both affective (emotional) and cognitive (informational) factors" increase the "protection motivation" in the learners.

If the stories are personally relevant and convincing, threat perceptions and change behavior in natural hazards contexts increase (Terpstra, 2009), developing cognitive, emotional, and psychomotor skills.

Disaster education-based storytelling should provide learners with the ability to acquire knowledge about appropriate protective actions that can be taken (Mangione et al., 2013). This knowledge should, in turn, result in an appropriate adaptive behavior (Finnis, Standring, Johnston, & Ronan, 2004) that the student acquires during dynamic and immersive experiences.

1.2. Aims and scope

The narrative has increasingly attracted attention in education over the last two decades (Dettori, Giannetti, Paiva, & Vaz, 2006). As many researchers affirm the narrative is a privileged instrument for developing cognitive skills and organizing knowledge. This potential depends on the fact that the narrative has mostly built in an implicit form, induced by the juxtaposition of events, supporting logical links between the elements involved as a result, where each component contributes to shape the global meaning and this in turn, gives meaning to each element (Bruner & J., 2002). In the educational framework, a milestone is the definition given by Bruner and J. (2002), which is rather general but well focused on the characterizing elements of narrative. He defines narrative as a "*unique sequence of events, mental states, happenings involving human beings as characters or actors: these are its constituents. But these constituents do not, as it were, 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*".

There are several narrative theories in literature, mainly developed in the context of narratology, highlighting that narrative could serve as the foundation for guided exploratory learning and can be used as an effective tool for exploring structure and process of "meaning making". The narrative experience can provide an essential guidance for effective exploratory learning and an "affective scaffolding" for achieving high levels of motivation and engagement.

Research in recent years has emphasized the need to review the design and generation processes of narrative learning resources in order to facilitate their reuse in adaptive and complex experiences (Göbel, de Carvalho Rodrigues, Mehm, & Steinmetz, 2009).

Suitable authoring tools enable educators to create engaging and interactive lessons that ease the learning with the integration of a myriad of multimedia contents. Unfortunately, many of the currently available tools are too complex to be used (Govindasamy, 2002).

Debates in the field are focused on who really needs to use such tools: teachers or knowledge engineers. The need for simpler e-learning authoring tools that could lower the skill barrier and allow more teachers to participate in the development and customization process is ever-increasing. Moreover, these tools, to be really useful, should be able to reduce development time, effort and cost, by allowing the reuse, enrichment and customization of available learning contents emphasizing the pedagogical dimension of the defined learning experiences.

Several studies report that many stories have common patterns (Cao, Klamma, & Jarke, 2011). For instance, Joseph Campbell's seminal work of comparative mythology illustrates an archetypal hero or protagonist from various mythologies (Campbell J., 2008). A similar template is about the four phases for story elements introduced by the Russian thinker Vladimir Propp. The hero's pattern is often repeated in criminal movies in which the hero is embodied in a policeman, an agent or a detective (Propp, 1958).

In order to take advantages of storytelling for improving learning processes, a pedagogical support is needed. The story templates can be applied to easily create stories in an interactive, adaptive and collaborative way facilitating the reuse.

Pedagogical templates or patterns are used in order to capture and communicate recurrent learning design problems and opportunities (Goodyear, 2005). Each pattern describes a problem that occurs repeatedly together with the core solution for the problem (Alexander, Ishikawa, & Silverstein, 1977). The templates can be applied to instructional design at two levels: for learning materials and multimedia production (Avgeriou, Papasalouros, Retalis, & Skordalakis, 2003), (i.e. defining patterns for learning management systems) and for instructional activities of different scale, (i.e. organizing an entire course or defining specific learning activities). In the storytelling model definition, we consider the latter interpretation in order to link a storytelling structure to different educational goals and activities.

Taking advantages of storytelling for improving learning processes requires a pedagogical support. Unfortunately, as clearly emerged from the analysis presented in the following sections, many of the currently available tools do not provide a specific pedagogical support and lack the capability for being integrated with an e-learning platform.

The proposed work aims to fill the lacks of existing storytelling models and guides the developing of an authoring tool that expresses the storytelling as a didactic complex learning resource providing the following distinctive features:

- *Non-linearity gained from educational template*: Each resource is the aggregation of atomic learning entities based on pre-defined but customizable schemas. We have proposed an approach to template-based storytelling that helps the instructional designer tell well-structured educational stories. The approach envisages incorporating various multimedia resources that allow the *non-linear path* (defined by an educational logic). The pedagogical templates, defined according to SDM, include elements closely connected to didactic activities (situation and non-linear path). One great benefit of this, results in the fact that story structure and story elements are completely separated. The element involved can be implemented both with scene contents (e.g. audio, video, media content, flash object) and collaborative activities (e.g. wiki, forum, social tagging, and so on).
- *Template operation and cross platform*: In order to implement these pedagogical templates and generate the SCLO, we have developed an authoring tool. The tool provides features enabling to organize and structure stories, to define storytelling complex object behaviors and to execute educational templates. It consists of an editor and a player. The output produced by the editor is an XML file that represents, declaratively, the entire story structure, all the activities configuration parameters and condition rules that constitute the logic flow. The player is utilized to present the story and, according to its designed flow and related logic, is intended to show the scenes to the user.
- *Integration with the e-learning platform*: The storytelling design model is integrated with the IWT e-learning platform. A SCLO is treated in IWT in the same way as any other kind of learning object. By exploiting the IWT mechanism for learning resource management (plug-in drivers), it is possible to insert a SCLO within a personalized e-learning experience, for the purpose of dealing with specific concepts which require a more sophisticated didactic method. Furthermore, IWT enables a macro-adaptation process. It consists in (automatically) supporting the generation of personalized remedial work on the basis of assessment results.
- *Interoperability and reuse*: Leveraging on the IWT features, the SCLOs can be exported in SCORM 1.3 in order to be executable within other systems. Furthermore, the SCLOs can be annotated with an IEEE LOM metadata schema to be stored in standard digital repositories for learning objects.

The validation and evaluation of both storytelling design model and authoring tool for a SCLO implementation, led us to conduct an experimental comparison (also called randomized controlled experiment) based on an evaluation methodology (defined in details in the further section) that helped us collect information about:

- *Validity and didactic originality of SCLO* that includes effectiveness of methodology, validation of resource and its originality and innovation.
- *Emotional aspects,* that outlines the learner's emotional state during interaction with the complex learning resource.
- *Usability*, that takes into account the perception of each user during the interaction with the storytelling tool.

The results of the present study demonstrate the efficacy of SCLOs for enhancing the knowledge about earthquakes threat in general and the knowledge in action concerning the recommended self-protective behavior during seismic event. Our data suggest that earthquake education, when combining innovative learning methods as the digital storytelling with a useful and playable interface, will contribute to an enhanced children preparedness level in facing natural hazard by improving their knowledge of laws and appropriate behaviors. This is confirmed by students' positive comments on narrative model, storytelling resources and system interface.

1.3. Storytelling authoring tools: state of the art

The development of ICT (Information and Communication Technology) and its increasing use in education has provided a variety of tools and techniques apt to exploit and strengthen the adoption of stories, giving rise to many different approaches to the application of narrative seen as a support for the learning, as well as to a variety of narrative learning solutions having different applications and aims.

Moreover, these tools are addressed to specialists (people who have developed specific technical skills), who usually do not need to provide any pedagogical support to learning activities.

The evaluation of current authoring systems is quite difficult due to several approaches and different underlying representations for story generation and execution.

We present a classification of the most relevant approaches for managing digital storytelling processes (Cao et al., 2011) also providing examples of tools belonging to one or more of these classifications/categories.

Linear vs. non-linear storytelling types are differentiated basing on action sequences of media occurring in the story. Non-linearity enables storytellers to tell more complex stories with different storylines within the same story (Spaniol, Klamma, Sharda, & Jarke, 2006). Different points of view on individual media could affect the normal flow of a story. Non-linear stories may be told in several versions with different content sequences (Soffer, Goldberg, Avisar-Shohat, Cohen, & Bar-Dayan, 2010). The interactive storytelling process enables storytellers as well as story listeners to make their own decisions actively to determine the later course of the storyline. Dynamic narratives are created by which users can interact at each part.

Adaptive/interactive storytelling gives storytellers the opportunity to make their own decisions actively to determine the further course of the storyline (Donikian, & Portugal, 2004) and to create narratives dynamically (Van Velsen, 2008) with which users can interact (Franz, & Nischelwitzer, 2004; Merabti et al., 2008; & Medler, & Magerko, B., 2006).

A collaborative/social storytelling process can help design the active experience. In particular reference is made to typical web 2.0 environments for narration like *articy:draft*[1] or *Storify*[2] that allow to define and design multimedia pathways using social features (annotation, collaborative writing, video-sharing, etc.) enabling a continuous improvement of the narrative structure (Cao, Klamma, & Martini, 2008).

Mobile/ubiquitous storytelling takes place in a physical environment where the digital natives actually move around and interact with digital content as well as with others using mobile devices and communication technologies. Solutions like *Storykit*[3] or *Mobile Storytelling*[4] make ubiquitous the storytelling process facilitating the digital native access (Cao, Hnnemann, Klamma, Kovachev, & Renzel. D., 2010). The *mobile storytelling* is considered as a part of the *transmedia storytelling*, the process where key elements of narration are spread out from different devices like smartphones, tablets, smart-TV, etc. (Jenkins, 2010).

In the following section we provide a detailed description of some existing solutions developed in the frame of research European projects belonging to one or more of the above mentioned categories.

Dramatica (Phillips, & Huntley, 2001), belonging to the first category (linear vs. non-linear), is a comprehensive framework suitable for creating multimedia stories with semantic knowledge. However, it does not allow any kind of non-linearity. This tool has been conceived to support dramatic fiction writers, providing the user with a structured theory of drama and an approved model of authoring. Dramatica guides the author towards creating a believable, well-argued and dramaturgically correct story. Unfortunately, it is only useful for creating linear, non-interactive narrations. The non-linear stories, built inside environments like *Storylining Suspense*, can be told in very diverse versions with different content sequences.

