Emotion-based digital storytelling for risk education: empirical evidences from the ALICE project

Giuseppina Rita Mangione* and Anna Pierri

Centre of Research in Pure and Applied Mathematics (CRMPA),
Via Giovanni Paolo II, 132, Fisciano (SA), Italy
E-mail: mangione@crmpa.unisa.it
E-mail: pierri@crmpa.unisa.it
*Corresponding author

Nicola Capuano

Department of Information Engineering, Electronic Engineering and Applied Mathematics, University of Salerno,
Via Giovanni Paolo II, 132, Fisciano (SA), Italy
E-mail: ncapuano@unisa.it

Abstract: Getting citizens prepared to emergencies, and especially children, is an essential issue which requires special attention in the educational process. Many evidences show that misconceptions about natural disaster and incorrect beliefs are often the basis for misguided actions that can lead to inefficient behaviours in case of dangerous events. Then school has a major role in the development of ‘disaster-aware’ citizens, since it is asked to design appropriate resources and select suitable methods able to guarantee retention and progression of the learning process. Teaching emergency preparedness involves studying several complex topics and more than some studies have shown that storytelling can be an effective method for teaching subjects that are intricate in nature. The educational technology considers research on construction of digital storytelling as an educational challenge. Digital narratives even gain noticeable importance when users’ emotions are taken into account. Basing on these considerations, we propose in this work an adaptive, dynamic and narrative-based digital artefact in which emotions are used to rebalance the learners’ status. We experimented this learning resource to teach earthquake preparedness in Italian secondary schools.

Keywords: risk education; digital storytelling; role taking; engaged learning; adaptive instruction; personalised learning experience.


Biographical notes: Giuseppina Rita Mangione holds a PhD in Telematics and Information Society. She is member of the editorial board of Journal of E-Learning and Knowledge Society and member of the Elsevier editorial reviewers for computers and education. She is a manager for the Methods and Pedagogies department at CRMPA. She is the author of several scientific papers. Her main research interests are: technology enhanced learning, adaptive learning system, CSCL and microadaptivity, metacognitive and self-regulated learning.
Anna Pierri holds a PhD in Mathematics from the University of Salerno. She manages research and development projects at CRMPA. She is the author of several scientific papers. She has been Contract Professor of Computer Science and is currently Contract Professor for the course of Computerised and Telematics Skills at the University of Salerno. Her research activity deals with learning platforms, artificial intelligence, semantic web and ontologies.

Nicola Capuano is a Research Assistant at the University of Salerno. His main research interest is artificial intelligence and, among its applications, intelligent tutoring systems and knowledge representation. He works as a project manager and research consultant within several research and development projects. He is the author of several scientific papers. He is a scientific referee and member of editorial boards for international journals and conferences.

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1 Introduction

Modern societies are increasingly asking for the development of risk management skills as one of the most urgent challenges. Risk education has become a main subject of interest in teaching and learning science, a way of promoting sustainable societies (Kagawa, 2005) keeping the pace with an apparent increase in natural disasters in the last century (Figure 1).

Risk education foresees an educational plan that may transfer to learners appropriate knowledge and skills on natural hazards and risks with the aim to help them protect themselves and make correct decisions in case of natural disasters (Janssen et al., 2006). When it comes to face natural disaster, in fact, both misconceptions (Alexander, 2007) and incorrect beliefs may lead to wrong action or inadequate behaviour, as many evidences demonstrate (Sinclair, 2001; Tannsever et al., 2008). For this reason the school has an important role in risk education (Shaw and Kobayashi, 2001) and should be aware that “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” (Cardona, 2004; Stoltman et al., 2004).

Several studies confirm that children who participated in school-based hazard education programs show an increased and accurate knowledge of hazards, reduced levels of fear, and a more realistic perception of risks than their peers (Norris et al., 2002). They also confirm that “disaster-risk education should be part of the national primary and secondary school curricula and be included in several school subjects” (Komac et al., 2010) such as geography, social sciences, biological sciences, forensics, physics, history, etc.
Figure 1  Natural disaster reported in 1900–2011 (see online version for colours)


Literature as well endorses that “European risk education landscape” is far from uniformity and suggests that much has to be done in this field of research. In terms of learning and teaching process, innovative pedagogies are recommended in risk education (Pigozzi, 1999; Nicholai, 2003) in order to make learners responsive in problematic and real situations, as well as to motivate them to learn more.

The narrative, in this view, is a privileged instrument that can help develop cognitive skills and organise the knowledge, a powerful cognitive tool whose potential can support the learner in the process of meaning construction. Teaching emergency preparedness (Gerrig, 1993) may involve many complex topics and, as shown by various studies, narrative strategies can be an effective method for teaching subjects that are intricate in nature (Hulya, 2010).

Since nature (e.g., through natural hazards) is closely interwoven with social and cultural development, it is important for education to refresh or preserve memories: for instance, through storytelling. Stories can be both personal (real) and general (universal); the more the stories used in education are realistic and embody aspects of real life they tell about, the greater symbolic potential they carry.

