Castor: Designing and Experimenting a Context-Aware Architecture for Creating Stories Outdoors

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Abstract—This work describes the design and the experimentation of Castor, a novel architecture for creating, editing and delivering engaging geolocalized context-aware stories outdoors. Castor is one of the first architectures that enable the direct creation of structured stories in-situ, rather than the simple gathering of material, and that use an extended set of context dimensions (i.e., environmental and social context) for augmenting the emotional engagement of the story listeners. The architecture was experimented in an educational project lasted two semesters, performed integrating the traditional educational path of a class of children aged 7, with the full collaboration of their teachers. Our architecture demonstrated to have an important role for bridging the gap between the structured classroom learning and the outdoor experience, engaging the children for obtaining interesting results in terms of acquisition of new skills, collaboration and social inclusion.

Context-awareness; Education; Learning; Storytelling

I. INTRODUCTION

This work presents a novel software architecture, named Castor (i.e., Context-Aware STORYtelling), for supporting all the phases of creation, editing and delivery of context-aware stories on the field. Compared with the available literature, the value added by Castor is the possibility to create stories compliant with a novel story model, where the narration is driven by the context conditions, matched with those ones specified by the story author for the delivery of the story. While other storytelling systems enable only the simple gathering of materials on the field for creating the narration elsewhere or limit the use of the context to the location, Castor enables the direct creation of narrations in-situ and uses an extended set of context dimensions (i.e., the weather conditions, the season, the time of the day and the number of listeners), for augmenting the engagement of the listeners. The architecture was tested in the context of an educational project that involved for two semesters a class of 19 children aged 7 in which the traditional educational path was integrated with the modern mobile technologies. The educational project was performed with the constant collaboration of the teachers. During the experimentation the class learned how to build, modify and listen to engaging context-dependent stories with the help of different tools, in classroom and outdoors. All these activities were composed in a smooth educational path that showed the positive role of our architecture for the acquisition of new skills and for bridging together the work done in the classroom and outdoors. The availability of a mobile platform permitted us to bring a structured learning experience outdoors, allowing to capture easily the creative activity of children and enabling the acquisition of literacy skills. The novelty of Castor lays also on its social dimension, being conceived as a social repository and publishing platform for context-aware narrations that can be accessed by pupils for sharing new stories and listening to the available ones. Children involved in the experiment learned how to build stories, starting from the traditional model to the context-aware model, and then shared their creations with their fellows, that listened to the narrations in the locations where they had been created. The analysis of the classroom and outdoors activities showed another benefit deriving from the use of Castor: an improvement of the levels of collaboration and social inclusion outdoors. The teachers confirmed this significant improvement, considering also the behavior of the children during the ordinary classroom work. This represented a confirmation of the role of the environment for learning and the importance of having tools, like Castor, capable of bridging the gap between structured learning and outdoor experience. The rest of the work is organized as follows: Section II will discuss the related work; Section III and Section IV will give an overview of the story model and of the software architecture; Section V will present the user interfaces of Castor; Section VI will present the five phases of the educational project; Section VII will discuss the findings; Section VIII will draw the conclusions.

