Educational games on a large multitouch screen

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Abstract— **Understanding how technology, coupled with skillful pedagogical solutions, can help to innovate and improve learning at school is the main goal of the "Learning for All" (L4A) research project. The combination of educational games and advanced technology has the potentiality of arousing pupils' attention, also engaging them in learning activities while having fun. This paper presents two educational games available through a large multitouch displays installed in the hall of a primary school. Such games aim at stimulating pupils to exercise their knowledge about history and geography. Field studies have been planned to study both educational and social aspects about the interaction with such games.**

Educational games; educational experience; multitouch displays; pupils

I. INTRODUCTION AND MOTIVATION

Capturing students' attention and engaging them in learning activities performed through electronic devices is very challenging. Gameplay is a promising solution [1, 2], especially if proposed through newfangled devices, which have the potentiality of arousing pupils' curiosity.

The research reported in this paper is part of "Learning for All" (L4A), a research project funded by the Italian Ministry. The main goal of L4A is to understand how technology, coupled with skillful pedagogical solutions, can help to innovate and improve learning at school. The project is carried out by seven partners, representing different institutions covering different fields of expertise: education and technology, mainly (further details can be found in [3]). The role of our research group in L4A is to design educational experiences based on advanced technology. In particular, we have proposed excursion-games on cell phones for supporting pupils visiting archaeological parks [4]. Field studies have demonstrated the learning effectiveness of excursion-games, which have been greatly appreciated by the teachers of the classes participating in the studies; they noticed that this game approach is able to engage pupils' interest in studying the historical site and that the notions learned seem to remain longer in their memory [2]. More recently, we are designing educational games on multitouch screens, which allow pupils to actively collaborate to solve the proposed challenges, manipulating by hand gestures the objects displayed. Thus, such games foster relational skills. Each pupil can carry out the activities s/he feels most congenial and, by working together on different parts, the whole group can solve the clues offered in the game and overcome difficulties thanks to their joint efforts. Thus, these games also foster the team spirit.

In [5], we have presented an early prototype of History-Puzzle, a game that asks participants to complete puzzles representing 3D models of historical monuments. History-Puzzle has been conceived to integrate the excursion-game experience of pupils visiting archaeological parks. Showing such 3D reconstructions it helps pupils to create a correct mental representation of the original environment, since in the park pupils are faced with ruins of ancient settlements that have lost their original image and whose current appearance no longer reflects their initial purpose. However, during the field studies, we have observed that pupils do not devote so much time to the 3D features, because they are engaged in rushing along the gameplay. Interacting with History-Puzzle represents a reflection phase, distinct from the true excursion-game, which allows pupils to reflect on their game experience.

An improved version of History-Puzzle is shown in this paper, together with EuroFlags, another educational game about the political geography of the European Union. We are going to investigate the impact of these games (another game is described in [5]) once used in the field, by planning some empirical studies in primary schools in Bari, Italy. We will study educational as well as social aspects of the interaction with such systems, by observing pupils' behavior and by interviewing teachers. The aim is to investigate if and how the presence of the multitouch screen influences their teaching and/or pupils' learning experience.

The paper has the following organization. Section II motivates the use of educational games. Section III describes two educational games on multitouch screen. Section IV illustrates field studies we are organizing and their goals. Section V concludes the paper.

II. RELATED WORK

Game is amusing and fun. Enjoyment is important when endeavoring to achieve teaching goals, because what is enjoyably learned is less likely to be forgotten. A second important aspect of gameplay is that it requires different skills to be deployed simultaneously, and each player can practice those skills felt to be most congenial. Another

important point is that gameplay is a relational activity: it encourages group activities, stimulates collaboration, helps with conflict management and is an excellent tool for individuating relational problems [6-9].

The motivating nature of gameplay pushed towards its use for educational purposes, rather than just for pure entertainment. The term *computer-based edutainment*, i.e. education in the form of entertainment, to let people to reach their learning goals by having fun [10], well expresses this concept. Empirical studies indicate the educational potential of interactive games (see for example [1]), primarily to teach mathematics [11-13], physics [14], logic [15], music [16], science [17], shape writing [18], art [19], and history [2, 20].

