DESIGNING PDA MEDIATED EDUCATIONAL ACTIVITIES IN THE FRAME OF A MUSEUM VISIT

ABSTRACT

The research aim presented in this paper, is to design a class of exploratory, constructivist and collaborative educational activities, mediated by handheld computers while visiting a museum. Design decisions are affected from pedagogical, technological and contextual issues which shape the possible design space. Our goal was to create a class of activities that give the students the opportunity to harvest information from artifacts that provided little interaction in the past, collaborate and actively explore the museum area in a personal way. To clarify our decisions which constitute the proposed approach for constructivist educational activities using handheld computers, we outline the general setting, the interaction model presented to the students in order to use efficiently the mobile devices and the pedagogical goals under the prism of activity theory which propels our decisions. A derived instance of our approach, named ‘inheritance activity’ was introduced to the students in a case study under real conditions. Results of the case study helped us to refine our design decisions and are discussed into detail in the following.

KEYWORDS

Handheld computers, museum visit, activity based design, collaborative learning.

1. INTRODUCTION

Recent years, usage of mobile computing in various domains of human activities is characterized by rapid growth. The latter is observed in the educational field as well. Personal Digital Assistants (PDAs), popular until now only in the corporate area are gradually penetrating in the fields of teaching and the learning. According to Pownell and Bailey (2001), the handheld computers, could be perceived as the enablers, of a new era in the frame of computer supported educational technology. This type of technology, coupled with the ability of wireless connectivity, incarnates the vision for 'anyone, anytime, anywhere learning'. PDAs usage can substantially enrich a learning experience, since they introduce a tiny computational device with a plethora of functions which can be used in any context, serving a variety of meaningful tasks. PDAs are considered as a motivation trigger for the pupils, augmenting their attention and allowing them to engage to more meaningful to them learning activities. Both independent and collaborative learning is equally supported. Additionally to this, the learning paths of the students can be easily observed and monitored, thus facilitating the learning outcome evaluation process. Moreover, PDAs usage could contribute to a better school experience organization and isomorphic growth of organisational dexterities both for the students as well as for the instructive and administrative personnel of the school units (Norris & Soloway, 2004; Savill-Smith and Kent, 2003; Crawford and Vahey, 2002).

PDAs could be used as means for acquiring, storing, transmitting, editing and visualizing data and information. Consequently, they should be treated as information and communication appliances and they can be used in the frame of informal forms of education. Such a form of education, sufficiently investigated and supported nowadays through PDAs is that of a museum visit. Exploitation of PDAs in the museums is an active topic of research, with substantial coverage in the international literature. The most frequent usage of a PDA in a museum is that of supporting visitors in the form of an electronic guide, providing information on the exhibits, predetermined guided tours based upon certain thematic criteria (Raptis et al., 2005). On the other hand, there are some sporadic examples of educational applications of PDAs in museums, mainly addressed to children aged 8-15. Such an example is the MUSEX application deployed in the National Museum of Emerging Science and Innovation in Japan. This application is a typical drill and practice educational system, addressed to young children aged 5-11 which work collaboratively in pairs and are challenged to answer to a number of questions. The children have in their disposal a PDA equipped with RFID reader, capable to extract information from the exhibits which select to focus upon. Afterwards reading the digitally attached information of each exhibit, a question is presented in the screen with four possible answers.

The screen of the application is separated in 12 white parts which hide an element for the final question of program. The children have to answer correctly in the questions in order to reveal all 12 parts and subsequently the description of the final question, required to be answered to complete the activity. Both students of a team share the same screen. When a student answers correctly a question, the piece is revealed in both pdas, but if an erroneous answer is given then her collaborator cannot answer the same question. The collaborators can physically communicate and discuss their opinions, or via transceivers in the case that are located in different areas of the museum. After the end of the activity, the participators have the possibility to track their initial path followed in a relative website. According to the authors of the application, the users have the possibility to interact deeply with exhibits that did not allow extensive examination. Additionally to this, the participants could review the progress of her partner, ask for help or discuss with her elements of the procedure. Some issues occurred were related to the need to communicate with the personnel to clarify issues about exact transceiver operation, and occasional ignorance of useful detail provided by the system which could help them to answer efficiently a question (Yatani et al., 2004).