II. RELATED WORKS

There are a number of models and architectures for computer-enhanced storytelling [1]. Most of them rely on the analysis of narratology theories, which study the structure of stories. This project relies on a story model based on the work of the Italian researcher Cesare Segre [2], chosen because of its generality and suitability to different literary genres and adapted to interactive storytelling. The derived software architecture is compliant with the “drama manager approach”, where a software architecture controls the narration on the basis of the story model and of the narrative choices of the author [3], opposed to the “autonomous agents approach”, where a set of software agents influences the evolution of the story [4]. We made this choice because we were more interested, as most academic researchers involved in the development of storytelling systems for educational purposes [5], to implement a system supporting the children creativity and expressivity rather than to generate stories with a higher - but probably less interesting - number of choices and endings. Storytelling has always been a powerful means in the educational curricula, not only for developing literary skills,
but also for improving the interest of children for other educational domains. Personal computing has been used in the last years to support the creation of stories in the classroom, permitting children to collaborate at various levels, in classroom or even from remote locations [6]. The collective authoring of stories composed by a whole class is one of the key points of the work proposed by Di Blas et al. [7], that focuses also on the integration with the children curricular activities and the inclusion of pupils otherwise marginalized. In recent years the rapid evolution of mobile technologies has permitted to support outdoor activities, such as fieldtrips [8]. Researchers have considered different educational domains, including history, geography and science. For example, in Ambient Wood [9], children provided with mobile devices explore a wood enhanced with ubiquitous technologies for gathering ecology data. Halloran et al. [8] [10] designed technology-enhanced fieldtrips for supporting the learning of literacy skills. The children were involved in the exploration of a historic English country building, Chawton House, supported by mobile devices for listening to the content prepared by curators and teachers and for gathering their own content (e.g., audio and photographic snapshots) at specific locations. They used also paper and pencils for fixing their thoughts. A peculiarity of this work is the integration with the classroom work: the children collected content and ideas outdoors, but wrote their stories the following day, when they returned to their classroom. Hansel et al. [11] take advantage of the Mobile Urban Drama [12] platform for designing an environmental drama where storytelling and study of natural sciences are mixed. The students listened to the narration delivered by mobile devices, but at the same time were asked to perform different assignments, involving sketching, collecting soil tests and taking pictures. As in [8], the students completed their work in classroom, in this case producing reports and presentations on the basis of the materials collected. The authors of the study underline the importance of learning outdoors, that stimulates the practical intelligence instead of the theoretical school intelligence [13] and the use of mobile devices that contribute to bridge the gap between symbol manipulation and contextualized reasoning. Both the [8] [11] approaches offer a very structured experience in terms of the content delivered to children, for inspiring the creation of stories or for stimulating the gathering of data. For what concerns the creation phase, they are more focused on the gathering of materials and on the solution of assignments rather than on the creation of narrations in situ. Fails et al. [14] propose a complete mobile system supporting both the creation and the listening of stories in-situ. The approach is focused mainly on the collaboration of children and uses the surrounding environment as a stimulating scenario for engaging them, even though the different parts of the narration have a loose coupling with distinct locations. Compared to previous literature, the project described in this work reserves a keen attention to the integration of classroom and outdoors activities, and provides a set of tools for the direct creation of the story in-situ, geolocalizing precisely all the story locations. Context-awareness concerns the capability of computer systems to log different dimensions of the context (i.e., according to Dey et al. [15], “any information that can be used to characterize the situation of an entity. An entity is a person, a place or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves”) and to use it for guiding and adapting the user experience. While the dimensions of the context are several and include the location, the environmental conditions, the user profile and history of previous interactions, the social conditions and the technological features of the devices (e.g., the width of the screen or the network bandwidth), only a part of them have been extensively used in context-aware architectures. Concerning the applications, in most cases the knowledge of the context has been used for delivering content and for lowering the cognitive load of the user rather than for other purposes. There are several implementations related to different interaction paradigms, including the hypermedia [16] [17], the web and the mixed reality. The implementations involve also different domains. As far as the cultural heritage is concerned, there are museum guides [18] or educational games for enhancing the visits of scholars to archaeological sites [19]. As far as tourism is concerned, Medina [20] uses multiple dimensions of the context, including the location, the device, the user profile, the network and the time for triggering the presentation of hypertextual information. The iLand platform [21] delivers to mobile users geolocalized content related to the oral culture and traditions of the island of Madeira. In [22] the user history is used for enabling proactive presentation of content in a virtual fair. The available implementations for the educational domain often limit the use of the context to the location [8] [11], for delivering appropriate content and augmenting the user engagement. The importance of the location for the user engagement is underlined in [10] also for the authoring phase: the curators that prepared the content for the children involved in the exploration of the Chawton House stressed that they could make a rich and detailed audio recording related to a specific location only because they were there. Engagement and stimulation of the user emotions are becoming important parameters of the user experience as the interaction paradigms shift from the traditional working environment and melt with the everyday life. For expressing the attention to these new aspects, Picard coined in 1995 the term “affective computing”, for denoting “computing that relates to, arises from, or influence emotions” [23]. As far as storytelling and education are concerned, StoryFaces [24] is an interesting project that tries to augment the emotional engagement of the children permitting them to record facial expressions that become part of the narration. We share with the research related to affective computing the interest for the design of computing systems that permit to influence the emotional engagement of users. That is the reason why in our work we designed a software architecture that uses not only the location, but also an additional number of context dimensions for augmenting the user engagement, with the final goal of obtaining educational benefits.