To the best of our knowledge, proposals of educational games on large multitouch screens are not reported in literature, while several learning applications have been proposed on tabletop displays. Tangible Interfaces for Collaborative Learning Environments (TICLE) strives to find new ways of helping children to learn math and science concepts [21]. Cmate is a tabletop collaborative concept mapping system, which aims at providing a means for a learner to externalize knowledge of a particular domain; Cmate fosters the development of strategies for organizing knowledge and facilitating communication of understanding [22]. The Augmented Knights Castle (AKC) offers children with autism the possibility to configure programmable elements allowing greater individual control and more socially oriented behavior [23].

III. EDUCATIONAL GAMES ON MULTITOUCH SCREEN

This section presents two games to be played by young students interacting with a multitouch screen to reinforce knowledge learned during class lessons. The scenario is that the multitouch system is in a hall of the school and students have free access to it during breaks (see Figure 1).

Figure 1. Two pupils interacting with History-Puzzle on the multitouch screen in our laboratory.

A. *History-Puzzle*

The name of this game comes from the fact that participants have to complete different types of puzzle. For example, the application proposes the map of an ancient city, referred to a specific age, and players have to complete it by placing the tiles representing the monuments/buildings that were present at that time. Another type of puzzle can be completed by putting together the two parts of a phrase reporting an historical notion related to an ancient site. For example, by referring to the game designed for the archaeological park of Egnathia, in Southern Italy, when a player touches one of the images representing a puzzle, such as the Via Traiana, a screen like the one shown in Figure 2 appears. The figure to be discovered by solving the puzzle is in the center of the screen, covered by nine incomplete messages about the selected place. The player chooses the rest of the sentence from the tiles displayed outside and drags it into one of the nine boxes in the central zone. If the selected association is correct, the box will reveal one ninth of the image of the 3D reconstruction of the original place. Figure 2 shows what it looks like when the player has discovered 5/9 of the image.

Figure 2. 5/9 of the "Via Traiana" puzzle have been completed.

In order to increment the difficulty of the game, many tiles are shown; these additional tiles report false answers or answers that do not match any of the nine incomplete sentences currently displayed. When the nine descriptions have been completed and the whole image is displayed, a 3D animated reconstruction of the place will appear. The system also reproduces contextual sounds, e.g. noises of the typical activities carried out in that place when the civilization of Egnathia was alive. In the example in Figure 2, showing the Via Traiana where carts run constantly, the noise of the wheels on the pavement is heard. Finally, the system returns to the map of the park to allow the participants to complete the puzzles of the other places.

For stimulating students to come back to the multitouch screen again, the position of incomplete messages and completing tiles is randomly reassigned every time the puzzles are run. Also the content displayed in such elements changes, thus proposing new challenges to the players.

B. *EuroFlags*

EuroFlags is primarily targeted at elementary and middle school students, who can engage in the game to test their knowledge on the capital, the geographical position and the

flags of each of the European states. Players can choose among four game modalities:

- **Play with capital cities**: player has to put together the capital city proposed by the application and the corresponding country on the map.
- **Play with flags**: player has to put together the flag proposed by the application and the corresponding country on the map.
- **Play with countries**: player has to put together the country proposed by the application and its corresponding position on the map.
- **Mixed**: the application randomly switches among the previous modalities.

Figure 3. EuroFlags: "Play with flags" modality.

Let us suppose the player has chosen "Play with flags" modality. In the box on the right of Figure 3, EuroFlags is asking "Which country has this flag?", also showing the Andorra's flag. To answer the question, the player has to touch the blue point between Spain and France, which represents the Andorra country. S/he scores 3 points at the first attempt, 1 point at the second; after that, s/he fails and a red cross substitutes the blue point representing Andorra, while EuroFlags will not pose the question about Andorra again. Besides the question and the flag, in the box further information about the current match is displayed: the score (38 points), the hints available (3) and the stage (19 answers given *vs*. 46 questions available). If the player is stuck, s/he can ask for hints by touching on the green button showing a question point. A couple of examples of hints are: "It borders France and Spain"; "It is on the Pyrenees Mountains". The thumbnail flags on the map indicate correct answers the player has already given (e.g. Norway, Finland, Germany, etc.).

IV. THE ON-GOING EVALUATIONS

Preliminary studies on History-Puzzle and EuroFlags with pupils in our laboratory (formative evaluation [24]) have confirmed that they find this novel technology highly engaging. We are now planning more extensive evaluation studies to understand their impact once used in the field. A 47 inches LCD multitouch screen proposing the two games will be placed in the hall of a primary school in Bari, Italy. Through this public display, pupils can interact both with History-Puzzle and EuroFlags during the breaks. The field evaluations we are going to carry out will address both educational and social aspects.