Inscape project (Gobel, Becker, & Feix, 2005), aiming at enabling ordinary people to use and master the latest ICTs for conceiving, authoring, publishing and experiencing digital interactive stories whatever their form, be it theatre, movie, cartoon, puppet show, video-games, interactive manuals, training simulators, etc. The INSCAPE project supports adaptive/interactive storytelling processes. The intended GUI (Graphical User Interface) concept for the INSCAPE authoring tool, as well as the underlying data model, describe interactive stories in such structural terms as those used in the INSCAPE story format ICML (Inscape Communication Mark-up Language), namely trees and graphs of connected objects and their diverse attributed properties. The GUI design provides four main areas, or functional blocks, to define an interactive story. In a first step, the authors can use one part of the interface and only in a top down fashion, to describe a story in a storyboard-like manner: A common-style text editing environment is used, including the possibility to insert sketches, icons etc. In contrast with that, there is another part more following the bottom-up approach: This part of the GUI provides a library of all story assets (objects, props), in a symbolic form, e.g. by showing icons for each library item. The central part of the GUI, includes interfaces used for editing the stages (assemblies of objects, and their positions within the stage), for defining interactive scenes taking place within these stages, and for previewing the INSCAPE stories in a 2D or 3D mode. In a special area (called the Story Editor), a visual representation of the story's transition graph is visualized as a graph structure, in order to manage the overall story flow, branches etc. In addition to these basic functions, there will be specific behavior editors, where authors can either integrate/reference predefined scripts associating them to story objects, or to add, set, or delete properties and variables. The Emotion Wizard (EW) is an authoring module of INSCAPE which enables authors to "emotionally" change environment and characters easily and

[1] http://www.nevigo.com/.
[2] http://storify.com.
[3] http://itunes.apple.com/it/app/id329374595?mt=8&affId=2201491.
[4] http://mobilestorytelling.se/.

quickly. The Emotion Wizard consists of audio-visual templates and models of character's behaviors that the author can use to speed up work or to help find the right emotional tone for the scene he or she is creating.

Storytec (Göbel, Salvatore, & Konrad, 2008) is a platform for Interactive Digital Storytelling applications developed in the context of the INSCAPE project. Storytec consists of a comprehensive authoring framework with different editors enabling authors (without development skills) to create interactive stories and a runtime engine, responsible for a fluent story and story control execution. Components of the authoring environment include a Story Editor, to create, organize and manage stories (structures), a Stage Editor, to createand manipulate story units (complex scenes and scenes), an Action Set Editor, to define transitions among scenes and an Asset Manager and Property Editor, to access and manipulate story objects. The runtime engine core builds a Narration Controller loading a story encoded in ICML and controlling the interactive scenario based on user's interactions and strategies defined beforehand by the author. The result of the authoring process is a computer readable description of the story which can be read by any application which incorporates StoryTec's runtime library. Compared to INSCAPE, a major benefit results in that the story structure and story content are largely separated. Hence, it is possible to create and play different story peculiarities (for instance 2D vs. 3D) based on the same story structure and subsequently to use different players to be controlled via high-level commands (provided by Narration Controller).

PaSSAGE (Player-Specific Stories via Automatically Generated Events) is an interactive storytelling system that adopts user modeling to automatically learn the preferred play style of the current player, and uses this knowledge to dynamically adapt the content of an interactive story. According to Peinado and Gerv́as (2004), PaSSAGE has defined some player types basing on Robin Laws' rules to create a player model; these include Fighters (who prefer fighting), Power Gamers (who prefer gaining special items), Tacticians (who prefer thinking creatively), Storytellers (who prefer complex plots) and Actors (who prefer taking dramatic actions).

During the game play, PaSSAGE learns a player model expressed as weights for each of these five play styles; the higher the weight will be, the stronger the model's belief that the player prefers that style is. Before run-time, potential courses of action are identified by the designer and augmented with weight deltas, allowing the model to be updated based on player's actions in the game.

MIST (Soffer et al., 2010) and YouTell (Cao et al., 2008) are two cross-related prototypes. MIST is a Java application and allows the creation (editor) and consumption (player) of multimedia stories. The editor allows users to create new or edit already existing multimedia stories. The viewer is used for the consumption of existing multimedia stories. The player allows the visualization of versatile media such as movies, music, texts or images. According to the media transitions defined in the editor's story-board the user might select a preferred medium in case of more available types. MIST does not support collaborative storytelling by different users. Users can create their own stories. Moreover, how the story is further used by other users is not traced at all. In order to overcome these limitations MIST authors extended the prototype implementing YouTell, a collaborative storytelling environment within community of practice using Web 2.0 technologies. YouTell is based on the idea of Personalized Storytelling Environment (PESE). The Web 2.0 features such as tagging and ranking stories are part of the environment. In addition, experts with certain knowledge can be identified in communities of practice. In particular, PESE enables communities to have joint enterprises (i.e. story creation), to build a shared repertoire (i.e. stories) and to engage mutually (i.e. expert contacts). The PESE uses a role model. Experts are users who have the knowledge to help other users. Users who have questions can contact an expert. Search facilities are provided by PESE to search for experts.

Users can provide feedbacks on the stories using either explicit or implicit feedback techniques. After visiting a story respectively getting an expert advice, the user has the possibility to fill out a questionnaire. This explicit form of giving feedback is fundamental for PESE. Though not every user likes filling out questionnaires. Therefore also implicit feedback is used, even if this is not as accurate as the explicit feedback is, it can be an effective substitute. In PESE the following user's behavior will be considered: the more a user visits a story the more interesting it is. The more a story is visited by all users, the more popular it will be.

MPISTE (Delgado-Mata, Velazquez, Pooley, Aylett, & Robertson, 2010), is an environment (for mobile devices) to tell personalized stories based on physical location. To locate the user GPS (outdoor) and RFID (indoor) technologies are used. It is part of a more ambitious project aiming at the development of an affective virtual guide.

In conclusion both authors and developers of interactive storytelling systems (Dettori et al., 2006; Goodyear, 2005; Mangione, Pierri, & Iovane, 2012) found themselves to face several challenges during the design of such systems: Interactivity brings about a branching story structure and issues of author control v/s user control of the storyline. Declarative representations of intelligent story directors do not intuitively convert to the game engine's procedural execution environment. Content from diverse media types needs additional integration and management support.

This confirms our idea of working towards the identification and definition of models that are based on didactic principles related to narrative pedagogy, and able to guide the creation of suitable storytelling learning objects.

2. The proposed model

In the following section we introduce a model, namely Storytelling Design Model (SDM) Mangione et al., 2011, for creating Storytelling Complex Learning Objects (instances of the aforementioned models). SDM is described by considering theoretical aspects, pedagogical aspects, adaptation strategies and assessment strategy.

2.1. Storytelling design model and pedagogical aspects

The accomplished research activity has been focused on enriching the application of "monomyth" hero (Campbell, 2008) with the instructional principles related to adaptivity and engagement. The archetype of the *monomyth* is common to any narrative structure in any culture: the protagonist needs to overcome a series of trials to achieve a result and eventually to manage them to get the reward they deserve.

To follow this proven path we propose the adoption of the *visual portrait of a story* defined by Dillingham Dillingham (2001) and further extensions proposed by Ohler (2008), with a time-diagrammatic view of the most emotionally important moments of a narrative described in Fig. 1.

In the SDM, a script is a logic composition of various *situations*, based on phases of a Visual Story Portrait – short VSP – (beginning, call adventure, problem, middle transformation, solution, closure).

In particular, the phases of a VSP are summarized below:

- *Elements of a beginning*: The story begins by the moving out of life ordinary events suggesting to characters a need to climb to get to where they are going.

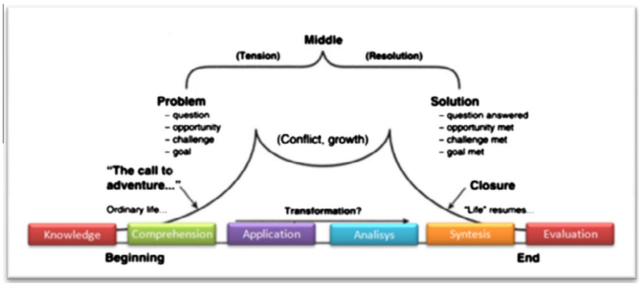

Fig. 1. Mapping among VPS situations, learning objectives and character transformations.

- *Elements of a middle*: The story focuses on a series of adventures that are related to solving the problem and relieving the tension. In the process of traversing the path from problem to solution, the character learns, grows and becomes a new person in some significant respect.
- *Transformation*: The key to transformation is that the central character needs to apply for some changes in order to solve the problem. S/he has to be pushed and tested by the situation to grow and learn something new.
- *Elements of an end (closure)*: After the story's problem is solved, there needs to be closure that does not leave the listener feeling like the story teller "has simply run out of material".

SDM (Mangione et al., 2011) exploits the concept of transformation formations, i.e. the transformation of characters. The characters can undergo different kinds of transformation. The levels are not mutually exclusive, therefore characters often transform at more than one level at the same time.

The SDM considers the *intellectual transformations* as changes in terms of learning objectives. At this level of transformation, learners (who lead the characters) are asked to use intellectual-creative abilities in order to solve a problem.

A distinctive feature of our model, that also highlights the relevance for the learning process consists in cross-relating Bloom's Taxonomy (Bloom, & Krathwohl, 1956) and character's transformations to map each transformation with a specific phase of the VPS (lower part of Fig. 1). In particular, Blooms' hierarchy of transformations identifies a taxonomy of intellectual changes in terms of six different levels of learning goals, which are considered in an increasing order of difficulty, from basic to higher levels of critical thinking skills.

In our model, the *learning situations*, based on the VPS phases (Beginning, Call to adventure, Problem, Middle transformation, Solution, Closure) have been related to the aforementioned levels.

In the *Beginning* situation, to obtain prior/background knowledge the character (i.e. the protagonist) has to know, to remember and to describe either the key concepts or the presented events.

The *Call to adventure* has the aim of understanding and therefore requires the protagonist (and his/her character) to explain, interpret, predict events, starting from some conditions and principles. The phase of *Problem* calls for a goal of applied knowledge and requires that protagonist to discover, construct or change something in order to demonstrate the ability to apply the knowledge in new situations.

During the *Middle transformation* phase, it needs to achieve an analysis objective. The protagonist, in this case, distinguishes between various options, organizes and compares alternatives and thoughts. In the *Solution* phase, the protagonist is required to achieve the ability to do a summary of the situation, to draw various conditions and to reconstruct the meaning of actions. Finally, the *Closure* phase is related to a goal assessment on the protagonist's ability to evaluate, criticize, and appropriately respond to proposed situations.

Each situation is defined as a composition of *instructional events* in a way that can ensure the achievement of assigned learning goals (Mangione et al., 2011). This structure also fosters the development of organization, selection and integration of the information carried out by the learners, and maximizes the results for a specific learning goal that identifies a specific level of knowledge.

Each story situation has 4 parts or events:

1. *Advancer event*, that is designed to activate the precursor prior knowledge of the student and to ensure his/her initial involvement in the situation.
2. *Learning event*, that supports learner's understanding of the topic goal and is based on a guided approach.
3. *Reflection event*, that is designed to support the learner to reflect on learnt concepts and allow him to consolidate the acquired knowledge.
4. *Assessment event*, that submits a test to learners (with respect to the specific VPS situation which they are involved in) to assess the type of transformation occurred.