III. THE STORY MODEL

For the whole project we refer to a story model adapted from the work of the Italian researcher Cesare Segre [2] and described in [25]. The model is based on the identification of the “stages” where the narration happens and the association of narrative fragments of the story to these locations. A story is composed by one or more ordered stages. The author of the
story, during the composition of the stages, decides the values of the context parameters for the delivery of the narration, that include the time, the season, the weather and the number of listeners. Fig. 1 shows the iconic representation of the context parameters used in the project. For example, the author may decide that a given story may be delivered when the user enters the locations of the stages, but only at twilight, in autumn, when is cloudy and when alone. The aim is to augment the emotional impact of the narration, associating the delivery of the content only to those context conditions that can increase the involvement of the listeners.

IV. THE SOFTWARE ARCHITECTURE

The client-server architecture for the creation and the delivery of stories has been designed starting from the story model summarized above. The architecture, represented in Fig. 2 at a very high level of abstraction, features a web-based application server for managing the different phases of the story's lifecycle. All the stories, created by different authors, are stored in a database connected to the server. Three different clients (i.e., two tablet apps and a web application) connect to this server for managing the creation, the editing and the delivery of the narration. The first client from the left is a tablet app that enables the story author to create the story outdoors and communicate to the server all the story data, including the GPS location of the story stages. The story author in this phase specifies also the contextual parameters for the delivery of the narration. The second client is a web application, accessible from any standard web browser, that enables each author to retrieve the data of his stories created outdoors, to modify and finally to publish the narration. The third client is a tablet app for delivering the stories in the locations where they have been created. The app allows to search all the stories available in the repository and published by their authors, starting from the ones that are near to the listener's current location. The context values indicated by the authors during the creation of each story are matched with the current values retrieved from the app (i.e., the location, retrieved through the GPS embedded into the device, and the other context values, retrieved from a set of web services). By default only the stories characterized by a positive matching can be delivered. Most of the implementations were realized using web technologies, for porting them to different systems. The adoption of the Phonegap framework [26] enabled us to implement the tablet apps as web applications embedded in native shells. Phonegap, available for most of the modern mobile platforms, enabled also the access to the hardware of the mobile devices, such as the GPS, the camera and the microphone that ordinarily can't be accessed by a web application. The adoption of this platform permitted to couple a rapid development of the client interfaces and the ease of delivery for different platforms and devices.

V. THE VISUAL INTERFACES

All the interfaces of the system have been designed and implemented using a user-centered approach, discussing and progressively refining them through a constant dialogue with the teachers of the class that was involved in the project.

A. The mobile app for authoring on the field

This mobile app enables the author to create a story on the field from scratch. The app resulted from an iterative development cycle shared with the teachers, characterized by a special attention to the use of lexical terms and visual representations easy to understand. The final interface (see Fig. 3-1) permits to select different types of narrative structures and to compose incrementally the different stages that are part of the narration. The main interface (see Fig. 3-2) allows to specify all the components for a given stage: the audio content, the images of the location and of the characters, the context values for the delivery. The selection of the icons representing the context values for the delivery of the stage content is associated to funny audio fragments (e.g., the sound of the rooster for the selection of the dawn), for augmenting the user engagement. The application accesses the tablet camera for gathering the required images: the story cover, the authors' photo, the characters' representations and the photo of the locations associated with the stages. The GPS location is automatically logged when the user takes a snapshot of the stage location. The composition process is iterated for each stage of the story, until the end of the narration. The application features also a map view, based on Google Maps, that permits to visualize the recorded stages as a set of flags connected by arrows and to preview the recorded content.

