Designing Innovative Learning Activities Using Ubiquitous Computing

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Abstract

In this paper we present our pedagogical and technological approach for supporting the design of novel situated learning activities that can be conducted both, outside the school and in the classroom. One main goal is to enhance the content of the curricula by bringing multimedia resources and mobile support to outdoor settings thus enriching the field experience. In order to illustrate these ideas we describe the outcomes of a trial we have conducted with thirty elementary school children. Moreover, we present the ubiquitous computing solutions we developed in order to support learning activities in the field of history. The results of our experiments indicate that children enjoyed learning in these kinds of environments where mobile devices are used in situ, thus supporting the learning activities in the context of which they are taking place.

1. Introduction

Situated learning [1] is a general theory of knowledge acquisition that is based on the notion that learning (stable, persisting changes in knowledge, skills and behaviour) occurs in the context of activities. Research increasingly indicates that the inability of students to apply concepts learned in formal contexts is in many cases due to the abstraction and decontextualization of learning [2]. But, it is not the abstraction of knowledge as such that distracts learners, but that the abstractions are not illustrated with examples in context. Context provides a framework that guides and supports the learner. Situated cognition argues that learning is simplified by embedding concepts in the context in which they will be used [2]. Situated cognition argues that learners must engage in authentic tasks as well.

Designing interactive learning environments (ILEs) to support situated learning is a challenging task, since in many cases the use of information technology tends to shift the learning environment to a more computer based representation, thus moving a step away from the core ideas of situated learning [3]. This latest view on technology-enhanced learning supported by wireless technologies and ubiquitous computing is referred to ubiquitous learning [4]. Ubiquitous computing also provides new possibilities for designing innovative educational activities that can be carried out both indoors and outdoors. The design of such activities is a challenge, especially in conceptualizing how these technologies can be used to support collaborative knowledge building in indoor and outdoor settings. Therefore, in the context of our efforts one main research question can be identified: *How can challenging learning activities that support the notion of situated learning be designed using ubiquitous computing?*

In this paper we present our on-going efforts connected to our AMULETS (**A**dvanced **M**obile and **U**biquitous **L**earning **E**nvironments for **T**eachers and **S**tudents) project. The paper is structured as follows; in section two we discuss those ideas related to design-based research as this approach guides our design ideas while in section three we present an educational scenario that integrates novel learning activities conducted with an elementary school classroom and supported by ubiquitous computing. In section four we present the assessment of these activities based on data we collected from our interactions with the children and the teachers. Section five concludes this paper by providing some conclusions and directions of future work.

2. Design-Based Research and Innovative Learning Activities

Design-based research is an attempt to combine the intentional design of interactive learning environments with the empirical exploration of our understanding of those environments and how they interact with individuals [5]. A recent view regarding the design of ILEs is presented by the Design-Based Research Collective group [6] who argue that design-based research, which blends empirical educational research with the theory-driven design of learning environments, is an important methodology for understanding how, when, and why educational innovations work in practice. Based on those claims, design is central in efforts to foster learning, create relevant knowledge, and advance theories of learning and teaching in complex settings. According to Edelson [7], the emerging design-based research paradigm treats design as a strategy for

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developing and refining theories. Design-based research follows an iterative cycle of designing, implementing, analyzing and modifying. The research efforts to be presented in the coming sections were conceived and implemented inspired by the ideas and rationale suggested by this methodology. In our particular efforts, the educational scenario we developed was created based on prior cognitive, educational and technological research, relevant learning goals and content pedagogy, and knowledge of the specific educational context.

Design studies are typically conceived as test-beds for innovation. One of the main objectives is to investigate the possibilities for educational improvement by stimulating new forms of learning in order to study them. We consider our efforts as being an attempt to create innovative socially-situated exploratory learning experiences threads throughout elaborated learning sequences supported by ubiquitous technologies. Within the context of our efforts, the notion of socially-situated extends to the idea of learning activities guided by the context in which they are taking place. Based on these guidelines we designed a set of educational activities that was conducted in indoors and outdoors settings. These activities were designed having in mind the notion of situated learning practices.

3. Scenario Design and Implementation

In this section we describe one particular example that describes how we used ubiquitous computing and mobile technologies for designing innovative learning experiences that took place in a variety of outdoor (main square and city center) and indoor settings (in this case a museum). We describe all those aspects related to design, technology and pedagogy in connection to this particular activity.