The combination of these elements for each situation has the objective to enhance the desired learning level and to support the learners' cognitive transformation (Mangione et al., 2013). Appropriate questions can then be developed to assess the desired level. Every situation included in an instance of SDM answers a specific didactic transformation path, based on Bloom's taxonomy. Different types of tests are submitted to the student in order to measure the achievement level of the six knowledge goals, whose weight is linked to different learning actions. Table 1 summarizes these relations.

The result, in terms of measurement of acquired knowledge level should determine a re-modeling of story and hero's path, aiming at guiding, supporting and motivating the student in reaching learning objectives (Mangione et al., 2012).

2.2. Adaptation strategies

SDM foresees multiple adaptation strategies that can support the execution of adaptive didactic experience (Peirce, Conlan, &

Table 1
Question cues for specific Bloom's Knowledge levels (adapted from Holden 2010[a]).

Level	Learner action	Question cues
Knowledge	Recall content in the exact form that it was presented. Memorization of definitions, formulas, or procedures are examples of knowledge-level functioning	List, define, label, identify, name
Comprehension	Restate material in their own words, or can recognize previously unseen examples of a concept	Describe, associate, categorize, summarize
Application	Apply rules to a problem, without being given the rule or formula to solve the problem	Apply, calculate, illustrate, solve
Analysis	Break complex concepts or situations down into their component parts, and analyze how the parts are related to one another	Analyze, compare, separate, order, explain
Synthesis	Rearrange component parts to form a new whole	Combine, modify, rearrange, "what-if"
Evaluation	Evaluate or make judgments on the worth of a concept, object, etc.	Assess, decide, grade, recommend, explain, judge

[a] Holden, 2010. A QUICK REFERENCE GUIDE TO DEVELOPING COGNITIVE LEARNING OBJECTIVES: http://www.fgdla.us/uploads/a_quick_reference_guide_to_developing_cognitive_learning_objectives_fgdla.pdf.

Wade, 2008). In particular, two adaptation strategies are provided both at a micro- and a macro-level. Both strategies adapt the experience on the basis of changes that occur in learners' knowledge. These changes are identified by assessing learners' behaviors.

Micro-adaptation is based on a non-invasive assessment and exploits *branching logic* by using pedagogical indications coming from different educational theories and approaches (Mangione et al., 2011; Mangione et al., 2013).

This kind of adaptation occurs for each situation within the storytelling flow and affects the presentation of specific learning scenarios, events and roles in order to overcome some knowledge gap in the disaster education.

In particular, in SDM, according to the aforementioned educational theories, the following three levels (rules) of micro-adaptivity are considered:

- *Level A* is activated if the learner achieves a score between 50% and 75% of the admissible maximum score. In this case the same events (in the same situation) are re-lived by the learner with different media. This level is defined according to the idea that the most effective learning occurs when the learning activities match most closely the learners' preferred style (*Learning Style Theory*) (Leite, Svinicki, & Shi, 2010).
- *Level B* is activated if the learner achieves a score between 25% and 50% of the admissible maximum score. In this case the same events (in the same situation) are re-lived by the learner in a different scenario (context). This level is defined according to the *Situated Learning Theory* (Wall, & Leonard, 2011).
- *Level C* is activated if the learner achieves a score between 0% and 25% of the admissible maximum score. In this case the same events (in the same situation) are re-lived by the learner taking a new character with a new role in the story. This level is defined according to a novel approach based on the main concept of *Point of View Theory* in a story (Walsh, & Hoskisson, 2013), where a given narrative situation can be represented differently depending on the perspective of a specific character (with a specific role) taking part in that action.

The flow depicted in Fig. 2 allows to link the alternative routes to the level of knowledge achieved by a learner (and assessed through e-testing) in order to guide him/her to remedial paths, aiming at facilitating, supporting and motivating them to reach their learning objectives.

Along the new paths, the learners re-live for example the same situations from different viewpoints related to different roles, or re-live the situation using different media or in different context.

Furthermore, it is important to underline that each level of micro-adaptivity can be associated to a specific didactic feedback; it supports the learner to achieve learning goals correlating them to the knowledge transformational process in a story.

Macro-adaptation is referred to the capability of automatically adapting (modifying) the learning path (i.e. sequence of subjects to be learnt) according to specific needs expressed during the learning activities performance (e.g. assessment results). As described in details in the next sections, the SDM is utilized to build learning contents that are packaged in the so-called SCLOs (Storytelling Complex Learning Object) and sequenced by means of IWT (Intelligent Web Teacher).

IWT provides an ontology-based representation of the knowledge domain, together with learner's profiles, also keeping data about student's cognitive state and learning preferences. Thus, IWT is able to automatically generate learning paths (starting from one or more selected target concepts) and to select the best learning objects (according to the specific learner's profile) (Capuano et al., 2008).

Definitely, the above described adaptation strategies (macro and micro) provide an effective solution that combines the efficiency of the adaptive learning environments with the effectiveness of narration and guided learning, and integrates these aspects by means of a conceptual vision consisting of two levels of granularity: intra-SCLO (provided by an implementation of SDM) and inter-SCLO (provided by IWT).

2.3. How to use the model for creating the storytelling complex learning object in the risk education context

This paragraph describes the adoption of the SDM for creating an Amusement Park SCLO (Storytelling Complex Learning Object). In a SCLO, the narrative *script* is a logic composition of various situations, based on phases of a VSP (*Beginning, Call To Adventure, Problem, Middle Transformation, Solution, Closure*). A situation is a combination of circumstances at a given time and place in the story flow.

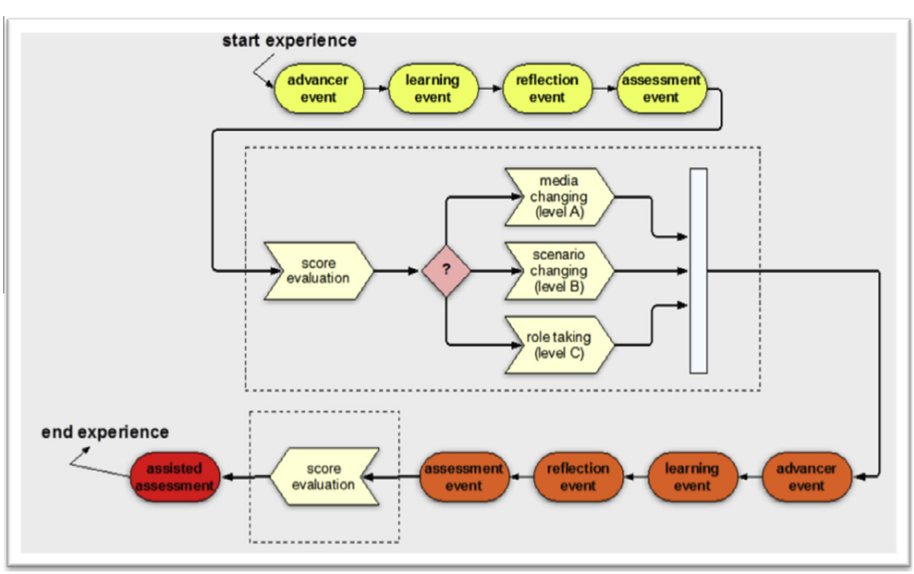

Fig. 2. Event flow and branching logic.

The *concept* of the Amusement Park SCLO is described having in mind the storytelling model. The concept is a description that aims at drawing the conceptual structure and content of the Amusement Park SCLO. It is focused on the park safety management for the purpose of releasing a full storyboard, which is relevant from the standpoint of educational activities and functional development of multimedia content. Specific reference is made to the management of seismic events in a complex structure (i.e. amusement park), intended as a critical infrastructure.

The didactic objectives will be measured basing on high school student targets. It is worth mentioning that the seismic event management in public complex structure is a very relevant topic in Italy due to the presence of several areas characterized by a high seismic risk.

In particular, it becomes a priority after tragic events like, to name a few, the Molise earthquake in October 2002 (mind you that in San Giuliano di Puglia 27 children died under the rubble of their collapsed school) and L'Aquila earthquake in April 2009.

The risk education experience has been integrated in physical science curricula and the didactic objective has been articulated in three sub-objectives:

- Physics of a complex and dynamic system, like the Roller Coaster ride, in ordinary conditions.
- Physics of a complex and dynamic system, like the Roller Coaster ride, in extraordinary situations connect to a seismic event.
- Definition and analysis of correct behavior and evacuation plans of high risk areas.

The case subject of our analysis is related to the occurrence of the previously cited natural event during a working week day, when school trips foresee visits to the amusement parks.

Every situation in the SCLO answers a specific didactic transformation path based on Bloom's taxonomy.

In order to check the transformation, each situation envisages some events that help reach specific targeted knowledge in distinct story phases.

Let us explain this aspect by means of an example and specifically showing how the *Beginner situation* of our model has been conceived for allowing the development of a *comprehension* type of knowledge according to the second level of Bloom's taxonomy.

As for the "*Beginner*" situation verbs connected to our objectives are: to describe, to associate, to categorize, to summarize, to list.

The situation has the aim to raise student's awareness on the key topic, namely an earthquake in the amusement park, providing basic information about the event and explaining further issues about open spaces in the Park.

The objectives of the beginning situation have been defined accordingly. They are:

- To identify key critical elements of the amusement park describing its main characteristics.
- To list the main characteristics of a Roller Coaster.
- To describe how the Roller Coaster works with respect to physic laws.
- To recognize what conditions may guarantee security of using the Roller Coaster during the seismic events.

In particular the *Advancer Event*, which providing information about the amusement park introduces the learner into the context. The learner is therefore provided with information like active graphical maps that describe the amusement park and its main areas (see Figs. 3–6).

The *Learning Event* describes in details the Roller Coaster attraction, that is how it works and what are the security laws for their regular use and under extraordinary conditions like earthquake events and other natural disasters.

Fig. 4 reports an example of learning event presented to the students under the shape of a multimedia content included into a personalized learning course created by the IWT platform.

In the *Reflection Event* the learner is provided with a summary (as synoptic tables) of the key concepts opportunely presented in order to facilitate their assimilation. These tables become the "*how to*" available for the learner to be recalled any time.

Lastly, with the *Assessment Event* we intend to measure the learner's ability to recognize (using either true–false or multiple choice questions), to recall (using the so called answer items or simple recall questions) and to sort (using numerical scale tests).