B. The web application for editing the stories

While the first app was meant for capturing the creativity of content creation outdoors, the web application was designed for giving the users the opportunity to improve the quality of the recorded content in classroom or at home. This web application is accessible from any HTML5 web browser and permits the registered authors to access his own stories and preview them on a map, where the stories' stages are represented as numbered flags connected by arrows. A simple interface permits to edit all the components of the stories, including the context values for the delivery of the narration, and to publish the final version of the narrations.
C. The mobile app for listening on the field

This novel mobile app permits to listen to the stories in the locations where they have been created, guiding the users to the different stages and delivering the appropriate content. For improving the engagement of the listeners, by default only the stories matching all the current context conditions (location, weather, time of the day, season, number of listeners) are available. An interface widget can however be used for making available also the stories matching only the location of the listener. This latter possibility was introduced in the context of the educational experience, for having a feedback by the children about how they perceived the importance of the different context dimensions for the delivery of the narration. When a story is selected, the interface (see Fig. 4-1) guides the listener towards the first stage, using a visual arrow pointing towards the location, a numerical label showing the distance and an audio signal whose frequency augments as the user gets near to it. Content is automatically delivered when the user enters the stage: the narration starts, while the visual interface displays the image and the characters associated to the stage (see Fig. 4-2). The process is iterated until the last stage of the story is reached. At the end of the story the users are invited to assign a score and to record an audio comment.

VI. The Educational Project

The software architecture was experimented in an educational project, articulated in five phases. The teachers, rather than adopting our methodology and system, were deeply involved in the design process, since the early discussions with them about the context-aware story model to the design of the interfaces for the creation and the delivery of the narrations. They fully participated to the experimentation, leading the first phase of the project and collaborating to all the other ones. They modeled their educational work for enabling a smooth integration of the new educational concepts with the traditional ones (e.g., the traditional story model that usually is not driven by the context), respecting the timing but widening the scope of the traditional curriculum. From the teachers we received precious indications about the skills of the children and what we could expect from them in terms of learning. We must however point out that the introduction of novel educational concepts, the integration of digital and traditional technologies, the combination of classroom and outdoors learning produced a new mix that surprised even the teachers, especially in terms of creativity, collaboration and social inclusion. More details are available in Section VII.

A. Writing stories in the classroom

In the first phase, carried out during the two initial months of the first semester, the 19 children aged 7 learned to compose and illustrate stories in the traditional fashion, using paper and pencils. The children - supported by their teachers - learned the basic components of the story structure, focusing on the locations and on the characters. They were encouraged to describe the different dimensions of context that characterized the story, as an exercise preliminary to the introduction of the novel story model in the next phase. The class was organized in 6 groups (2 groups of girls, 3 groups of boys and 1 mixed group) that were maintained for the entire project. Stories were created both in the classroom, where the children worked in groups, and at home, where the children created the stories alone.

B. Composing stories in the classroom with visual tools

In the second phase the children were guided to compose a story, compliant with the context-aware story model, starting from: a poster representing an inspiring scenario; a set of adhesive visual icons representing the different types of story stages and the different values of the context dimensions; a set of adhesive blank sheets for writing the content and drawing the characters associated to the stages. The goal was to give to the children a structured vision of the story components, permitting them to get acquainted with the set of symbols (see Fig. 1) that they would have used also in the following phases of the project. Each group worked autonomously in the classroom with a different copy of the scenario, composing stories with different structures, including the simple single stage story, the story based on a sequence of stages and the story with a branching structure. The children composed each story positioning on the poster (see Fig. 5) the stage icons associated with the locations of the narration and the related components (the written content, the drawings of the characters and the icons representing the values of the four context conditions). Overall the children worked in the classroom for...
about eight hours partitioned in two different days. This activity was very useful for giving the children a deeper comprehension of the story structure, in particular for what concerned the splitting of the narration content in stages. Besides, the children learned the concept of context-awareness related to the delivery of content. Most groups associated to the stages context values compliant with the mood of the narration, aimed at underlying its emotional quality.