A. Educational aspects

Both History-Puzzle and EuroFlags are educational games to be played by young students interacting with a multitouch screen. They are designed to reinforce knowledge learned during traditional class lessons; students could also interact with History-Puzzle after a possible visit to an archaeological park. The aim of the proposed games is to allow students to exercise the historical/geographical knowledge previously acquired, also discovering their gaps.

Understanding the "value" of an educational experience and analyzing how this value was achieved can be difficult, much beyond what it can be expected at first sight. This difficulty is especially relevant when some degree of innovativeness (in technology or pedagogy) is introduced, since unknown paradigms are at stake, and "what determines what" is less obvious [25]. There is a list of questions, apparently easy but very difficult to answer in practice: What did the pupils learn? Did they acquire specific knowledge or skills? Did they change their attitude and motivations? Did something not trivial begin? How was the technology used and when? How were the pupils instructed, how was technology made available?

Because we want to understand in detail what goes on in the class, questionnaires, with predetermined questions and predetermined answers, seemed too rigid and confined. Thus, interviews to teachers seemed the most suited method of research. The L4A educational partners set up a procedure aiming at making up a "dossier" of the educational experience: teachers are interviewed on expectations before the beginning of the experience; then, they carry out the educational experience and report, on a 'day-by-day' diary of observations, few notes, taken every day, about what went on and the most relevant facts and anecdotes. After the experience's completion, teachers are interviewed again for understanding what actually happened, how the experience was conducted and which were the outcomes in terms of learning, inclusion, etc. Relevant features are then "extracted" from each interview, by means of a schema, which helps in synthesizing all the interesting aspects of the educational experience.

B. Social aspects

Previous studies (see for example [26]) report that it is hard to entice people to interact with public displays; social embarrassment is the key factor which determines whether people will interact in front of an audience. Brignull and Rogers performed two field studies examining several

variables: the flow of people around public displays; the level and types of interaction around displays; the transitions between types of interaction; factors that cause social awkwardness and embarrassment around public displays. They observed that interaction with public displays is accepted if the displays have strong physical and social affordances, which allow people to rapidly understand the purpose of the social activity to be performed at the display [26]. Our users are represented by pupils and we want to observe if they will be embarrassed as adults usually are, or if they will use the multitouch display as a stage for showing their skillfulness.

Other studies also investigated social aspect of adults interacting with multitouch public displays; for example, Jacucci et al. considered aspects such as the dynamics of approach (how people notice that there is an interactive display) [27]; the interaction at the display with others (parallel use, teamwork, and playful activities); conflict management; transitions between activities and participants (floor and turn-taking); roles and social configurations. It will be interesting to observe how pupils approach, participate, and interact with the multitouch display installed in the hall of the primary school in Bari, and to compare the results of our field studies with those reported in [27].

V. CONCLUSION

This paper has presented the work we are carrying out about educational games on large multitouch screens. History-Puzzle and EuroFlags have been described, which are two games about history and political geography, respectively. Formative evaluation has confirmed that pupils find games on multitouch screens highly engaging. In order to further investigate educational and social aspects related to the experience of interacting with the proposed system we are going to install a multitouch screen in a primary school in Bari.

ACKNOWLEDGMENT

Partial support for this research is provided by Italian MIUR through grants "L4A" and "CHAT".

REFERENCES

[1] F. Garzotto, "Investigating the educational effectiveness of multiplayer online games for children", *Proc. Int. Conference on Interaction design and children* (IDC'07), ACM, pp. 29-36.

[2] M.F. Costabile, et al., "Explore! possibilities and challenges of mobile learning", *Proc. 26th annual SIGCHI conference on Human factors in computing systems* (CHI'08), ACM, pp. 145-154.

[3] L4A, "Learning for All (L4A): a multi-paradigm, multi-channel and multi-tecnology approach to innovative pedagogy," http://www.learningforall.it/.

[4] C. Ardito, et al., "Experiencing the Past through the Senses: An M-Learning Game at Archaeological Parks", *IEEE Multimedia*, vol. 15, no. 4, 2008, pp. 76-81; DOI 10.1109/MMUL.2008.87.

[5] C. Ardito, M.F. Costabile and R. Lanzilotti, "Gameplay on a Multitouch Screen to Foster Learning about Historical Sites", *Proc. Advanced Visual Interfaces* (AVI'10), ACM, pp. 75-78.