Another prominent example of educational usage of PDAs in the frame of a museum visit is the bunch of applications developed for the Exploratorium, a science museum in San Francisco. In this museum, the visitor has the possibility to manipulate and experiment with the exhibits, although the tour and recognition of each exhibit is not an easy task. A separate class of exhibits does not allow to be manipulated by the visitors, but stimulates observation and reasoning upon them. An electronic guidance was realized which provides information for the exhibits, for the phenomena related with them and relative questions for deeper visitors' engagement (Hsi, 2002). Other supportive applications are also provided, such as Rememberer which allow visitors to record their visit path and re-experience it through museum's website (Fleck et al., 2002).

Another approach is presented through the Scavenger Hunt Marriage activity used in the Chicago Historical Society Museum (Kwak, 2004). In this case, the children are challenged to answer in a series of questions related to the exhibits of museum referring to the local region history. They undertake the role of a historical researcher and they are called to answer correctly in 10 multiple choice questions. The questions are presented randomly or are related with certain topics according to the user preferences. The user has to read the information provided in every exhibit prior answering to a question. Additional hints are provided to the user, if requested, first in the form of supplementary information related to the question and subsequently by pointing out the exhibit which facilitates question answering. Each user is individually engaged in the activity, and his progress is evaluated in a way similar to that of electronic games, thus enhancing her motivation to engage to the activity.

The goal of this paper is to describe a design paradigm for educational activities using pdas in the frame of a museum visit. The aforementioned context is undoubtedly rich in learning opportunities and could be further enhanced with proper integration of mobile technology (Gay et al., 2002). However, we argue that proper decisions should take into account a solid theoretical cognitive framework, as well as the particularities of mobile devices and challenges presented by such an informal learning setting. In the following, the design approach adopted to create the class of exploratory activities is presented. Our goal was to create an activity that gives the students the opportunity to access information from artifacts that provided little interaction in the past, collect and manage meaningful information related to them, collaborate and actively explore the museum area in a personal way. The initial approach, has been refined through a small scale controlled observation session, and has been further tested in real conditions using representative students. The results of the study are promising and are discussed in detail.

2. ACTIVITY DESIGN

Our decisions for the design of the activity were deviated from three basic factors: the particularities of the *museum context* where the activity is to take place, the affordances of the *mobile technology* to be used with its special characteristics, and the goals of the *educational approach* to be followed. The activity was designed to support a visit in a historical museum, named Museum of Solomos and Eminent Zakynthians, located in Zakynthos, Greece. The majority of the exhibits are paintings and personal objects of the national poet of Greece and other important people of the area. These are objects that allow very little interaction. The visitor cannot touch them or experiment with them. The material we had in our disposal to use in the activity was comprised of documents and biographies referring to the life and work of the people represented in the paintings or owners of the exhibits.

The aforementioned museum context is undoubtedly rich in learning opportunities and could be further enhanced with proper integration of mobile technology. As a result, a visit supported and mediated by mobile devices could trigger the learner's motivation in various ways: by stimulating her imagination and engagement giving sufficient opportunities to reorganize and conceptualise historical, cultural and technological facts in a constructivist and meaningful manner. The adoption of a proper *interaction model* is of fundamental importance for the overall effectiveness of the presented architecture. An effective interaction model between the student and the PDA, should augment physical space with information exchanges, allow collaboration and communication and enhance interactivity with the museum exhibits by seamless integration of instantly available information delivered in various forms. However, the synergy between technology and pedagogy is not straightforward, especially if we take into account the need to tackle issues such as efficient context integration, transparent usage of the PDA, and novel pedagogical approaches to exploit the capabilities of the mobile devices.

Our extensive research of various interaction models used in indoor museum applications (Raptis et al., 2005), showed that three issues are critical to adopt an effective model. Those are, effective and efficient *positioning and context awareness* methods and models to present useful information to the user with respect to the information communicated to him/her by the environment, models to *invert the flow of information*; concerning context of use in mobile device, and finally *contextualization* and *personalization* of information according to personal needs, and instant presentation to the user rather than having her searching endlessly for needed information. Results of our research, showed that the model balancing most effectively the aforementioned requirements is that of using RFID tags to identify the exhibits, using an RFID reader in the pdas to ‘scan’ them. Communication between the visitors, and data delivery is achieved through Wi-Fi infrastructure. When an exhibit is scanned, the PDA sends a request for information to a server. The server delivers appropriate content, for the desired exhibit, presented in the form requested by the user according to her needs (e.g. age, specific interests, etc). Data exchange between two users, whenever desired, is accomplished through alignment of their devices and pointing the one to the other, thus mimic the exhibit scanning procedure.