C. Composing stories outdoors with a tablet

In the third phase the children created the stories outdoors, using the first tablet application. We chose a park near to the school site as the inspiring scenario for the creation of stories. The park featured a small lake, a green area for sports and a wood named “Magic Wood” because a local artist decorated its trees and stones with fairy representations. The outdoor sessions were performed in two different days in the middle of December. Two groups worked in parallel in each session, that included an initial briefing and visit to the park area, the creation of a story with a single stage, the creation of a sequential story and an individual post-test questionnaire. Each group worked independently for the creation of the stories, supervised by one researcher and one teacher. Each group was provided with a tablet, paper and pencils. We established a support protocol that graduated the help from a simple invitation to examine more carefully the interface to practical demonstrations. In most cases however the simple invitation to consult the interface more carefully was sufficient for letting the children to proceed with their task. Each group worked for about two hours and was able to complete the task. The number of stages for the sequential stories varied from group to group, ranging from two to four stages. Overall, 12 stories were created in different locations of the park area (see Fig. 8).

D. Editing stories in the classroom with a web application

The fourth phase was carried out in the computer lab of the school after a few months from the outdoor experience, in the second semester. The goal of this phase was to let the children to listen to the stories created outdoors and to improve the quality of narrations. We wanted also to check if the return to a more formal environment would have caused significant effects on the stories’ structure and on the children’s behavior. Each group worked for about two hours, assisted by one researcher, for editing the stories authored outdoors. At the beginning there was a short briefing for each group, aimed at describing the goal of the session and the basic functionalities of the interface. The children worked with a laptop that was alternatively used by each component of the group. The children were initially asked to browse the content of the stories, focusing on the quality of the different components authored outdoors. After that, the children were showed how to edit the different audio and visual components of the stories. Finally the children were invited to focus on the context parameters for the delivery of narration, inviting them to confirm or to change them at their pleasure. At the end of the experiment the children were asked to fill in a short questionnaire, focused on the ease of use of the interface. Children were asked also how they would have improved it with additional features. The questionnaire included both open and closed questions based on a 3-points Likert scale.

E. Browsing the stories outdoors with a tablet

We came back to the park at the end of the second semester, for offering the children the possibility to listen to the stories that had been created by their fellows (see Fig. 7). The session was divided in two parts: in the first part the groups could select only the stories matching all the current context conditions; in the second part they were given the possibility to access also the stories matching only the location. The support protocol included an initial invitation to look more carefully at the components of the interface, a verbal explanation and finally a practical demonstration of the features. At the end of each story the groups were invited to vote it and to record a comment about the quality of the narration. At the end of the session, the children were asked to fill in a questionnaire, including both open and closed questions.

VII. FINDINGS AND DISCUSSION

The exploratory study provided interesting findings that were collected and evaluated through the direct observation, questionnaires filled in by the pupils, discussions with the teachers after the authoring sessions and the analysis of the stories created by children. The findings are summarized in relation to the three phases that involved the use of the tablet apps and the web applications. For the authoring sessions at the Magic Wood and in the classroom the analysis was focused on the acquisition of skills, the cooperation between children and the role of the context for augmenting the children engagement. For the final listening session, because of the different nature of the task, the analysis was less focused on the acquisition of new skills and more on the children engagement and the evaluation of the quality of the narrations.
A. The authoring sessions at the Magic Wood

Table I and Table II display the evaluation grid, filled in collaboratively by the researchers and the teachers, and the children questionnaire. Table I displays the scores assigned to each group (from A to F) using a 5-points scale (1=worst, 5=best). The composition of groups is represented as follows: “M” for males, “F” for females and “FM” for mixed groups. Table II displays the scores assigned by the children in the post-test questionnaire at the end of the authoring sessions. The values express the mean calculated from the scores assigned by each child using a 3-points scale. The following discussion evidences the most interesting results of the fieldtrip, derived from these tables and from all the other sources cited above.