An interesting example is the ‘Tsunami Story’ which is available through several websites. ‘Inamura no Hi’ (Asian Disaster Reduction Centre, 2005) is the story of a man that “noticed a precursor of a large tsunami at the earliest stage and led village inhabitants
to higher ground by burning harvested rice sheaves”. This story was based on a true story at the time of the Ansei-Nankai Tsunami (1854), which claimed about 3,000 lives in coastal areas of western Japan (Komac et al., 2010).

“To increase levels of motivation, a narrative experience should be addressed to both affective (emotional) and cognitive (informational) treatments, tailoring to a natural disaster context” (Mangione et al., 2013). This means that a meaningful context is not only essential for learner’s understanding and development of concepts, but also for arising motivation in the story and creatively engaging learners in finding solutions to a problem and building their personal responsibility.

Again literature (Black, 2010) observes that in the Digital Age, students express a need for more varied forms of communication and report that they are easily bored with traditional learning methods. Educational strategies as digital storytelling help digital natives increase their attention and engagement level and improve their reasoning capability (Costagliola et al., 2010). In recent years, digital storytelling has emerged as a powerful tool for teaching and learning, and has proven to involve both teachers and students (Robin, 2008). As Bruner (1996) observed, all forms of narrative, are a dialectic between expectations and events and a call for problems, not a lesson on how to solve them.

The narrative in fact is a privileged instrument for developing cognitive skills and organising the knowledge. Recently, different advantages of using digital storytelling in education have been listed (Van Gils, 2005). The first advantage of digital storytelling is that it can offer more variations than traditional practicing methods. This gives a big advantage because once a story-based educational content is developed, it can be continuously used by the learners, thus avoiding repetitions and troubles.

Another major advantage of using digital storytelling is that education can be further personalised. Some systems could be developed in such a way that they allow the education level to be ameliorated on the basis of specific learner’s needs. A third advantage is that the way of telling a story could start a persuasive process. Digital storytelling systems can offer several types of interactive learning and can improve students involvement in the learning process.

The prevalence of storytelling in human culture may be explained by the use of narrative as a cognitive tool for situated understanding (Gerrig, 1993). By taking advantage of these considerations, the use of storytelling can become one of the most successful forms for students to be responsible for their own learning and to maximise the lesson learnt in a particular context like emergency situations.

The educational technology must imply research on construction of digital narratives, taking into account users’ emotions, and exploiting them to improve engagement and responsibility in a story. The storytelling represents a challenge in education in that the emotions felt by the learner are of primary importance in producing compelling and engaging adaptive dramas.

The Adaptive Learning via an Intuitive, Interactive, Collaborative, Emotional (ALICE) system project explores the use of digital storytelling as a complex learning object (SCLO) introducing novel opportunities for supporting student’ skills of problem solving and learning in specific contexts (e.g., training for huge risks) combining direct experience, observation, discovery, and action into an inseparable whole (Kolb, 1984).

Basing on results coming from this project, this work investigates the importance of emotion modelling within narrative-based educational resources and conceptualises a new type of educational resources defined as SCLO able to meet two goals:
1 to interactively tell a story allowing participants to experience specifically targeted learning objectives and leverage different user’s emotions
2 to use this data as the basis for managing actions that may guide role taking in the story portrait.

The paper is structured as follows: Section 2 presents some related works about emotional storytelling; Section 3 provides details of the defined SCLO from a methodological point of view (PoV) and focuses the attention on the story structure, learning situations and role taking; Section 4 refers to the emotion-based storytelling and explains story manager’s components; Section 5 presents the experimentation results; Section 6 presents the final conclusions.

2 Related work

A correct dramatisation of a story is important and has an impact on the learner’s participation in the narrated events, and also because it affects the process of memorisation of key information and their integration within the learner’s natural mental scheme.

All emotions are known to play an important role in the user’s engagement: by engrossing their own attention, perception and memory skills, learners may better understand a story and feel it as an entertaining experience (Costagliola et al., 2010; Bevilacqua et al., 2009). If narration is interpreted as able to generate various emotional states (e.g., tension), which derive from its aesthetic qualities (e.g. suspense), a logical consequence of that should be the analysis of student’s emotional states and reactions and their use to choose a new flow in a narrative sequence (Rank et al., 2006; Cheong and Young, 2006).

Several researches have been focused on the model and the way of recognising student’s personal traits in learning environments, and have started exploring mechanisms of repair or coping with negative emotions (Bevilacqua et al., 2009). Specifically, the application of theories and principles related to emotions in digital storytelling, is connected with the objective of building empathic interactions between user and story, and in using the output of this interaction, with creating coherent and dramatic interactive stories.

The literature on storytelling introduces two main approaches, which deal with emotion handling in narrative-based resources:
1 modelling emotions for believable virtual characters
2 capturing user emotions to generate affect-based interactive narrative.