In order to validate appropriateness of the technology used in the activity for the young pupils, we studied how easily they could take advantage of them even without having prior experience. According to Inkpen (1999), the design of handheld technology for children must not follow models used for adults. Therefore, some child-centered research was required to determine the right models. For this reason a preliminary study took place. 5 children, aged 8 to 10 participated in the study. Only one had prior PDA experience. They were given a PDA using Windows Mobile OS and they were asked to carry out a series of tasks after a short demonstration by the researcher. They were asked to paint, write a short text, read a text in a form of eBook, play games and browse on their own the capabilities of the PDA. The children did not experienced significant difficulties in using the PDA. They showed great interest and desire to use this kind of appliances in their every day life. The only task they found extremely difficult to handle was the input of text by using an onscreen keyboard. The results of this study drove us to discard the possibility of requesting text input from the users during the activity. Additionally to this, our approach had to confront with the technological and usage limitations presented by the PDAs. For instance we took into account, research results reported by Hayhoe (2001), which stated that the most significant design restrictions of palmtops are the small display screen, and the limited brightness and contrast. Therefore we opted for small chunks of text since reading online at low resolution reduces reading comprehension significantly. The information presentation is extended by extensive usage of audio which distracts the user from the physical context to a lesser extent, compared to the need to focus frequently upon the PDA's screen.

The educational approach adopted was inspired by the social and cultural perspective of constructivism, and the need to engage the students into meaningful problem solving and exploratory learning activities. In the center of our design is the child which uses the PDA as a tool. Computing is ubiquitous in this activity. The emphasis on the activity was given to stimulate the pupils' imagination, allowing them to engage with information personally extracted by the exhibits, and align them towards a synergistic approach to accomplish their goals instead of just answering multiple choice questions like in other applications (Kwak, 2004; Yatani et al., 2004; Cabrera et al., 2005). The activity has been designed in a way to allow the students to use the PDAs to actively explore and harvest information related the exhibits of the museum, of complementary nature compared to that presented in the physical space. In particular, students are challenged to collect related information from a variety of exhibits through reading and storing of the clues in a notepad. Towards accomplishment of their goal, the students had to collaborate and exchange data as the teams send clues to each other. Finally, they had to engage into a problem solving process to extract meaning from the correlation of their findings.

The scenario of the activity was designed in a way that students were motivated to read information about the exhibits and collaboratively search to locate one of the exhibits, described by clues placed in information of other exhibits in the room. Students were asked to help the people of the museum to find the will of an imaginary historian that worked for years in the museum. If the children manage to find the will, all of the property of the historian will be inherited by the museum. Each team is provided with a PDA equipped with RFID tag readers. They use the PDA to extract information related to the exhibits by reading the tags attached to each of the exhibits. Initially, the children are introduced to the scenario and are prompted to exchange a certain amount of information the historian left in order to start their quest. This package of information informs the children that the will is hidden behind the favorite exhibit of the historian. Inside the description of six of the exhibits the children can find six clues that describe the target-favourite exhibit.

The first part of the activity consists of finding all of the clues. The students use the PDAs to read information about the exhibits and locate the clues inside the text of the other exhibits description. The clues are sentences beginning with the hint "this is a clue" and give information about the favourite exhibit. The application for the activity provides, besides the option of reading tags and displaying information, the possibility to store the clues found by the teams in a notepad inside the application (Figure 1). After collecting all or most of the clues the teams are able to beam their clues to each other. When every team sends its clues to the other team, all the clues appear in every team's notepad.