a) Satisfying acquisition of skills for the creation of context-aware stories. The children acquired a good knowledge of the story model and successfully applied it to the creation of stories. They created the stories with a good level of autonomy, selecting the theme, the locations, the characters and all the other components of the stages. The support of the teachers was limited to some hints related to the narrative content rather than to the structure of the narration, as shown by the parameter evaluating the children independence (Table I-a1). The complexity of the stories created, measured in terms of stages and content, was satisfying (Table I-a2), given the time constraints for finishing the work. The organization of the story in stages and the association of the stages with the different locations was generally satisfying (Table I-a3). The children questionnaire (Table II-a1.-a2) is coherent with the researchers' evaluation, showing modest levels of perceived difficulty by the children for both the single stage and the sequential story, with a modest increase of difficulty for the latter one. Although most children didn't have previous experiences with the use of multi-touch devices, they generally didn't have problems in using the application (Table I-a4). When in difficulty, in most cases an invitation to examine more carefully the interface, reading all the labels for understanding how to proceed, was enough. The mobile app worked as a trait d'union between the symbolic system of icons representing the components of the story, already used in the classroom, and the practical context, providing engagement but also a structured experience. We had a confirmation about this issue when, in the few cases where there were slight differences between the icons used in classroom and outdoors, the children complained that the app interface wasn’t “correct”. In this sense the experiment confirmed the role that may have mobile devices, coupled with good design, for a valuable integration of symbolic manipulation and practical experience [11].

b) Improved levels of collaboration and inclusion. We registered good levels of collaboration between the components of the groups (Table I-b1). More interestingly, comparing the activities done in the classroom and outdoors, we registered a higher degree of collaboration for those groups that were less collaborative in the classroom work. Besides, the experiment showed also higher levels of inclusion for those children that in the ordinary classroom work seemed to be less integrated with the rest of the class. These results were confirmed also by the teachers, which compared the children behavior outdoors and the ordinary classroom activities during the year.

c) Emotional use of the context dimensions. In most cases the children selected, for the delivery of the content,
environmental and social context parameters that were coherent with the content and that aimed to augment the emotional engagement of the listeners. We noticed the highest levels of attention for the context in the groups composed by boys, but also the other groups chose carefully the context values in relation to the quality of their narration (Table I-c1). For example, the groups that chose, as theme of the story, fairy tales populated by gnomes and ogres often specified dramatic contextual parameters such as "winter", "twilight" or "storm" for the story delivery. Groups narrating scary stories required often that the narration should have been delivered to solitary listeners. Although the interface permitted to specify the delivery of the story also for all the values of the context conditions, only few groups decided to take advantage of such "neutral" choice, preferring an emotional use of the context. The result was confirmed by the answers to the children questionnaire, measuring high levels of appreciation for the possibility to choose the different dimensions of the context for the story delivery (Table II-c1 to c6).

d) In-situ authoring as a stimulus for cognitive elaboration. In spite of the fact that the park offered a number of benches and tables, the groups, after the initial exploration phase, chose to author the content in the locations chosen as story stages. Table I-c2 expresses, according to the observation of teachers and researchers, the relation between the creation of content and presence of the groups in the associated locations (i.e., the higher the number, the closer the distance). We noticed also that, during the creation of the content, many children kept on looking around the place, touching the objects that were part of the environment and trying to catch interesting details to add to the narration. Again this result is a confirmation of the importance of practical intelligence related to the discovery and to the manipulation of the elements of the location [11].

e) Good levels of engagement. The direct observation showed that the children were very engaged during the experiment. They were excited to create the stories outdoors and dedicated all their energies to this task, in spite of the low temperatures and the unfair season that we had to choose for the experiment. Children were engaged also by the multimodal features of the authoring environment, such as the audio feedback associated with the selection of the different values of the context, and by the multiple analogue and digital means to gather content. Overall, coupling outdoors and digital tools seemed to boost the children creativity and engagement.