With respect to the first approach, the application of cognitive theory guides the development of educational environments where the emotional experience is seen in terms of appraisal (individual’s interpretation of their relationship with the environment or events) and coping (individual’s cognitive responses to the appraised significance of events) (Gratch and Marsella, 2006; Ellsworth and Scherer, 2003). Storytelling environments adopting this approach are, e.g., ActAffAct, Papous and FearNot! (Rank and Petta, 2012).
Emotion-based digital storytelling for risk education

ActAffAct (Figure 2) presents a graphical representation of an environment inhabited by four agents, taking on the roles of narrative archetypes: a hero, a mentor, a villain, and a victim (Paiva et al., 2001). In this system, the conflicts between characters in a play and emotions involved in resolving the former are the constituents of a dramatic structure, namely a plot. The use of an appraisal-based architecture is thus seen as “a key to construct emotionally and dramatically believable characters for interactive drama” (Rank and Petta, 2005). Papous (Silva et al., 2001) is a virtual narrator who reads a text enriched with control tags. These tags allow the storywriter to script Papous’s behaviour. There are four types of tags: behaviour tags, where a specific action or gesture is scripted; ‘scene tags’, that allow Papous to change the scene where he tells the story; ‘illumination tags’, to allow a new scene illumination pattern; and ‘emotion tags’, to change Papous’ emotional state (Silva et al., 2001).

Figure 2 The ActAffAct interface (see online version for colours)

The texts, enriched with these tags, are then processed by different Papous’ modules, which contain an affective speech module and an affective body expression module. The storywriter is free to use the tags as he/she pleases, but should also take into account the story context. A deliberative module receives emotion and behaviour tags and sends commands to affective speech and affective body expression components (Figure 3).
To transmit emotions via the voice, a series of relations between emotions and voice parameters have been established, based on theories accounting for the interrelationship between speech and emotion (Scherer, 2000). The affective body expression component receives the information about specific emotional state and changes the character body in order to express the pertinent emotions and to perform different gestures.

Papous is designed basing on psychological theories of emotion, without considering the narrative requirement of generating engaging stories in terms of dramatic flow. Therefore, although the virtual character is designed to be believable and autonomous, the user may find difficult to empathise with them because the plots lack of dramatic effect.
The case of written interaction has been integrated, although in different manner, in FearNot! (Figure 4) (Louchart and Aylett, 2004), a virtual world inhabited by synthetic characters, with whom the user interacts in a physical bullying scenario. The users influence the story development by providing the victim with advice (written input) on what to do next. Then, according to the users’ answers, the story path evolves and, at the end, an educational message is given to the viewers. The efficiency of the story has been based on the modelling of characters and agents. The agents are emotionally driven and react or plan their following actions with respect to their dominant emotional state. This articulates an emergent narrative approach and provides flexibility with regard to the story articulation.

By assessing and reacting on each other’s action and reactions, the agents in FearNot! truly interpret their role in the same way as an actor would interpret a character. Each agent is defined according to his role in the drama and his personality (i.e., emotional triggering thresholds) is connected to a set of actions, goals and emotional reactions. These are developed and written with respect to agent’s personality and role.

FearNot! is especially thought for anti-bullying education of children aged 8–12. Thus, it features a virtual world inhabited by synthetic characters (portraying children) acting autonomously with the roles of ‘bully’, ‘victim’, ‘bystander’ or ‘helper’. The user interacts both with a physical bullying scenario and a relational scenario. After the introduction of characters, school and situation, he sees a first bullying episode, followed by the victimised character seeking rescue in the school library, where he can start to communicate with the child user. Within the initiated dialogue, the user selects a piece of advice from a list of coping strategies, explains his/her selection and what he/she thinks will happen after having implemented the selected strategy (Louchart and Aylett, 2004).

ActAffAct, Papous and FearNot! treat emotions only by defining emotionally-driven virtual characters. These tools do not consider users’ emotional status but the character’s pre-authored personality. To increase the user’s level of enjoyment and engagement, the second approach of the emotions’ research in a narrative context is focused on the need to allow the user to express his/her emotional states and dynamically adapt the character’s actions and storylines along with the user’s emotional states.

A number of tools have been developed incorporating the user’s emotional state into the interactive storytelling. Such tools may adopt different techniques to captures the emotions but, predominantly, objective approaches are used. An objective approach captures user emotion based on behavioural, expressive and physiological modalities. CALLAS, Façade and SenToy are example of systems using these approaches.

CALLAS, for example, is an affect-based interactive narrative system that detects user emotions from vocal expressions. The core components of the system include EmoVoice (Vogt et al., 2009), a system for vocal feature extraction and classification. Also in Façade the emotion detection is voice based and influences both the character’s behaviour and the storyline (Mateas and Stern, 2004). The story focuses on the relationships of one couple that is having an argument and the user that plays the role of a couple’s friend that, with his interaction, can modify the couple’s story (Figure 5).