2.4. Assessment and facilitation strategy

In SDM, the assessment events support the branching logic mechanism in the story plot. The model allows to link alternative routes other than the level of knowledge achieved by a learner (and assessed through e-testing) in the perspective of conducting the latter to remedial paths, with the aim of help him/her get

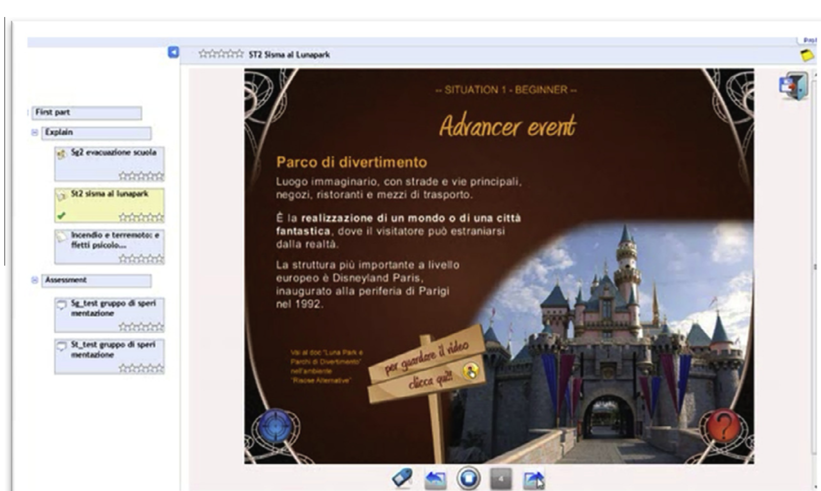

Fig. 3. The advancer event – explanation of the Roller Coaster.

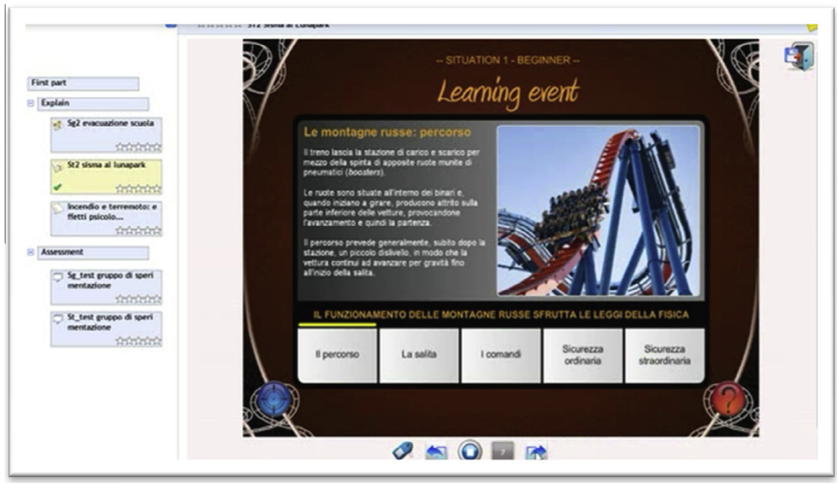

Fig. 4. The learning event – explanation of the Roller Coaster.

Fig. 5. The reflection event – explanation of the Roller Coaster.

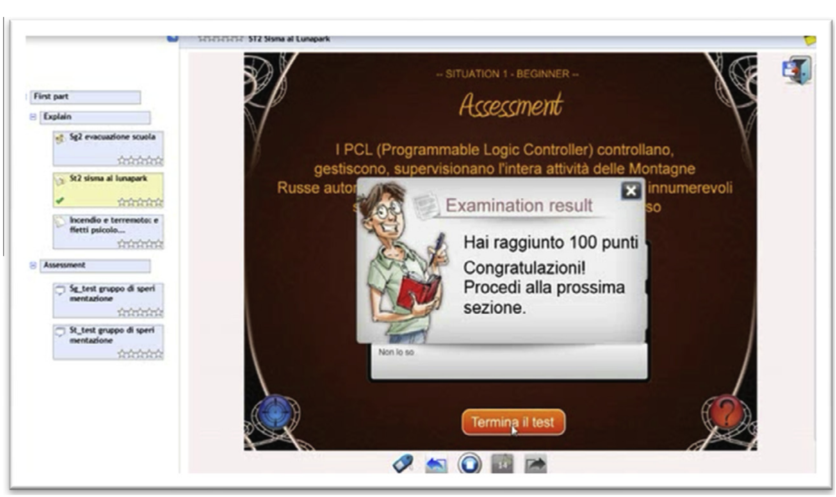

Fig. 6. The assessment event – explanation of the Roller Coaster.

motivated for the achievement of specific learning goals in an autonomous or collaborative way.

According to the three micro-adaptation types, the first iteration of Amusement Park SCLO only exploits role taking.

After having received an alternative narrative scenario, aimed at promoting the recovery of a specific learning goal, the student may still have difficulties and or may fail the assessment test linked to that situation, at this point he/she will view new modes to answer the questions again which are placed in the help bar.

In the first mode (*Simplified assessment-single mode*), a helper enters the scene. Actually, by clicking on a pedagogical agent (who can be specifically a classmate in Situation 1, a teacher in Situation 2, the emergency situation officer in Situation 3) enters the scene and "suggests" some answers. For example, he can facilitate the task by eliminating some of possibly wrong answers to a question (in case of multiple choice questions) or inserting key words in texts to be completed (in case of test completion or fill in the blank) or pointing out false answer in true/false questions, or even suggesting some correct matches (in case of matching questions). The goal is to make the test less difficult and to ensure students to pass the assessment.

The second mode (Simplified assessment-social mode) *allows* the user to exploit any support and help from peers. The collaborative mode of test resolution, provides the user with two other types of aid from the IWT classroom environment (these types of support are only suggested through representative icons in the course button bar) namely: searching and communicating through chats or in multiplayer mode with peers (students enrolled in his/her class) that are active and that can help him/her to pass the test.

If the previous icon is not accessible, the system searches for students who are enrolled in the portal but are not enrolled in the class. These users are also searched according to their expertise. They can enter the experience spontaneously and help out in the resolution of the test.

Definitely, SDM aims at filling lacks of the existing storytelling models by providing ways to empower the pedagogical drivers during the storytelling definition phase in order to connect storytelling situations and events and help achieve specific levels of educational objectives. The SDM, exploiting a branching logic to define remedial paths tailored to meet the learner's learning progress, supports an innovative way of applying concepts of adaptive learning in the narrative experience that gradually aims at supporting the development of student's metacognitive and regulative skills in emergency contexts (Mangione et al., 2013).

In addition some parameters about learner behaviors are here defined to measure attention and effort as well as elements which could be interesting for the tutor and the continuous scaffolding during the learning experience (Costagliola, De Rosa, Fuccella, Capuano & Ritrovato, 2010). This *implicit assessment* is based on the interpretation of learneŕs actions and interactions (behavioral indicators) within the educational environment and it is linked to Educational Data Mining (EDM) Romero, & Ventura, 2010 a new research trend in education.

Our focus is on the implementation of what can be called as a *Learnogram* (namely a graphic representation only available to teacher, a teacher's view detailed on some key parameters) an *experiential report* that will allow the teacher to visualize, besides standard flows, also additional behaviors that "communicate" important information on the way the student is approaching a didactic experience:

- *Between-patch processing*: this term refers to all the times the student quits the storytelling study session, but keeps moving within the didactic environment, and re-accesses the study session at a later time, starting from the point he/she had quitted the story before (having the system recorded his/her path status). This parameter could give the teacher a measure for the student's attention and motivation in attending the experience continuously (Costagliola, et al, 2010). From the calculation of specific parameters (e.g., the number of "entrances" and "exits" to/from the resource and the achieved learning level*)* it can be possible to award the student for the constancy he/she had or to ask him/her for a greater continuity providing tutor's help seeking. *Within-Patch processing:* this term refers to the student's involvement and sensitivity towards the course subjects (giving proper value to things to be learnt). In fact, indications like: the number of times the student visits a specific "event" rather than others, if he/she takes deepening resources opportunely created inside each situation, or if he/she shows taking time in line with the average time needed for the learning, estimated by the teacher in the design phase, can accurately measure both student's attention and activity.
- *Receiver type*: this indicator and Set of Behavioral Indicators (e.g. Time of permanence on a scene with predominant media, exploration levels and so on) allows to detect the user' style (*auditory receiver, visual receiver or kinaesthetic receiver*) and the most suitable media-mix that micro-adaptivity must have. As for a visual style (visual-linguistic or visual-spatial) it will be advisable to re-address to alternative situations in which the media-mix is more prevailing into the visual side (images, texts, videos), while for an auditory style it will be better to re-address the path to situations with prevailing spoken texts, reading aloud activities done by the student, podcasts, and finally, for more kinaesthetic styles it is better to rely on structures that present a demand for student's active actions so to keep high his/her's concentration and interest.
- *Strategies utilized to perform the tests*: a fourth traceable element to implicitly assess the student is concerned with the understanding of "strategies" that the student applies (e.g., single phase, active revising, or passive revising in Costagliola, and Fuccella (2009)) to face moments of intermediate assessment (that is, moments included into assessment events of the six situations).

As illustrated later on, the research has shown an appraisal with respect to the model didactic structure, and therefore, also about the integration of aided/facilitated assessment with implicit assessment for achieving knowledge goals associated with storytelling. Currently, the parameters linked to the assessment are manually retrieved by the teacher during the experience, but in the future this will be done through a set of algorithms of datamining able to make data gathering and visualization automatic by means of a defined teacher dashboard.

3. SCLO authoring and playing tools

The authoring tool is essentially composed of two components, that is an editor and a player. The solution adopted to create the Storytelling Editor exploits Microsoft Workflow Foundation (WF) Framework v3.5. A workflow designer is a good and flexible solution, in fact it has allowed us to define the story's backbone, to arrange and set up the didactic activities that can be alternated during different situations and events, and to bind the story logic inside the activities flow in a natural way, reducing the amount of codes to be written.

We have created our application starting from the Microsoft Workflow Designer, hosting its environment into a desktop application. Even though we reserve in the future the possibility to make it web-based, this solution has permitted us to conveniently face our needs.

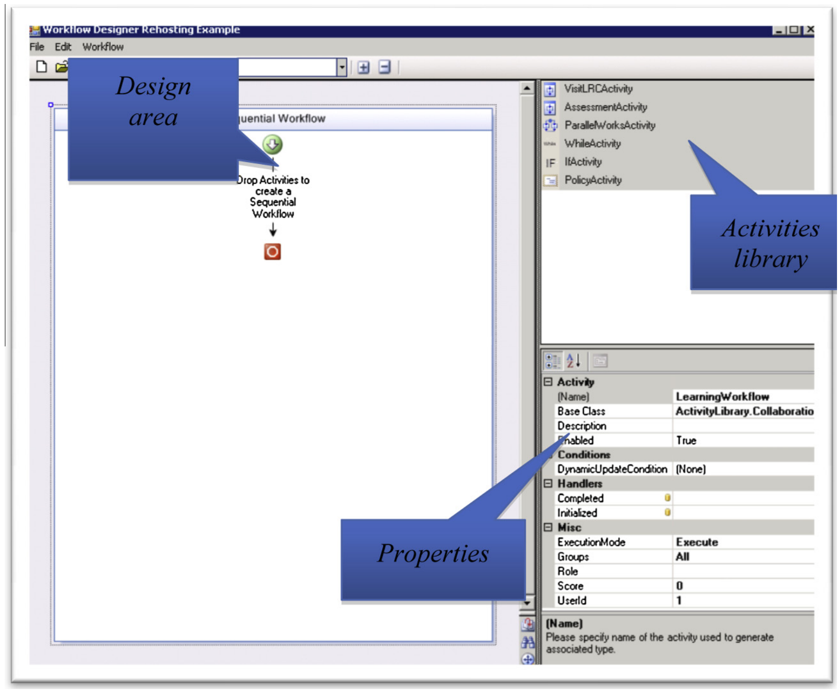

Fig. 7. The editor tool.