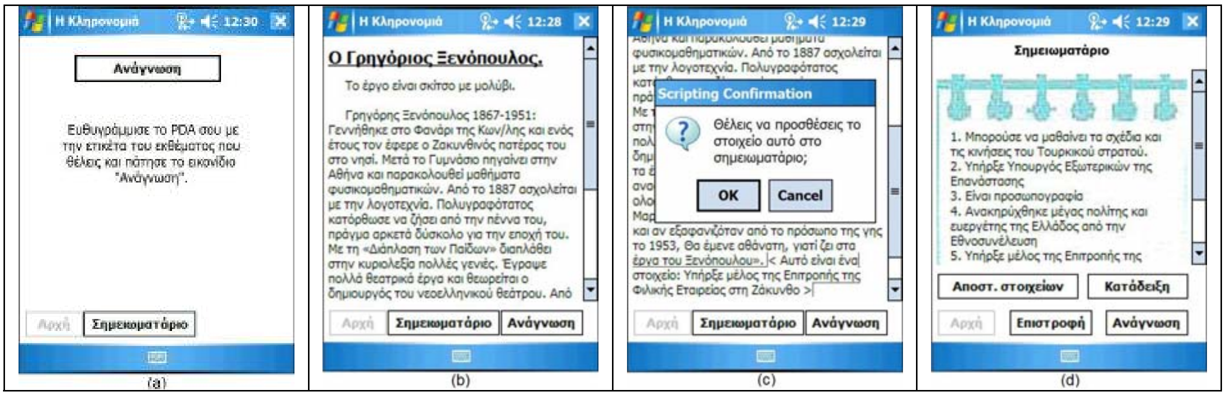

Figure 1. Screenshots of the "Inheritance" application. (a) dialogue for RFID tags reading (b) information for a selected exhibit (c) clue selection (d) the notepad screen.

In the second part of the activity, students are challenged to locate one exhibit found in the room which matches the description provided by the six clues. They can retrieve the unveiled clues from the notepad provided in the application and compare them with the description of the exhibits. When both teams agree that one exhibit is the favourite exhibit they can check the correctness of their choice by reading with both PDAs the RFID tag of the chosen exhibit. If their choice is correct the activity is completed. A screen appears in both PDAs which show a message congratulating and thanking the children for their successful effort followed by animated fireworks and a sound of clapping hands. Otherwise they are informed about their mistaken choice and are prompt to continue the search. Each team is free to move around the room and read information about any of the exhibits desired.

A pilot study to investigate the appropriateness of the aforementioned activity took place after the development of the supporting application. The study took place in a room emulating the original museum setting in which photographs of 19 exhibits were placed (Figure 2). An RFID tag was also placed underneath each photograph. Six children, two male, four female, aged 8-12 participated in the study. In every observation session, two children carried out the activity simultaneously using one PDA equipped with a RFID reader each. Data were collected through two cameras appropriately placed to monitor student's behavior. After the end of each session, the students were asked to fulfill a questionnaire and participate to a short interview to investigate their opinion about the activity and the accompanied application.

Figure 2. Children collaborating and reading tags during the pilot study

The scenario of the activity was presented briefly to the children by a member of our research team. This activity is intended for a museum where the children are able to move freely around the rooms without having always the possibility to ask for support. Our goal was to investigate possible problems, unforeseen during the design process. The children had never seen a PDA before but despite their lack of experience they didn't experienced any severe problems. They mainly experienced slight difficulties to properly align the PDAs in front of the exhibits or position it in a stable manner for the requested amount of time (about one second). All the pairs accomplished the required task, but it took more than the predicted time (45 minutes). All the children enjoyed taking part in the activity and strong collaboration activity expressed by them during their effort. They adopted unforeseen collaborative patterns of behaviour, such as using one PDA for reading the tags and the other for displaying the notepad for clues in order to compare more efficiently the retrieved clues with the description of the exhibit. Increased difficulties and weaker collaborative activity was detected in the team of the younger participants. This led us to the ascertainment that the activity is suitable to children older than ten years. As derived from the interviews and the questionnaires, the children enjoyed the procedure of collecting and managing data. The procedure appeared to be highly motivating and engaging.