However, alternative approaches have recently been proposed, one of them is the use of tangible user interfaces (TUI). SenToy (Paiva et al., 2003) is a storytelling system that detects a set of user’s emotions transmitted through a set of gestures (Andersson et al., 2002). SenToy’s components include the ViewManager that controls the scripted and the Doll Manager that maintains a state that describes what is the last emotion felt by the user and send this emotion to Display Doll which is the component responsible for
displaying a cartoon face with emotions in the screen providing immediate feedback to the user on what emotion she/he was expressing. Such components have been also included in FearNot! (Figueiredo and Paiva, 2005) (Figure 6).

**Figure 5** The Façade interface (see online version for colours)

**Figure 6** Integration of SenToy in FearNot! (see online version for colours)
CALLAS, Façade and SenToy adapt the narrative to user emotions using a specific approach aimed at eliciting the predominant emotional dimension and to compare it with the author’s ideal emotional value. The user emotion in this case serves as an ‘assistant’ to help the author manage the story “rather than serving as a driving force to move the story forward and motivate the user’s interactions” (Zhao, 2013).

Although a number of techniques have been explored to detect user’s emotions, few attempts have been made to apply these techniques in educational storytelling and to adapt stories to link emotional responses with learning objectives defined and associated to a narrative strategy. How to apply the said methods of emotion recognition to a storytelling learning experience? How to adapt the story to possible user’s emotional states in order to maximise learning achievement? What are the approaches to be used to adapt narration with respect to user’s emotion?

This work tries to suggest an answer to these questions by introducing a novel storytelling tool which exploits emotions to improve the learning process. Differently from other surveyed tools, the proposed approach exploits emotions mainly to adapt the story path. In particular, it applies a subjective approach rather than an objective one based on capturing emotions through open or closed questions. This approach is not so widespread in literature mainly because all questions must be defined coherently with the story in a way that they are not intrusive or do not impact negatively on learner’s concentration and engagement (Yannakakis and Togelius, 2011).

In the defined subjective approach, the prediction of emotional states relies on explicit questionnaire-based detection. The idea to adopt a self-reporting technique to measure the emotional state, is tied to a need for obtaining reliable data and, at the same time, to maximising students’ locus of control. The subjective approach is integrated with a story adaptation model, different from the models presented in Callas and Façade. In the proposed approach in fact the narration is adapted basing on real-time user’s emotional states during the assessment event.

More in details, users’ emotions are detected by means of questionnaires [defined by considering the classes of emotions defined by Arroyo et al. (2009)] provided by the environment when the student, after an assessment phase, obtains a poor score. Furthermore, detected emotions are used to identify and assign him/her a new role (i.e., a new character with a different story perspective) in order to make him/her more engaged and aware of him/her responsibility.

The detection of an emotional state and the mapping between possible narrative archetypes as well as the use of such archetypes to rebalance emotions within the learning experience, can be considered as the main added value of the proposed approach with respect to similar methods and systems presented above.

3 The proposed approach

We define a SCLO as an educational resource characterised by cross-linked narrative sequences that we call story scripts. In a SCLO, a script is a logic composition of several situations, based on the visual story portrait (VSP) phases: beginning, call to adventure, problem, middle transformation, solution, closure. The VSP has been defined by Dillingham (2001) and further extensions have been proposed by Ohler and Raymond (2008).
The proposed storytelling design model (SDM) (Mangione et al., 2011) considers the intellectual transformations as changes in terms of learning objectives. At this level of transformation, learners (who lead the character) 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 a learning process, consists in an association between Bloom’s taxonomy (Bloom and Krathwohl, 1956) and some character transformations, to map each transformation with a specific phase of the VSP.

In Mangione et al. (2011), the authors report a table with a mapping among VSP situations, Bloom’s learning objectives and character transformations. In particular, Bloom’s hierarchy of transformations identifies a taxonomy of intellectual changes according to six different levels of learning objectives, which are sorted by an increasing order of difficulty, from basic to higher levels of critical thinking skills. In the SDM, the learning situations have been related to the aforementioned levels (Figure 7).

**Figure 7** The defined storytelling design model (see online version for colours)

To ensure the achievement of the assigned learning objectives, each situation presents itself as a composition of events (advance, learning, reflection and assessment) whose structure helps the development of organisation, selection and integration of information carried out by the learner to maximise the results for a specific learning objective, which is associated to a specific level of knowledge. The assessment event, in particular, presents a selection of assessment modes through arrangement of different types of tests and items with different levels of interactivity and complexity in order to detect possible learners’ abilities during the storytelling path (Figure 8).