[6] I. Blecic, A. Cecchini, P. Rizzi and G.A. Trunfio, "Playing with Automata. An Innovative Perspective for Gaming Simulation", *LNCS 2493*, Springer-Verlag, 2002, pp. 337-348.

[7] J.P. Gee, "What video games have to teach us about learning and literacy", *Comput. Entertain.*, vol. 1, no. 1, 2003, p. 20.

[8] M. Prensky, "Digital game-based learning", *Comput. Entertain.*, vol. 1, no. 1, 2003, p. 21.

[9] D. Shaffer, *How Computer Games Help Children Learn*, Palgrave Macmillan, 2006.

[10] Z. Pan, "E-learning and game", *Computers & Graphics*, vol. 30, 2006, pp. 1-2.

[11] C. Conati and X. Zhao, "Building and evaluating an intelligent pedagogical agent to improve the effectiveness of an educational game", *Proc. 9th International Conference on Intelligent User Interfaces* (IUI'04), ACM, pp. 6-13.

[12] F. Ke, "Classroom goal structures for educational math game application", *Proc. International conference on Learning sciences* (ICLS 2006), Intern. Society of the Learning Sciences, pp. 314-320.

[13] N. Shin, C. Norris and E. Soloway, "Effects of handheld games on students learning in mathematics", *Proc. 7th International Conference on Learning Sciences* (ICLS 2006), International Society of the Learning Sciences, pp. 702-708.

[14] K. Squire, M. Barnett, J.M. Grant and T. Higginbotham, "Electromagnetism supercharged!: learning physics with digital simulation games", *Proc. 6th Int. Conference on Learning Sciences* (ICLS 2004), Int. Society of the Learning Sciences, pp. 513-520.

[15] R. Lanzilotti and T. Roselli, "An Experimental Evaluation of Logiocando, an Intelligent Tutoring Hypermedia System", *Int. J. Artif. Intell. Ed.*, vol. 17, no. 1, 2007, pp. 41-56.

[16] G. Denis and P. Jouvelot, "Motivation-driven educational game design: applying best practices to music education", *Proc. International Conference on Advances in Computer Entertainment Technology* (ACE 2005), ACM, pp. 462-465.

[17] Y. Rogers, et al., "Ubi-learning integrates indoor and outdoor experiences", *Commun. ACM*, vol. 48, no. 1, 2005, pp. 55-59.

[18] P.O. Kristensson and S. Zhai, "Learning shape writing by game playing", *Proc. 25th annual SIGCHI conference on Human factors in computing systems* (CHI'07), ACM, pp. 1971-1976.

[19] J.S. Cabrera, et al., "Mystery in the museum: collaborative learning activities using handheld devices", *Proc. 7th International Conference on Human Computer interaction with Mobile Devices* (MobileHCI'05), ACM, pp. 315-318.

[20] K. Kardan, "Computer role-playing games as a vehicle for teaching history, culture, and language", *Proc. Sandbox - ACM SIGGRAPH symposium on Videogames* (Sandbox 2006), ACM, pp. 91-93.

[21] L.L. Scarlatos, "TICLE: using multimedia multimodal guidance to enhance learning", *Inf. Comput. Sci.*, vol. 140, no. 1, 2002, pp. 85-103.

[22] R.M. Maldonado, J. Kay and K. Yacef, "Collaborative concept mapping at the tabletop", *Proc. Interactive Tabletop displays* (ITS 2010), ACM, pp. 207-210.

[23] W. Farr, N. Yuill, E. Harris and S. Hinske, "In my own words: configuration of tangibles, object interaction and children with autism", *Proc. International Conference on Interaction Design and Children* (IDC'10), ACM, pp. 30-38.

[24] J. Preece, Y. Rogers and H. Sharp, *Interaction Design*, John Wiley & Sons, Inc., 2002.

[25] P. Paolini, et al., "Assessing and Sharing (technology-based) Educational Experiences", *Proc. World Conference on Educational Multimedia, Hypermedia & Telecommunications* (Ed-Media'11). In print.

[26] H. Brignull and Y. Rogers, "Enticing people to interact with large public displays in public spaces", *Proc. INTERACT 2003* (Enticing people to interact with large public displays in public spaces), IOS Press, IFIP pp. 17-24.

[27] G. Jacucci, et al., "Worlds of information", *Proc. 28th International conference on Human factors in computing systems* (CHI'10), pp. 2267-2267.