3. CASE STUDY

In order to validate the implemented activity a case study took place in the real conditions of the museum. 17 children, 6 male, 11 female, aged 10, participated in the conducted case study. The students worked in groups of 4 and 5 members, a fact which is in line with the specifications of our activities (Figure 3). The experimental procedure took place into a room of the museum. RFID tags were attached to each of the 19 exhibits which were the same compared to the exhibits used in the pilot study. In order to collect rich behavioural data, a screen capturing module was embedded directly into the PDA application and 2 web cameras placed appropriately to record different parts of the room were used. We also used one video camera operated by a researcher who moved around the room, following the teams in a distance. Two mp3 voice recorders were given to one member of each team to capture their dialogues. Also the children wrote an essay about their experience one week after participating in the case study.

The children reported lack of experience in terms of PDAs usage. They showed enthusiasm and were very committed in the completion of the activity. The object of the activity was the children to find the exhibit described by clues hidden in other exhibits information. The object was not clear to the children from the beginning. A 5 to 10 minutes session took place in the beginning to explain the activity to the children. During this period of time questions were posed by the children. The goal of the activity (pointing out the favorite exhibit of the historian) was accomplished both times the activity took place. In both cases it took less time (approximately 15 minutes) in comparison with the pilot study to finish the activity.

Figure 3. Children engaged in the activity

The data collected during the experimental process were analyzed according to the Activity Theory Model. Activity theory is a group of concepts and do not consist a theory in the strict definition of the term Theory. It is mainly a conceptual tool used to study human practices from the perspective of consciousness and personal development. It is an extension of the theory of Vygotsky who supported that knowledge is mediated by cultural tools in a social context. (Kuuti, 1995; Waycott et al., 2005; Zurita & Nussbaum, 2006). It takes into account both individual and collaborative activities, the asymmetrical relation between people and things, and the role of artifacts in everyday life. An activity is seen as a system of human process whereby a subject works on an object in order to obtain a desired outcome. In order to accomplish her goal, the subject employs tools, either conceptual or embodiments. The structural components are used in our case study as axes of analysis. Those are: s*ubject*, which includes all the persons engaged in the activity, *object*, which is the scope of the activity, *outcome*, representing the desirable outcome of the activity and *tools* which are the means used by the subjects during the activity. Further axes are the *rules-roles* which are the individual or team rules that define the activity process. *Community*: The context in which the activity takes place. All the individuals engaged directly or indirectly to the activity's tasks. *Division of labor* which is the tasks division among the participants.

The inheritance activity carried out by the students is described into detail under the prism of Activity Theory in Figure 4. The tools used during the activity were categorized into *technological* and *symbolic*. The technological tools were the PDAs, RFID tags, RFID readers and the application. Despite the fact the children had never used a PDA before they did not encountered serious problems during the activity. There were some problems with the time required by the application to respond to the user's actions. Feedback was not given instantly and this confused the children in some cases. This issue mostly occurred during the exchange of clues between the teams. As for the symbolic tools, these included the written texts of information inside the application and the dialogues between the children themselves and between the children and the researcher. The data collected, showed that the children did not have problems with reading large texts that required scrolling. However, it seems they did not paid as much attention as needed to the instructions provided by the application. They asked the researcher for instructions already contained in the application. The data analysis also indicated that collaboration between the children existed throughout the activity, but most of the interaction took place during the selection of the exhibit to be read and at the end of the activity to decide which the favorite exhibit is.