Our model exploits a branching logic approach to design micro-adaptivity mechanisms in digital story using information coming from assessment results, and to define remedial paths tailored to meet the learner’s progress (Lee and Park, 2008). The model allows to link (pre-scripted) alternative routes to the knowledge level achieved by a learner (and assessed through e-testing) to direct them to remedial paths. These remedial paths are aimed at facilitating, supporting and motivating learners to achieve their learning objectives (Kickmeier-Rust et al., 2008).
Different remedial paths are defined. The first level of remedial path has been defined according to learning style strategies. It matches the idea that the most effective learning only occurs when learning activities match learners’ preferred style more closely. According to the situated learning strategy, a second level of remedial path presents the same events re-lived by the learner in a different scenario (context).

The role taking is a further specific level of micro-adaptivity. This level has been defined according to a new approach based on the concept of PoV in a story, where a perspective of an identified character (with a specific role) takes part into that action (Vaz and Paiva, 2005, 2006). The roles management is fundamental as for educational aspects of the defined SDM. The characters, in the story, play specific roles that allow the learner to live situations and events from a given viewpoint. Changing the role of a learner means modifying the viewpoint by which he/she interacts with the story as well as the didactic value of the story itself.

The affective dimension is an additional variable that we have integrated in the SDM. In particular, to create an emotional storytelling, we propose to extend the model with the following additional components (Mangione et al., 2012) (Figure 9):

- an emotion tracking engine (ETE), used to keep track of the user’s expected emotional state
- an emotional path graph (EPG), a time dependent graph, similar to a Freytag’s graph (Blom and Beckhaus, 2005), depicting what a learner may be feeling during a specific event
- a story logic engine (SLE), used by the story manager to manage and operate on story segments (situations).

Each of these components is associated with given events and conditions, which must be met in order to start a particular situation in the story context. The following paragraphs provide additional details on each of these components. The emotions are captured and exploited by these components, and manage story flow, logical consistency of the story path and micro-adaptivity.
3.1 The ETE

The ETE has been conceived with the aim of permitting a prompt identification of a student’s altered emotional states, during his/her learning activities. Following the study and analysis of the most used paradigms and models for the management of emotions and affection in intelligent tutoring systems, reference is here made to the emotions suggested by Arroyo et al. (2009), which are important for the learning.

In our work we have identified four axes characterising the emotional sphere: resilience (safety vs. anxiety), curiosity (interest vs. disinterest), engagement (excitement vs. indifference) and self-confidence (self-esteem vs. frustration). The assessment’s questions of an emotional state are designed as inputs that, as a result of choices made by the user, are able to assign a value to the character’s emotional state on two levels:

- state identification, which gives Boolean feedback (yes/no);
- measure/quantification of the state (–1, 0, 1).

The assessment of emotions as Boolean types is achieved using a questionnaire with 12 questions, three for each axis, that will lead the system to assign a score in which value –1 corresponds to an extreme, value 1 corresponds to the other one, and 0 corresponds to emotional indifference.

The quantitative emotional assessment, identified by a specific emotion, is then mapped on a scale ranging from 1 to 10, through ten questions, targeted and specified for each emotional class. The system thus is required to catch and distinguish alterations in the emotional state, and to adopt suitable strategies that can balance it.

Questionnaires are submitted to learners in order to detect their emotional states with respect to a storytelling experience. The questionnaire is implemented by using e-tests of two types:
a pre-quantification test, is used to detect possible changes in the considered emotional states.

2. a test is then used to measure the level of alteration in the emotion.

If the student accepts to answer the test, the pre-quantification test appears. In case at least one emotional state results to be altered, the quantification test, meant to measure the level of alteration, is presented (Figure 10). The ETE component then shows the results obtained through an EPG as detailed in the next section.

Figure 10  Test for safety/anxiety emotional axis and quantification (see online version for colours)

3.2 The EPG and the SLE

In order to examine the elements of a good story, we studied basic roles of story characters, driver of human behaviours and relationship of human personality, emotions and behaviours, especially non-verbal ones.

Stories are very largely made up of characters whose lives inspire the story plot. The list of characters is often called dramatis personae (especially in a theatrical setting). A person in a story may have a single character theme, but may also have a complex mix, in the way that each of them implies multiple personalities. The literature presents specific character collections and more character family groups or archetypes. The most relevant character collections in story have been defined in Jung’s (1964) characters, Propp’s (2000) dramatis personae, Vogler’s (1992) archetypes and Pearson’s (1991) heroic archetypes, where character’s structures depend on their roles in the story.

After conducting a study aimed at investigating research perspectives concerned with the definition of archetypes (character types or character groupings in digital stories, their personality, emotions and style) it was possible to go back to different existing taxonomies and to possible groupings of five basic archetypes (protagonist, helper, innocent, neutral and antagonist) characterised by personality traits useful to rebalance
emotional states that could be non-functional or discordant with those required for the learning in a specific emergency situation of the story path.

Going back to the study conducted on various models, employed to describe roles’ personalities in narrative stories and their behaviours or main activities, it was imagined to map them by using the emotional model lexicon in order to describe those personalities and understand some archetypes able to orient the story design and the re-addressing of role micro-adaptivity. For each archetype (Figure 11) a role taxonomy was defined, useful to rebalance the emotion in a new branch of a story.