The development works have also regarded the implementation of custom workflow activities[5] that allow to run the story scenes (situation events) and in particular to configure and view the scene content (*contlets*), such as audio, video, media content, flash object, etc., inside html pages. Each story scene is then a single workflow activity, that shows to the users the scene content and allows an interaction with them.

The creation of a SCLO (in practical terms) is carried out in two steps:

1. *Story design* – To create the skeleton of the story (i.e. event flow design).
2. *Activities configuration* – To set the appropriate contlets to be visualized inside the scenes (i.e. storyboard design).

The output produced by the editor after these two phases, is an XML file that declaratively represents the entire story structure, all the activities configuration parameters and the condition rules that constitute the flow logic. This file, together with other optional files (e.g. a code file containing the business logics for the activities) must be compiled before being executable. The compilation can be done directly in the editor, but also by the player at a later time, due to the fact that the XML content can be slightly modified (also in the player) in order to refine the activities configuration.

The editor tool presents three main areas, besides Menu and Toolbar areas as described in Fig. 7. The Design area is on the left, here the activities can be dropped and composed together in order to create the story structure. On the top-right there is the Activities library, where all the available activities can be found, here it is possible to drag the activities and drop in the Design area. The activities available for the design of storytelling objects are:

- *VisitLRCActivity* – where LRC stands for Learning Resource Content. This activity allows to configure and see scene content.
- *AssessmentActivity* – this activity allows to configure and execute an assessment scene.
- *ParallelWorksActivity* – allows to execute in parallel two branches of activities.
- *WhileActivity* – allows to create a conditioned cycle (that simulates the while statement) in the activities flow.
- *IfActivity* – allows to create two or more conditioned branches (that simulate the if statement) in the activities flow.
- *PolicyActivity* – allows to apply a policy in a given point of the flow, i.e. to execute some code when a condition is reached.

On the bottom-right we can see the Properties area where the activities parameters can be configured.

The story design is just a matter of composing activities together, dragging and dropping the items from the Activities library area to the Design area.

In Fig. 8 a sample structure has been designed, there, an *IfActivity* with two branches has been used, and, inside each branch, a different activity (*VisitLRC* and *Assessment*) has been dropped. Another aspect useful to note in the figure is the Properties area: each time an activity is selected in the design area, the configuration parameters of that activity is shown in the Properties area.

Once the design of the story is complete, it is possible to save it, clicking on Save As in the File menu toolbar. Three files will be created after saving: a .xml that is the xml representing the story, a *.cs* that may contain some code useful for the editor and a *.rules* file containing rules and conditions configured during the editing. All these files are required to create the Storytelling object as shown in the next section.

3.1. How the editor works and manages micro-adaptivity flows

Fig. 9 shows both the storytelling structure and details of one specific situation, namely the solution as it is represented within the editor.

[5] http://msdn.microsoft.com/en-us/magazine/cc163504.aspx.

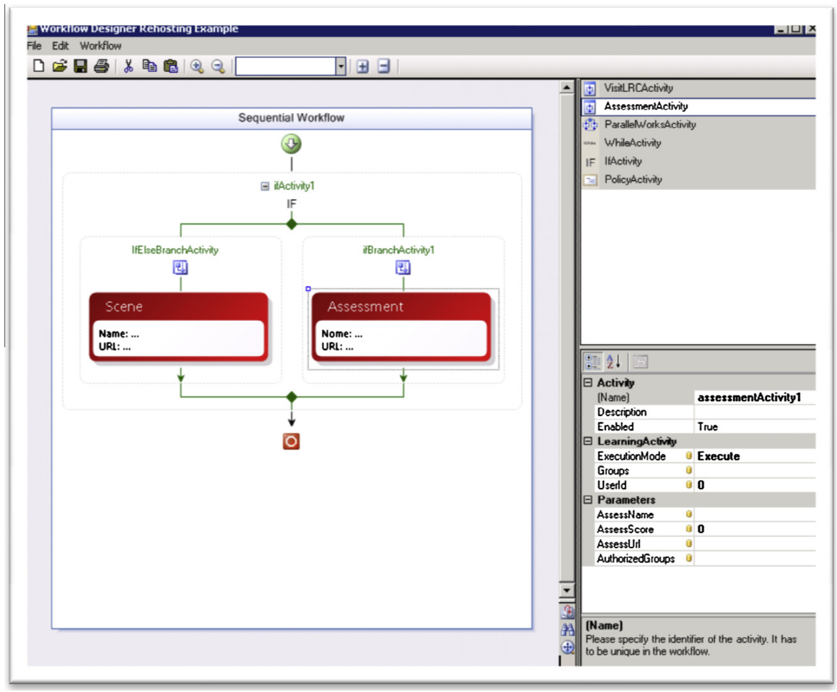

Fig. 8. Sample structure of a story.

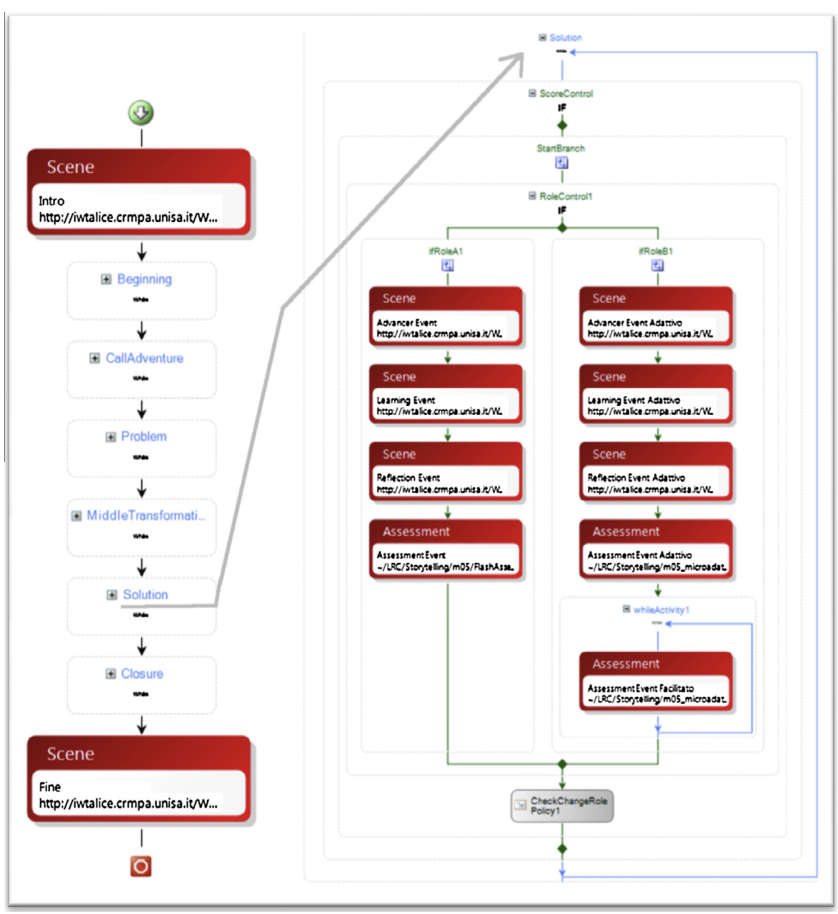

Fig. 9. Example of storytelling structure (left) and details of the “solution” situation (right).

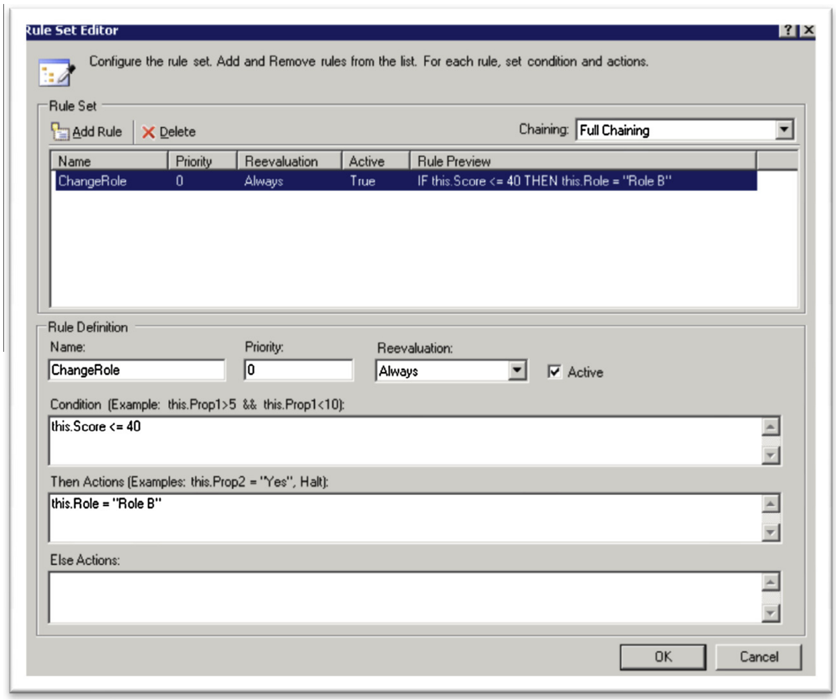

Fig. 10. Rule editor: change role policy configuration.

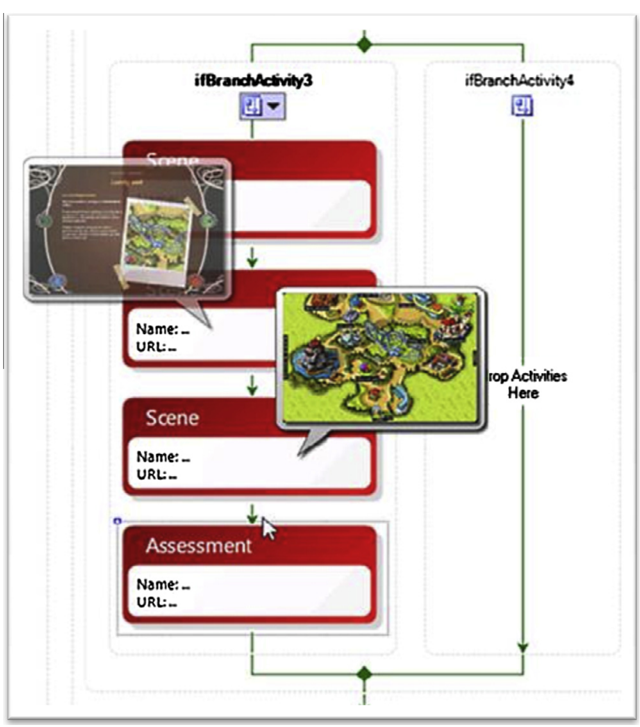

Fig. 11. Linking contents to scene.