B. The authoring sessions in the classroom

The web application received positive feedbacks for its case of use and permitted to all the groups to obtain improved versions of the stories composed outdoors. We noticed however that coming back to the classroom resulted in a minor level of engagement. In particular the males were less involved and focused on the critical revision of the stories. Most revisions were focused on the technical improvement of the content rather than to the creation of new one. Besides, the children felt the relation between the content and the context for the delivery as less urgent, because in a number of cases (13 cases out of 48) they modified the values for listening to the stories shifting towards more inclusive values (i.e. “always”).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>mean</th>
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<tbody>
<tr>
<td>a1. easiness to find the locations of the stages</td>
<td>4.1</td>
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<tr>
<td>a2. helpfulness of the visual hints</td>
<td>4.0</td>
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<tr>
<td>a3. helpfulness of the audio hints</td>
<td>3.8</td>
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<tr>
<td>b1. engagement in listening to stories in the classroom</td>
<td>3.7</td>
</tr>
<tr>
<td>b2. engagement in listening to stories outdoors</td>
<td>4.8</td>
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C. The listening sessions at the Magic Wood

We registered 30 listening sessions, derived from the selection of the 12 available stories. As stated at the beginning of the section, this session was not characterized by the acquisition of new skills, aside from learning the new browsing interface. Therefore we focused our attention on measuring more carefully the engagement and evaluating the quality of the narrations. We mapped the findings derived from the direct observation, the scores assigned by the children to the stories after having listened to them and the post-test questionnaire (see Table III) to the six factors that according to O’Brien et al. [27] define the engagement.

- Perceived usability: we considered the answers to the following issues: easiness to find the locations (Table III-a1, mean 4.1), helpfulness of the visual hints (Table III-a2, mean 4.0), helpfulness of the audio hints (Table III-a3, mean 3.8);
- Felt involvement: we considered the engagement declared by the children listening to stories outdoors (Table III-b2, mean 4.8);
- Focused attention: we measured the distance between the children that carried the tablet and the other components of the groups, using the four space zones defined in [28]; during the listening phase for 121 measures out of 144 the distance was close to the edge between the intimate and the personal distance (0.45 m.) and only in 5 cases the distance reached the edge between the social and the public distance (3.6 m.);
- Aesthetics: we considered the scores assigned by the children to the stories after the listening sessions (mean score 3.4);
- Novelty: the answers to the open questions evidenced that a number of children were surprised by the ability of the system to guide them to the locations of the stage; we may infer that the application functionalities were perceived as novel at least by a part of the users;
- Endurability: we didn't measure directly this parameter but, because O’Brien et al. [27] relate high levels of endurability to high levels of perceived usability and felt involvement, we assume good levels of endurability for our application.

The analysis of the six parameters suggests a good result in terms of engagement for the children participating to the listening experience. The parameter associated to the felt involvement received a particularly high score (mean 4.8), that
can be also compared with the lower score assigned by the children to the session in the classroom (mean 3.7), when they listened to and edited the stories with the web application. In a related open question, the children associated the outdoor engagement to the fact of being in the places where the stories were supposed to happen and of moving in the real environment, following the hints of the application. Finally, the analysis of the scores assigned by the children to stories shows that the mean score of stories matching all the user context conditions (8 stories for 19 listening sessions) was higher than that of one stories matching only the location (4 stories for 11 listening sessions): respectively 3.8 and 2.7. Resuming, also the listening sessions displayed the positive effects of Castor for what concerned the engagement and the quality of the experience in an educational context.

VIII. CONCLUSION

In this work we discussed the design and the experimentation in an educational context of Castor, a social platform for context-aware storytelling. The mobile platform implemented a novel story model meant to improve the engagement of the listeners through the use of an extended set of context dimensions. We used this platform in the context of an educational experience for checking if the possibility of proposing a structured experience outdoors and the use of an engaging story model would have produced results in terms of learning or other interesting parameters. The study produced significant results in terms of acquisition of new skills. Compared to traditional classroom activities, the analysis of outdoors activities revealed higher level of engagement, creativity, cooperation between children and social inclusion. The availability of a digital tool for creating stories, installed on a mobile device but modeled on the structured experience designed for the classroom, permitted to bring a structured learning process outdoors, taking advantage of the benefits given by this more informal environment in terms of collaboration and inclusion. Concluding, while the learning benefits of Castor deserve further investigations, we may infer from the experimental study that this architecture had a positive role on bridging the gap between the educational experiences performed in a formal classroom context and outdoors.

REFERENCES