**Figure 11** ETE/EPG and mapping with emotions (see online version for colours)

<table>
<thead>
<tr>
<th>Archetype</th>
<th>Associated Roles</th>
<th>Emotional axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protagonist</td>
<td>Hero, Martyr, Savior, Genius, Crusader</td>
<td>A (Resilience; 0) or C+ (Engagement; indifference)</td>
</tr>
<tr>
<td>Helper</td>
<td>Wise, Mentor, Magician, Caregiver, Jester</td>
<td>D+ (Self-confidence; frustration) or C- (Engagement; excitement)</td>
</tr>
<tr>
<td>Innocent</td>
<td>Avenger, Scapegoat, Victim</td>
<td>D- (Self-confidence; self-esteem) or B+ (Curiosity; disinterest)</td>
</tr>
<tr>
<td>Neutral</td>
<td>Enforcer, Ruler, Narrator…</td>
<td>C (Engagement; 0) or A+ (Resilience; anxiety)</td>
</tr>
<tr>
<td>Antagonist</td>
<td>Bad boy, Sneak, Fanatic, Thug, Shadow</td>
<td>A (Resilience; safety) or B- (Curiosity; interest)</td>
</tr>
</tbody>
</table>

When disinterest emotion occurs, the system can re-address the student to take a different perspective (role) that may let him/her understand what is the damage resulting from a lack of knowledge or ability to act in a given context (e.g., hero, innocent, etc.). If this emotional axis indicates a negative value and therefore a student’s interest but with insufficient learning results, the system tries to re-address him/her to active roles of greater relevance (e.g., hero, helper, etc.).

When the emotion detection indicates a state unbalanced towards indifference, it needs to re-address the student to higher rewarding or responsible role with respect to the story, so to increase the level of excitement and control (e.g., antagonist). If the student has already reached a balanced or positive engagement but shows big cognitive gaps, it needs to reduce his/her self-confidence level because this could lead him/her to underestimate risks and not to pay attention to the situation, re-addressing them to a more reflexive PoV belonging to that character (e.g., wise or ruler).

The SLE is a module aiming at adapting (at micro-level) the story by using the score achieved by learners during an assessment test. In particular, if the assessed learner’s knowledge level (with respect to a given situation) is insufficient (with respect to a fixed threshold) the learner takes a new role by which he/she re-lives the previous situation and gets a different viewpoint on the story (Figure 12).
The SLE is enhanced taking into account the emotional data captured by ETE. This data is used in order to identify the best narrative archetype traits, which are useful to re-balance the emotional state (non-functional with the states required for the learning in a specific situation of the story path) and to select the new role to be assigned to the learner. In particular, the SLE module bases its action on a tuple (emotion, role, situation) able to redirect micro-adaptivity.

4 The storytelling prototype

Suitable authoring tools have been developed to support both editing and playing of the narrative outline constructed on the basis of SDM. Such tools enable educators to create engaging multimedia lessons that facilitate the learning with the integration of a myriad of multimedia content.

The authoring tool (Figure 13) is a desktop application that allows educators to build digital stories that can be played both on a PC through a web browser or on a tablet with iOS Operating Systems. In this multimedia tool, simple and clear editing layouts and various content editing functions enable authors to make story creative content and to publish it quickly. Besides, it also integrates multimedia objects such as textboxes, images, videos, audios and flash files to let authors insert specialised multimedia story components in each situation and make simulative and dynamics contents.

The storytelling editor allows for an easy creation of multimedia resources, for the design of the story elements and the creation of testing activities as well as the management of different flows (referring to prearranged SDM). A table of rules can be defined for this purpose. The rules guarantee that checks on user’s assessment score are executed in every situation: if the score exceeds a given threshold, the story flow proceeds to the next situation, otherwise the learner is redirected to a different narrative path able to overcome the gap for learning objectives associated to that situation of the story (Figure 14).
The player component can follow the story and allows the user to live the experience according to a single-learner use logic. During the story the user interacts with predefined scenes and receives feedbacks from the system, enabling him/her to think of the appropriate actions and behaviours to adopt in the story.


Figure 15  Changing the role policy with TH rule editor (see online version for colours)

Figure 16  Playing the SCLO (see online version for colours)
Inside the table of rules there is a specific rule named RoleControl that does a check on the role variable. After an assessment, if the result is too low (between 0 and 40%) the user role must be changed, thus starting a micro-adaptivity in the story flow. The role variable is then changed taking into consideration the data communicated by the ETE and applies specific rules defined by the SLE in order to identify archetypes for the remedial path, which offers the highest functional role with respect to emotional balance and overcoming of cognitive gap. Then a different (pre-scripted) view of the same story is proposed to achieve the learning goals (Figure 15). The SCLO produced with the story editor is an archive containing a folder with all multimedia files linked to resources and other specific files for the SCLO structure and properties, an HTML file and a Silverlight file that constitute the player component through which the SCLO can be started and viewed. The main part of the player page is composed by a play area that shows contents and allows users to interact with them (Figure 16).