In particular, the left side of the picture shows the representation of the story elements: an *Intro* scene, the *Beginning* situation, the *Call to Adventure* situation, the *Problem* situation, the *Middle Transformation* situation, the *Solution* situation, the *Closure* situation and a *closure* scene.

The main activity of the situation is a *While* containing all other activities. The *While* construct checks out in every cycle of the user's assessment score, if the score overcomes a threshold, the flow proceeds towards the next situation (in this case the *Closure* situation), otherwise the cycle is restarted. The instructional design for the Storytelling Complex Learning Object aims at developing narrative learning experiences that promote and support learners' knowledge or skill acquisition. These learning experiences include assessment activities able to redirect the story in different and appropriate situations, provide some feedback, and use emotional state in order to understand the best point of view etc. Micro-adaptivity happens within the storytelling flows: affecting the presentation of a specific scenario, situation and role. Rules referred to different branches, manage adaptive scenarios presentation and adaptive story navigation supporting role taking and collaborative help.

Inside the *While*, there is an *IfActivity* named *RoleControl* that checks the *Role* variable; in fact, after an assessment, if the result is too low (between 0% and 40%) the user role must be changed, starting a micro-adaptivity in the story flow. The *Role* variable is changed through the *Policy* activity (*CheckChangeRolePolicy1*), whose configuration is reported in Fig. 10 (Mangione et al., 2012).

Taking into account the *Role* variable, one of the two branches in the *RoleControl1* activity is followed. Each branch is composed of a sequence of three *Scene* activities and one *Assessment* activity (that correspond to the *Advancer*, *Learning*, *Reflection* and *Assessment* events of the storytelling model).

Finally, at the end of the *ifRoleB1* branch, there is a second Assessment activity, foreseen in order to propose a facilitated assessment in case of failure of the first assessment during the micro-adaptivity.

The teacher goes on in preparing the narrative story embedding contents, in our case html files, containing multimedia content and flash animations (as shown in Fig. 11) within the Scene activities and a particular testing object within each Assessment activity.

4. SCLO player and integration with the IWT Platform

The following sections introduce the advanced features (from a functional and architectural point of view) of the Intelligent Web

Teacher e-learning platform, and shows how the student can access and interact with the created SCLO.

As already mentioned in the section about the description of our model, IWT plays a relevant role. It is the enabling technology for supporting the macro-adaptation in terms of learning experience personalization, according to learner's cognitive state and their didactic preferences. None of the learning platform available in the market presents the same capabilities as those provided by IWT. Moreover, the integration with the IWT platform allows us to make a full experimentation creating a learning path, where some of the contents include the SCLO, and validating the effectiveness from the learning point of view (learning goals achievement, competence development, etc.).

4.1. The IWT platform

IWT aims at covering the lack of support, in terms of flexibility and extensibility, that existing e-learning systems show to have. IWT arises from the consideration that every learning/training context requires its own specific solution. It is not realistic to use the same application for teaching, for instance, foreign languages at primary schools, mathematics at university and marketing management to enterprise employees. It should be not only the content to vary but also the Didactic Model, the type of training modules to be used, the application layout and, over all, the connected tools. IWT solves this problem with a modular and extensible solution, to become the foundation for building up a virtually infinite set of applications for traditional and innovative e-learning. IWT is able to deliver, to the students, personalized courses (Albano et al., 2007) which take into account their previous knowledge (in that it does not repeat/submit explanations about already known topics) and their preferences, allowing each student to learn the course subject-matters through types of didactic material (video, audio, simulations, texts...) that are most appropriate to his/her characteristics (profile). The key elements of the personalization process are sketched in Fig. 12. The teacher will simply select the learning objectives (target concept) of the course he/she intends to publish and IWT will automatically prepare a personalized course for each student enrolled in course. IWT guarantees this feature through the adoption of three models: the Knowledge Model, the Learner Model and the Didactic Model.

The Knowledge Model (KM – the graph in Fig. 12) is able to represent in a machine understandable way the information associated with the available didactic material. In particular, the KM allows the experts to define and structure disciplinary domains, by constructing domain dictionaries (relevant concepts), and constructing ontology (represented with OWL) on such dictionaries. The ontology used in synergy with metadata associated with the learning contents, allows for the definition of the learning path and the automatic selection of the most suitable learning objects according to the learner profile as described in Gaeta, Orciuoli, and Ritrovato (2009).

The IWT Learner Model stores the knowledge the student acquires during the learning activities and the learning preferences shown (considered as cognitive abilities and perceptive capabilities) with respect to important pedagogical parameters such as: media, didactic approach, interaction level, and semantic density.

The Didactic Model defines the approach to be followed by the students to acquire the domain knowledge, according to subject-matters (formalized with the Knowledge Model) and learning characteristics of the involved learner (learning styles). This feature will be used in order to guarantee macro-adaptivity in SCLO after the summative assessment.

Extensibility, personalization of content and aggregation modalities: IWTimplements a paradigm based on a pattern adapter which allows to use any kind of Learning Object (LO) after the definition of a suitable module named Driver, which manages LO creation, delivery (enabling the use of different rendering and devices technologies) and possible feedback in a transparent way, both for user and for other modules running on the platform (Capuano et al., 2008). Apart from the considerable set of pre-defined Drivers already available in the system, IWT provides the specifications (API) in order to allow the creation of new ones. This makes it possible to extend the platform for the management of whatever type of Learning resource (reference is made to simulation, interactive exercises, virtual experiment, etc.). We have created a SCLO Driver so that IWT can play the content and is aware of what is likely to happen when the learner interacts with the SCLO (micro-adaptation) and updates the learner profile accordingly.

5. Experimentation results

In the context of the ALICE project, where methodology and tool have been developed, specific SCLOs have been created and experimented. This section reports the results of experimentations car-

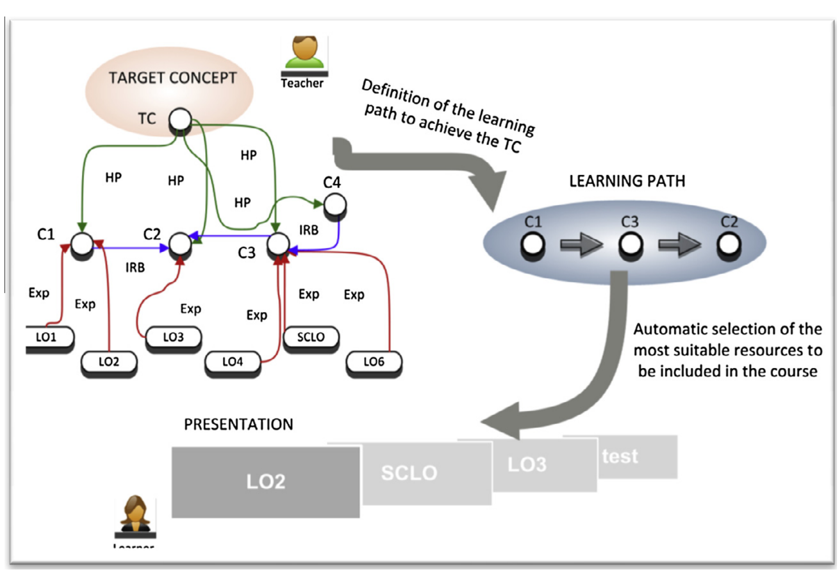

Fig. 12. IWT: personalized e-learning experience generation process.

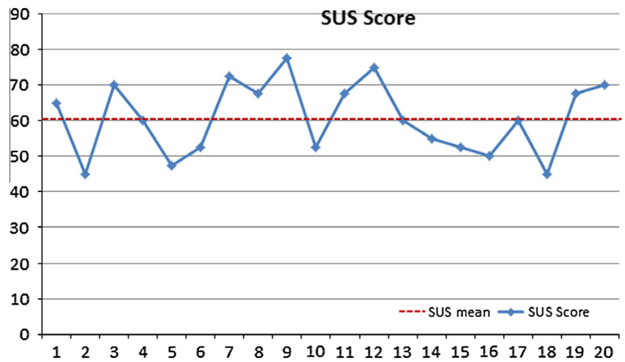

Fig. 13. Authoring tool SUS questionnaire results.

ried out for evaluating both usability of the authoring tool and effectiveness of the produced SCLO (amusement park).

The usability of the authoring tool has been evaluated using a traditional approach, based on the SUS (System Usability Scale) questionnaire, involving 20 students in the last year of the degree course in Computer Science Foundation (Fondamenti di Informatica) at the Faculty of Educational Sciences (Scienze della Formazione) at the University of Salerno. The effectiveness of the SCLO (including storytelling content and player) has been evaluated involving two Italian secondary schools.

5.1. Usability of the authoring tool

The evaluation of the storytelling authoring tool usability was conducted through a 3-h workshop, arranged during the above mentioned course. The workshop presented key concepts of the proposed methodology and demonstrated the authoring tool. The 20 students selected (all female) were requested to use the tool to create simple storytelling with some branches and micro-adaptation flows for a week timeframe. After that, they were submitted, all together, the SUS questionnaire (Finstad, 2010) with the traditional 10 questions being measured basing on the 5-point Likert scale. The results are summarized in the following picture (see Fig. 13).

The SUS mean score is 60.625. The minimum score is 45 (achieved 2 times) the maximum score is 77.5. It is worth mentioning that due to the specimen nature (students that play the role of content creators) some questions (like Q1 "I would use this tool regularly" and Q7 "I think other would find the tool easy to use") show a predominance of score 3 of the Likert scale (Neither/Nor) and there are very few 1's (Strongly Disagree) and 5's (Strongly Agree) on the even and odd questions respectively. Considering the information provided to the students, it is clear that the tool requires to be improved even though it is a research prototype, and for this reason the results can be considered satisfactory (it is close to the satisfactory score threshold of 68).

5.2. Evaluation of the SCLO effectiveness

Two secondary schools have taken part into the experimentation.

In the first school called "E. Striano", the course was composed of 14 students: all male and 16 years old (on average). In the second school called "Pitagora" the course was composed of 28 students: 26 female (98%), 2 male (2%) with an average of 14 years old participants. Each class was supervised by two tutors. Within each class the students were divided in two groups: experimental and control, in order to make a comparative analysis of the effectiveness of the SCLO.