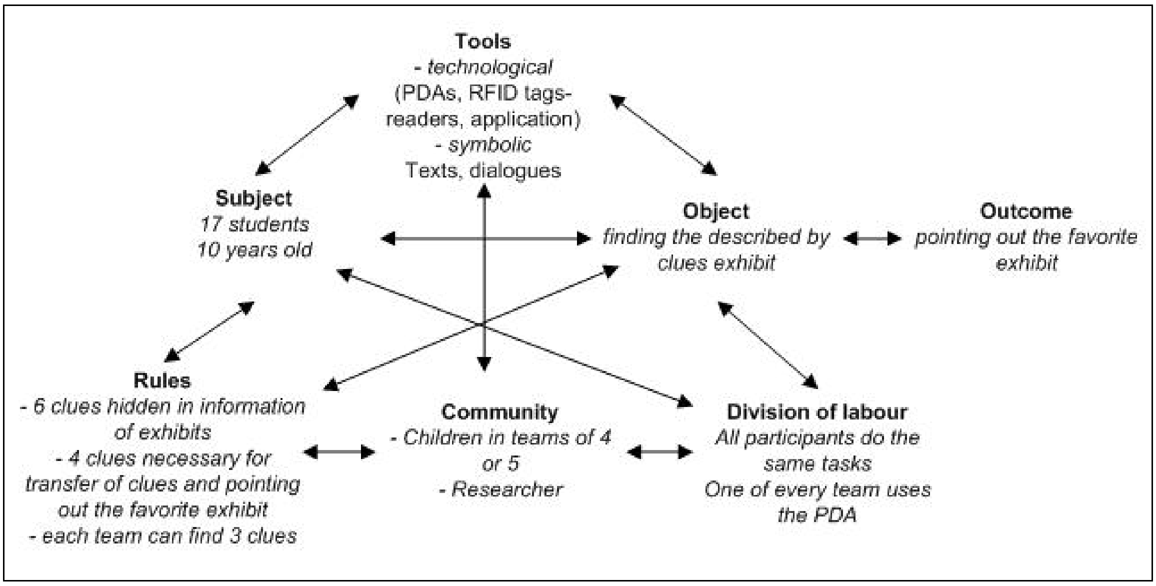

Figure 4. Description according to the Activity Theory Model

The activity has been defined in a way to force the two participating teams to work collaboratively. One child uses the PDA. All the participants have to read information about the exhibits carefully and not only search for clues. Six clues are provided. In order for the application to allow the users to exchange clues or point out the favorite exhibit, at least four clues should be collected. Each team can collect up to three clues. The clues found by one team can not be found by the other team. All these rules where defined in order to support and motivate collaboration between the participants. The children understood the rules and worked according to them. Although they had the option to point out the favorite exhibit after collecting 4 out of 6 clues the children insisted on finding all the clues since it was a pleasant and engaging procedure for them. Also despite the fact that they were warned about reading the information of the exhibits carefully all the teams sooner or later chose a different strategy than the one prescribed in the design of the activity. They preferred to look quickly through the information and locate the clues and after finding all the clues return and read carefully the information in order to find the favorite exhibit. This was the reason we believe the activity took longer to finish than the time predicted during the design process.

The community of the activity was comprised by children as individuals, children as members of a team and the researcher. The researcher facilitated the children and did not participated in the task. As for the teams, it was noticed that only 2 to 3 children were active during the activity and 1 to 2 children in every team were simple observers. We believe that this was the result of putting too many children in each team. Labor was divided only as regards to the use of the PDA. Only one child could use the stylus and the application but all could read the information and decide their next action.

In general, the activity found to be very enjoying and engaging for the children. In the report they wrote one week after their participation the PDA was referenced as a supporting tool and all the children were willing to participate again in a similar activity and interact in a new way with the exhibits of the museum.

4. CONCLUSIONS

This paper described an activity based design paradigm for educational activities using handheld computers in the frame of a museum visit. Learning in a museum context could be conceived as the integration, over time, of personal, sociocultural, and physical contexts. The physical setting of the museum where learning takes place mediates the personal and socio-cultural. This experience, which is in the border between a learning and an entertaining activity, seems ideal to be supported by PDAs, since the most important benefit for educators and students is the PDA’s ability to extend the learning environment beyond the classroom (Juniu, 2002).We argue that proper design decisions should take into account a solid theoretical cognitive framework, as well as the particularities of the mobile devices and challenges of such an informal learning setting. A suitable activity should be properly supported by adequate interaction models, deeper understanding of the tasks involved to carry out the activity as a whole and their expectations while carrying out specific actions. For this reason, further validation of our approach, took place under real conditions, into the Museum of Zakynthos. The results of the study showed that student welcomed the activity as presented to them, and enhanced their motivation to learn more about the cultural and historical context represented by the exhibits.

However, we should stress that despite the general design approach proposed, instantiation of an activity is affected from issues such as the scope of the museum and the type of the exhibits, the content provided by historical and cultural experts, and the ability to adopt an 'active' interaction model, using the pdas as a means to point out a specific exhibit and harvest relevant information. As a result, proper adoption of our approach and further research in general is required to examine the possibility to apply it effectively to a slightly modified environment. Additionally to this, further research is required to investigate the effect of awareness mechanisms presented to the user, to support distant PDA mediated communication, across the members of each team, while in the effort to carry out the activity.

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