A SCLO can be loaded and used in the context of a wider learning unit. In our case, we adopted intelligent web teacher (IWT), an adaptive LMS, where the SCLO becomes one of the learning resources in a personalised sequence proposed to the learner. IWT is an e-learning platform allowing the definition and execution of personalised e-learning experiences tailored basing on learners’ cognitive status and learning preferences (Adorni et al., 2010).

IWT is the enabling technology for supporting macro-adaptation in terms of learning experience personalisation carried out according to learner’s cognitive state and their didactical preferences. IWT is based on three main models: knowledge model, learner model and didactic model (Capuano et al., 2008).

The knowledge model is based on the definition of ontologies used to model the knowledge of the didactic domain of interest. These ontologies are applied to organise learning objects that are building blocks exploited to implement the personalised e-learning experiences.

The learner model stores the knowledge acquired by the student 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 discipline (formalised with the knowledge model) and learning characteristics of the involved learner (learning styles).

In IWT, the learning objects are annotated with IEEE LOM. This metadata allows to include a link between a learning object and one or more concepts of an educational ontology (Gaeta et al., 2011). A learning object is linked to a concept whereas it can be used by learners in order to acquire knowledge on the aforementioned concept (Capuano et al., 2009).

By exploiting IWT, a SCLO can be added in a personalised e-learning experience in order to deal with specific concepts requiring a more sophisticated didactic method and advanced content. An IWT adapter has been developed to deliver SCLO in personalised learning experiences that can be composed of different educational resources such as simulation, collaborative activities, video lectures, assessment test and SCLO to support the learning for a specific conceptual path in different context domains (Figure 17).
5 Experimentation results

In the ALICE project, a specific SCLO has been created and experimented in a possible scenario of risk education. The goal of this scenario is to allow an efficient learning about knowledge and behaviour to be adopted in civil emergency situation (like seismic event in amusement park) through the use of complex and innovative learning resources (storytelling learning object). As a result, an emergency course was created for providing suitable learning resources that meet different learners’ needs.

In order to evaluate the storytelling scenario and validate it through the effects in the learning process, four Italian schools have participated in the experience. Specifically, four tutors and 58 students were involved. The participants in each school were on average 18 years old. They were located into a classroom composed of two groups: experimental and control. The experimental group included analytical students: a type of student who likes testing and, in a later time, matching solutions and problems. The control group included holistic students: a type of student that likes analysing problems, and associated information, before starting a specific activity.

The experimental group was delivered a learning course which made use of complex learning resources (as the SCLO); the control group was delivered a learning course that adopted traditional learning materials as power point presentations, PDF files, etc. Before facing the learning course, the students were introduced to the overall context: indeed the tutor explained typical activities and steps that they should follow in a risky situation. After that, they delved into all information through active interaction with the course.
All students were supervised by a tutor during the experiment. At the end of the course, both students and tutor were questioned with a qualitative survey in order to test their acquired knowledge after using storytelling, with respect to a passive learning resource. Actually, a qualitative questionnaire makes possible to evaluate the efficiency of storytelling didactic resources. The qualitative questionnaire is composed of six questions (as shown by the six colours in Figure 18). For each school (School1,…,School4), we reported an average of provided answers.

For example, if we analyse the answer to question Q2 “Have the suggested reflection moments given you a key to understand the objective?”, we observe that a number of students have successfully answered it. This suggests that the students appreciated the combination of activity and reflection for each situation. This is particularly true for the third school where this value reached the maximum score.

Figure 18 Average answers to open questions (see online version for colours)

A good percentage has been also obtained for question Q3 “Have the assessment events, distributed within diverse key situations, allowed you to delve into learned concepts before moving forward?”. The assessment events have contributed to stimulate their critical judgment with respect to what they were supposed to learn before encountering new difficulties and challenges in the story in terms of knowledge and skills to be deployed.

Very appreciated was the opportunity to evaluate the emotional state at a given point of the story, as shown by question Q4: “You had the chance to assess your emotional state at some given points in the story. Is it helpful for you to understand whether your emotional state may influence your interaction with the story?” that indirectly influences the story sequence.

Multimedia resources have caught students’ attention motivating them to adopt suggested behaviour in case of emergency situations. Concerning question Q6: “Were visual and auditory stimuli opportunely defined so to allow you to follow the story events and focus on the most important ones?” in fact students’ answers reported a good level of satisfaction in using multimedia despite a high complexity of such resources.