For the aim of the paper, the following part reports the experimentation and evaluation results from the Pitagora School. We have selected this school because the number of participants is twice the size of the other school yet the results are in any case comparable with the other school.

5.2.1. Effectiveness from the methodological point of view

We asked the experimental group to interact with the storytelling learning object. Students under the supervision of the tutors spent 2 days playing with the environment. Upon session completion they filled a Post-Questionnaire, which included the following sections: demographic data, storytelling learning object activity, usability of the storytelling environment, and further comments or suggestions.

With reference to the section "Storytelling Learning Object Activity", the students were asked to express their assessment answering to questions concerning:

Effectiveness of the methodology

- Does the combination between exploration and guide of the storytelling resource allow you to maintain a good level of motivation?
- Could you measure out the autonomous navigation and exploration of the different paths?
- You have explored different didactic situations characterized by a sequence of 4 educational events. In your opinion, does the sequence allow you to turn your attention to the problem, to encourage the discussion, etc.?
- Does the reflection events allow you to reflect on what you have acquired?
- Are the advancer events useful for resolving the problems?

Validation of the storytelling resource wrt the knowledge objectives

- Does the explorative logic that characterizes the storytelling allow you to capture different types of knowledge to put into practice in an emergency situation?
- Have the recovery paths guided you or have been useful in order to recover any gaps?
- Has the storytelling structure allowed you to understand the different expected results and their importance?

Originality and innovation in the educational structure

- What do you think about the mix of linear and alternative paths?
- Has the ability to repeat a learning path through different viewpoints got involved you?

Storytelling interface

- Does the storytelling have a user friendly interface?
- Could you browse and operate with the educational content at various levels of detail?
- How well have you interacted with the story?
- Has the visual quality of the experience contents helped you to get a higher awareness of the task and tests to overcome?

The answer categories in this section are based on a 7-point likert scale.

With regard to a quantitative/statistical analysis we made use of basic statistics, such as Mean (M), Standard Deviation (SD) and median (Md). The results are summarized in Fig. 14.

As Fig. 14 shows, the achieved results are quite satisfactory. Indeed, the mean for the evaluated aspects is above 5 on a 7 points scale with a standard deviation ranging from 0.90 to 1.23. In partic-

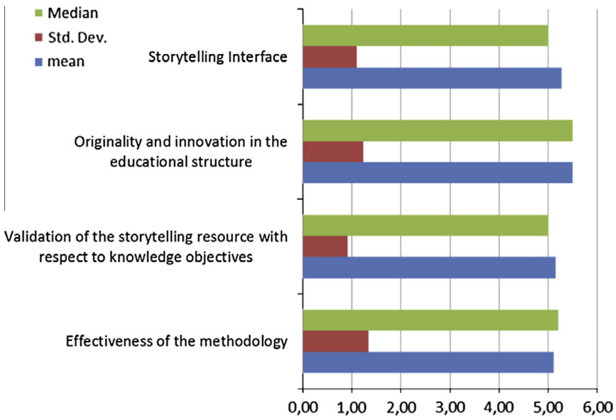

Fig. 14. Overview of quantitative analysis for questions concerning storytelling learning object activity (Pitagora school).

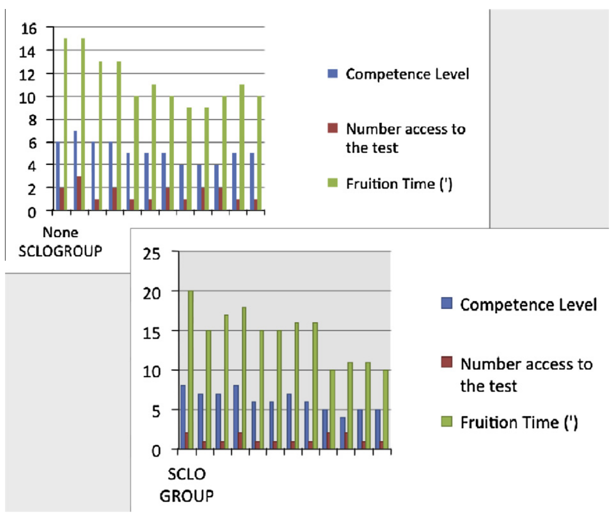

Fig. 15. Analysis of comparative results for the Pitagora school.

ular analyzing the answers received in the second activity (originality and innovation of the educational structure) the students found the educational structure of the storytelling learning object to be particularly interesting and innovative. The developed SCLO provided students with the opportunity to experiment the micro-adaptivity related to the role change, which gave them the possibility to see the story from other viewpoints. That allowed them to better understand techniques and evacuation procedures. This consideration is also confirmed by the answers provided for the first question (explorative logic) of the validation of storytelling resource aspect with a mean value of 5.8 and standard deviation of 1.2. Another interesting result concerned with question 2 of the effectiveness of the methodology. Students found the different paths within the SCLO very easy to explore (mean of the answer 5.7 and std dev below 1).

As for what concerns section "usability of the storytelling environment" (player and SCLO content) in the Post-Questionnaire, the student were given a SUS questionnaire, as for the authoring tool. The average SUS score is 64.125. This is also in line with the score achieved by questions concerned with the Storytelling interface mentioned above.

5.2.2. Effectiveness from the learning point of view

Below an overall evaluation is reported, concerning the effectiveness of the proposed methodology and related content from the learning point of view. When all groups completed the delivery of learning resources, each member of a group took an assessment test to verify the knowledge acquired by the storytelling for the *SCLOgroup* and by a passive learning resource for the none *SCLO-group* (see Fig. 15).

The majority of students of the SCLO Groups obtained good levels of competences (from 6 to 8 out of 10 as a maximum score) while the competence range for the control groups was (Avgeriou et al., 2003; Banaszewski, 2002; Barnes et al., 2007). Another important aspect to be taken into account is a high competence level, achieved with a very low number of accesses to the test (often a unique access) compared to the None SCLO Group. This demonstrates the SCLO is a comprehensive and effective resource compared to the traditional expositive Learning Objects used in the None SCLO Group. The demonstration about the high engagement of the students is provided by the longer execution time recorded for the SCLO group. In addition, particularly anxious students (in the ALICE project the emotional aspects are also measured (Mangione et al., 2012) showed greater concentration especially in front of more animated and involving situations, and passed the different tests more easily than others, completing the whole path faster. Moreover, it is worth mentioning that on average the SCLO group of students had accessed at least 4 times the story.

The *none SCLOgroup* was provided, in parallel with the *SCLO group*, with a learning path of passive learning resources (IEEE LOM Learning resource type: slides) using IWT. Nevertheless, the tutors reported a low students' engagement. This was confirmed by the IWT log data analysis about mean LOs execution time with very low values precisely indicating the low students' engagement. Consequently, the final test was executed more times than the number of times it had been executed by the SCLO Group (some students passed the test by the *trial and error approach*). Therefore, these results seem to confirm the fact that there is a gap between the way young people prefer learning and the old ways of teaching.

6. Conclusions

In this paper a model and an authoring tool for designing and implementing pedagogy driven storytelling resources useful to guarantee the achievement of specific learning objectives have been presented. The proposed Storytelling Design Model and the authoring tool (encompassing the story flow/event editor and the player) aim at covering the lacks of existing solutions in terms of effectiveness for learning and training scenarios, considering pedagogical aspects, and at facilitating the integration in the e-learning platform allowing users (like teacher) with a moderate ICT skill to create contents, assemble and reuse them in different contexts. Through the integration of both model and tool in the e-learning platform (IWT is already available in the market) a first experimentation involving two Italian high schools has been executed in the context of the ALICE European project. The achieved results are encouraging and demonstrate the effectiveness of the model and tool from the learning point of view.

The most relevant future works that will be carried out in the frame of the ALICE project, concern, other than the improvement of the authoring tool usability, with the integration of a new model for capturing and managing the emotional aspects during the execution of a SCLO and the evolution of metadata schema in order to increase macro and micro-adaptivity. As for the emotional aspect, the methodology and related algorithms will be integrated within a SCLO for capturing the learner's emotions during the learning process and using these pieces of information for micro-adaptivity within the SCLO. The work related to the metadata aims at extending and revising the IEEE LOM (Learning Object Metadata) in order to better represent the pedagogical aspects presented in the SCLO, also including motivational aspects. It is worth mentioning that metadata play an important role in IWT with respect to the automatic generation of learning paths (the so-called personalized learning courses), a better covering of these aspects will increase the macro-adaptivity, also facilitating the reuse of the SCLO.

Acknowledgements

The research reported in this paper is partially supported by the European Commission under the Collaborative Project ALICE "Adaptive Learning via an Intuitive, interactive, Collaborative, Emotional system", VII Framework Program, Theme ICT-2009.4.2, Grant Agreement no. 257639.

References

Albano, G., Gaeta, M., & Ritrovato, P. (2007). IWT: an innovative solution for AGS e-learning model. *International Journal of Knowledge and Learning, 3*(2/3), 209–224.

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A pattern language*. Oxford University Press.

ALICE. (2010), *Adaptive learning via an intuitive, interactive, collaborative, emotional system*. web site: <http://www.aliceproject.org>.

Avgeriou, P., Papasalouros, A., Retalis, S., & Skordalakis, M. (2003). Towards a pattern language for learning management systems. *Educational Technology & Society, 6*(2), 11–24.

Banaszewski, M. T. (2002). Digital storytelling finds its place in the classroom. *Multimedia Schools, 9*(1), 32–35. Ja/F 2002.

Barnes, K., Marateo, R., & Ferris, S. (2007). Teaching and learning with the net generation. *Innovate, 3*(4). Available at http://www.innovateonline.info/.

Berk, R. A. (2009). Teaching strategies for the net generation. *Transformative Dialogues: Teaching & Learning Journal, 3*(2), 1–23.

Black, A., & Gen, Y. (2010). Who they are and how they learn. *Educational Horizons, 88*(2), 92–101.

Bloom, B. S., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: the classification of educational goals, by a committee of college and university examiners, handbook I: cognitive domain*. NY: Longmans, Green.

Bruner, J.S. (2002). *Making stories: Law, literature, life*. Harvard University Press.

Campbell J. (2008). *The hero with a thousand faces* (3rd ed.). New Word Library. ISBN 978-1577315933.

Cao, Y., Klamma, R., & Martini, A. (2008). Collaborative storytelling in the Web 2.0. In R. Klamma, N. Sharda, B. Fernández-Manjón, H. Kosch, M. Spaniol (Eds.), *Proceedings of the First International Workshop on Story-Telling and Educational Games (STEG'08)*, September 16, 2008, Maastricht, The Netherlands. CEUR-WS.org.