The analysis of averages for each question reinforces the data previously reported, and partially validates the SCLO as a way of changing and renewing the educational experience of digital natives. The experience takes into account an instructional architecture which permitted to have successful assessment and reflection moments.
All students involved in the experimentation interacted with the SCLO also through multiple accesses. Figure 19 shows a satisfactory linear progression: namely from situation #1 (beginning, see section 3) to situation #6 (closure, see section 3), students’ attention increases, showing a higher level of involvement corresponding to the same level in Bloom’s taxonomy. In other words, the average interaction’s time (expressed in seconds) is proportional to levels and types of knowledge to be acquired in different situations.

As we can see, the first three situations (beginning, call adventure and problem) are quite introductory, thus the average time of student’s execution is between 20 and 30 minutes; while for the following three situations (middle, solution, closure), that required a higher student’s cognitive involvement, the average time of execution is between 30 and 40 minutes. This is in line with the defined storytelling model. The first three situations are preliminary; only from the fourth situation the learner is more involved in the story since he/she is called to a careful reflection with the aim of resolving the problem.

Specifically, situation #5 indicates a higher time of involvement for all experimental groups, as for micro-adaptivity situations where students were addressed to in order to fill the knowledge gap (Figure 20). The investigation of the micro-adaptivity added value, have brought us to focus on situation #5 (solution) and on how the assessment results changed after the students took a different emotional-based role.
The emotional assessment linked to the cognitive assessment, has determined the story experiencing through a new narrative archetype called ‘helper’. In such a way the student ‘reviewed’ the story from a different PoV, delivering the solution situation more responsibly. Figure 20 shows an optimal student’ score, which is more aligned with his/her classroom average; the score is the result of their answers to the assessment questionnaire, but with a different role.

The same figure also shows how students, who had benefited from a micro-adaptivity based on emotions, gained good results during the assessment events thus demonstrating they had finally acquired a greater ability to evaluate and synthesise. We can also obtain a measurement of the students’ involvement in the story as well as the interest in such topic as emergency situations, earthquakes, after their interaction with role micro-adaptivity.

For the purpose of accurately representing these aspects, we have compared comments and tags posted from students to various story scenes with the execution time measured for different situations. The combination of these two factors, depicted in Figure 21, allows us to measure the level of ‘pacing’ or concentration shown by the students and their work as a ‘note taker’ during the experience and after taking a new role.

Figure 21  Note taking activity (see online version for colours)

The data also show a good relationship between average time of use and note taking activities. Situation #5 instead shows about twice note taking activities compared to others. This latter is related to the micro-adaptivity role that required a greater student’s responsibility for acting with the role of helper.

Figure 22  Skill acquired through the storytelling (see online version for colours)
Figure 22 shows how the SCLO structure-guided exploration allowed the students from the experimental group to acquire, in accordance with the educational concept “What to do in case of an earthquake”, a level of competence equal to 5.72. On the contrary, the blue line shows the skills acquired through the assessment test that is equal to 6.53. This result denotes that the assessment test, delivered within the storytelling resource itself, opportunely addressed/guided the students, providing, as a consequence, a final assessment result far above the minimum threshold indicated by the teacher (5).

It can also be observed that no big gap resulted between the relevant skills acquired through interaction with the resource, and skills measured at the final assessment level. On the one hand, this may mean that the resource is complete from the educational PoV, and able to guide specific teaching concepts related to risk education. On the other hand, the results confirm that the resource is able to keep a balance between attention and multitasking attitude (exposure to multiple and confusing stimuli), encouraging students to optimise both of them intelligently. This in fact has permitted students to achieve a good level of performance to be held in the event of an earthquake.

In this experiment, we again observed a greater motivation in the experimental group and better marks achieved in the final assessment thus confirming that storytelling learning resources, applied to education, can enhance traditional teaching methods. The experimentation has also confirmed that this interactive didactic element is more oriented to a student-centered educational approach. It is able to involve students emotionally, provide them with directed and adaptive guidance and facilitate critical reflection.

6 Conclusions and future work

The systematic research activity conducted within the Alice project about storytelling allows us to confirm the value of this educational strategy in risk education and to summarise several challenges and pedagogical issues in this field. In this paper, we presented the SCLO, an intensive narrative educational resource able to capture and manage learner’s emotional aspects in order to select the most suitable roles to better live the story and to achieve specific learning objectives assigned to story situations.

The SCLO experimentation and validation activity have confirmed the capability of this educational resource to let the student master the acquired knowledge and the correct behaviour to be adopted in an emergency situation. The SCLO is able to involve emotionally, providing guidance and making the reflection easier. The teachers who participated in the experimentation and helped validate the underlying storytelling model, agreed that the SCLO provides the opportunity for a progressive exploration of the knowledge in a guided and verisimilar context. This result encourages us to apply this methodology to a larger domain of disaster education.

Future works will focus on additional experimentation activities intended to gather more empirical evidences that may allow us to understand whether this innovative instructional method can affect learning outcomes, and, to validate the association between emotional axis and narrative archetypes by means of an analysis of aggregated (across multiple sessions executed by different learners) assessment data.
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References


Notes