Cao, Y., Hnnemann, A., Klamma, R., Kovachev, D., & Renzel. D. (2010). Mobile multimedia management for community-aware storytelling. In *Proceedings of the 11th International Conference on Mobile Data Management (MDM 2010)* (pp. 59–64), Kansas City, Missouri, May 23–26, 2010 IEEE.

Cao, Y., Klamma, R., & Jarke, M. (2011). The hero's journey – Template-based storytelling for ubiquitous multimedia management. *Journal of Multimedia, 6*(2), 156–169.

Capuano, N., Gaeta, M., Marengo, A., Miranda, S., Orciuoli, F., & Ritrovato, P. (2008). LIA: An intelligent advisor for e-learning. *Interactive Learning Environments, Taylor & Francis, 3*(17), 221–239.

Cardona, O. (2004). D: Curriculum adaptation and disaster prevention in Colombia. In J. P. Stoltman, J. Lidstone, & L. M. Dechano (Eds.), *International Perspectives on Natural Disasters: Occurrence, Mitigation, and Consequences*. Dordrecht: Kluwer academic publisher.

Costagliola, G., De Rosa, M., Fuccella, V., Capuano, N., & Ritrovato, P. (2010). A novel approach for attention management in e-learning systems. In *The Proceeding of the 16th International Conference on Distributed Multimedia Systems* (pp. 222–227), Chicago, October 14–16, 2010.

Costagliola, G., & Fuccella, V. (2009). Online testing, current issues and future trends. *Journal of e-Learning and Knowledge Society, 5*(3) (English Version).

Delgado-Mata, C., Velazquez, R., Pooley, R.J., Aylett, R., & Robertson, J. (2010). MPISTE: A mobile, personalised, interactive story telling environment, In *Proceeding of Electronics, Robotics and Automotive Mechanics Conference (CERMA), IEEE* (pp. 243–248).

Dettori, G., Giannetti, T., Paiva, A., & Vaz, A. (Eds.). (2006). *Technology-mediated narrative environments for learning*. Sense Publishers.

Dillingham, B. (2001). *Visual portrait in a story: Teaching storytelling*. Juneau, AK: School Handout.

Donikian, S., & Portugal, J.N. (2004) Writing interactive fiction scenario with DraMachina. In *The Proceedings of the Technologies for Interactive Digital Storytelling and Entertainment: Second International Conference* (pp. 101–112), Darmstadt, Germany, 2004. Springer Berlin/Heidelberg.

Finnis, K., Standring, S., Johnston, D., & Ronan, K. (2004). Children's understanding of natural hazards in Christchurch, New Zealand. *The Australian Journal of Emergency Management, 19*(2), 11–20.

Finstad, K. (2010). The usability metric for user experience. *Interacting with Computers, 22*(5), 323–327.

Franz, K., & Nischelwitzer, A. K. (2004). Adaptive digital storytelling: a concept for narrative structures and digital storytelling build on basic storytelling principles, adaptive story schemas and structure mapping techniques. In L. Zimmermann (Ed.), *Multimedia Applications in Education Conference (MApEC) Proceedings* (pp. 28–33), Graz.

Gaeta, M, Orciuoli, F., & Ritrovato, P. (2009). Advanced ontology management system for personalised e-learning. *Journal of Knowledge-Based Systems 22(4)*, 292–301.

Göbel, S., de Carvalho Rodrigues, A., Mehm, F., & Steinmetz, R. (2009). Narrative game-based learning objects for story-based digital educational games. *Narrative, 14*, 16.

Gobel, S., Becker, F., & Feix, A. (2005). Inscape: Storymodels for interactive storytelling and edutainment applications. In G. Subsol (Ed.), *Virtual Storytelling: Using Virtual Reality Technologies for Storytelling: Proceedings of Third International Conference, ICVS 2005* (pp. 168–171), Strasbourg, France, November 30–December 2, 2005, LNCS 3805, Springer.

Göbel, S., Salvatore, L., & Konrad, R. (2008). StoryTec: a digital storytelling platform for the authoring and experiencing of interactive and non-linear stories. In U. Spierling & N. Szilas (Eds.), *2008 International Conference on Automated Solutions for Cross Media Content and MultiChannel Distribution*, vol. 5334 (pp. 103–110).

Goodyear, P. (2005). Educational design and networked learning: Patterns, pattern language and design practice. *Australasian Journal of Education Technology, 21*(1), 82–101.

Govindasamy, T. (2002). Successful implementation of e-learning pedagogical considerations. *Internet and Higher Education, 4*, 287–299.

Herman, D. (2007). Storytelling and the sciences of mind: Cognitive narratology, discursive psychology, and narratives in face-to-face interaction. *Narrative, 15*(3), 306–334.

Jenkins, H. (2010). Transmedia storytelling and entertainment: An annotated syllabus. *Continuum: Journal of Media & Cultural Studies,, 24*(6), 943–958.

Kuhlicke, C., Luther, J., McCarthy, S., Tapsell, S., Dinarès, M., Fernandez, A. S., & Miloševič, M. V. (2010). Risk education and natural hazards. Cap-haz-Net FP7 Project report Available at <http://caphaz-net.org/outcomes-results/CapHaz-Net_WP6_Risk-Education2.pdf>.

Leite, W. L., Svinicki, M., & Shi, Y. (2010). Attempted validation of the scores of the VARK: Learning styles inventory with multitrait–multimethod confirmatory factor analysis models. *Educational and Psychological Measurement, 70*(2), 323–339.

Lieblich, A., Tuval-Mashiach, R., & Zilber, T. (1998). *Narrative research: Reading, analysis, and interpretation* (Vol. 47). SAGE Publications.

Malone, T., & Lepper, M. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. In Snow, R., & Farr, M. (Eds.), *Aptitude, learning, and instruction: III. Cognitive and affective process analyses* (pp. 223–253). Erlbaum, Hillsdale, NJ.

Mangione, G. R., Capuano, N., Orciuoli, F., & Ritrovato, P. (2013). Disaster education: A narrative-based approach to support learning, motivation and students' engagement. *Journal of e-Learning and Knowledge Society, 9*(2), 133–156.

Mangione, G.R., Orciuoli, F., Pierri, A., Ritrovato, P. & Rosciano, M. (2011). A new model for storytelling complex learning objects. In *The proceedings of International Workshop on Adaptive Learning via Interactive, Collaborative and Emotional Approaches, in conjunction with 3d IEEE Third IEEE International Conference on Intelligent Networking and Collaborative Systems* (pp. 836–841), November 30–December 1, 2011, Fukuoka (Japan).

Mangione, G. R., Pierri, A., & Iovane, G. (2012). Using Emotions to Improve Role Taking in Storytelling Complex Learning Objects. In *The IEEE Sixth International Conference on Complex, Intelligent and Software Intensive Systems (CISIS)* (pp. 893–898).

Mc Drury, J. & Alterio, M. (2003). *Learning through Storytelling in Higher Education*, Kogan Page, London.

Medler, B., & Magerko, B. Scribe: a general tool for authoring interactive drama. In *Third International Conference on Technologies for Interactive Digital Storytelling and Entertainment* (pp. 139–150). Darmstadt, Germany.

Merabti, M., Rhalibi, A. E., Shen, Y, Daniel, J., Melendez, A., & Price, M. (2008). Interactive storytelling: Approaches and techniques to achieve dynamic stories. *T. Edutainment* 1, 118–134.

Ohler, J. (2008). *Digital storytelling in the classroom*, Corwin Press.

Peinado, F., & Gervás, P. (2004). Transferring game mastering laws to interactive digital storytelling. In *2nd International Conference on Technologies for Interactive Digital Storytelling and Entertainment (TIDSE 2004)* (pp. 1–12).

Peirce, N., Conlan, O., & Wade, V. (2008). Adaptive educational games: providing non-invasive personalised learning experiences. In *Digital Games and Intelligent Toys Based Education* (pp. 28–35).

Phillips, M. A., & Huntley, C. (2001). *Dramatica – A new theory of story* (4th ed.). Screenplay Systems Inc.

Prensky, M. (2006). Listen to the natives. *Educational Leadership, 63*(4), 8–13.

Propp, V. (1958). Morphology of the folktale. *International Journal of American Linguistics* 24(4, Part II).

Robbins, R. (2012). Stories of risk and protection: a turn to the narrative in social policy education. *Social Work Education (ahead-of-print)*, 1–17.

Romero, C., & Ventura, S. (2010). Educational data mining: a review of the state of the art. *Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on, 40*(6), 601–618.

Selby, D., & Kagawa, F. (2012). *Disaster risk reduction in school curricula: case studies from thirty countries*. Paris/UNICEF Geneva: UNESCO, p. 207.

Shaw, R., Kobayashi, K. S. H., & Kobayashi, M. (2004). Linking experience, education, perception and earthquake preparedness. *Disaster Prevention and Management, 13*(1), 39–49.

Soffer, Y., Goldberg, A., Avisar-Shohat, G., Cohen, R., & Bar-Dayan, Y. (2010). The effect of different educational interventions on schoolchildren's knowledge of earthquake protective behaviour in Israel. *Disasters, 34*(1), 205–213.

Spaniol, M., Klamma, R., Sharda, N., & Jarke, M. (2006) Web-based learning with non-linear multimedia stories. In Wenyin Liu, Qing Li, & Rynson W.H. Lau (Eds.), *Proceedings of the 5th international conference on Advances in Web Based Learning (ICWL'06)* (pp. 249–263). Springer-Verlag, Berlin, Heidelberg.

Terpstra, T. (2009). *Flood preparedness – thoughts, feelings and intentions of the Dutch public*. The Hague: Albani drukkers.

Thompson, P. (2013). *The digital natives as learners: Technology use patterns and approaches to learning*. Computers & Education.

Van Velsen, M. (2008). Narratoria, an authoring suite for digital interactive narrative. In *Proceedings of the FLorida AI Resarch Society Conference – Special Track on Games and Entertainment*, Coconut Grove, FL.

Wachinger, G., & Renn, O. (2010). Risk perception of natural hazards. Report of the FP7 CapHaz-Net Project. Available at <http://caphaz-net.org/outcomes-results/CapHaz-Net_WP3_Risk-Perception2.pdf>.

Wall, T., & Leonard, D. T. (2011). Developing a pedagogical model for facilitating situated learning: A study. *European Association for Practitioner Research in Improving Learning Nijmegen*, The Netherlands.

Walsh, R. L., & Hoskisson, D. (2013). Toward a theory of story for digital storytelling. *In Society for Information Technology & Teacher Education International Conference, 2013*(1), 1788–1793.

Wan Chi Wu, & Ya Ting Carolyn Yang (2008). The impact of digital storytelling and of thinking styles on elementary school students' creative thinking, learning motivation, and academic achievement. In *Society for Information Technology & Teacher Education International Conference* (Vol. 2008), Issue 1.