3.1 Settings of the Trial

Twenty-nine 5th grade children (11-12 years old) participated in this trial that was conducted during the fall 2006. The content explored in this activity was related to the field of local history, which is part of the school curriculum. The physical settings where the trial took place were the main square and the museum of history in the city of Växjö, Sweden. The children were divided in three groups, each group consisting of ten students. Additionally, each group was divided in two subgroups of five children each, where one subgroup was working indoors in the museum while the other group was outdoors. The outdoors subgroups were supervised by several teacher candidates from our university. The overall activity was divided into three sessions over two days.

The outdoor subgroup was equipped with four smartphones (Nokia 6630) for content delivery, content generation, instant messaging and decoding visual semacodes[1] tags. The indoor subgroup was equipped with a laptop computer equipped with a GPRS connection and a mobile handset for still photography. While the outdoor subgroup was in the field, the indoor subgroup was in the museum. In order to successful accomplish all the educational tasks the subgroups needed to collaborate using mobile technologies in a variety of ways.

3.2 Learning Activities

Together with teachers from one of our local schools, we developed a set of activities to foster collaboration between the subgroups participating in this trial. We decided to carry out this activity in the form of a collaborative game that has been organized as a set of missions that took place in different locations and across different time periods. The activities were designed containing challenges to be solved by the children in which they needed to collaborate and to apply problem-solving strategies. The game started when the field group scanned the "StartGame" semacode and a short movie was delivered to the groups' mobile phones containing instructions from a set of three animated guides about how to proceed. The indoor subgroup task was to visualize the activity flow in the form of a mind map as the missions unfolded. The outdoor subgroup first task was to scan the semacode tag in the square. Once this was accomplished both subgroups received instructions about the first mission (see figure 1).

Fig 1. *Starting the game*

The outdoor subgroup needed to identify the building in the square that had Roman numerals while the indoor subgroup got instructions about how to decipher them. The task in this stage was to identify the year written in Roman numerals in the building in the main square. The collaboration started when the outdoor subgroup sent the picture of Roman numerals to the indoor subgroup (see figure 2). The discussion and argumentation about deciphering the roman number has been carried through mobile instant messaging (IM).

After the children decided which was the correct answer for the Roman numerals task, the outdoor subgroup scanned the correct semacode and the second

[1] Is a 2D barcode tag for embedding URLs to a specific location (source: http://www.semacode.org/). Semacode tags can be read by a camera-enabled mobile phone.

mission started. The goal of this mission was connected to mid 20th century history. The outdoor subgroup received in their mobile phone an audio file from 1939 while their task was to identify what happened on this day, the start of World War II. For the indoor group the task was to identify an audio segment of a poem from a famous Swedish poet from the same time. The indoor group had Internet access for help concerning their task and to support the outdoor group.

Fig 2. *Roman numerals*

When both subgroups successfully answered this question, they proceeded to the third mission of the game. The task here was to identify a building located close to the main square using a historical photograph as a reference. The indoor group received the reference photo and their task was to identify what the building looks like now. To accomplish this mission they needed to collaborate with the outdoor subgroup sharing photos taken with the mobile phone and exchanging information via IM (see figure 3). After they came to an agreement, the outdoor subgroup needed to scan the semacode on the selected building to continue.

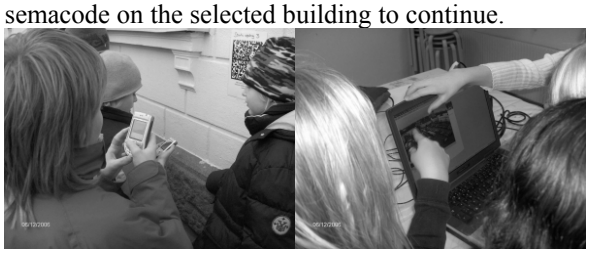

Fig 3. *Identifying the old building*

This triggered the fourth mission where the outdoor group needed to meet with a blacksmith (a real person representing a character from the 19th century) who had a stand in the local square market. The task for the outdoor group was to identify which one of the tools in the blacksmith's stand did not belong to that historical period. In order to solve this task they needed to negotiate with the indoor group by exchanging photographs and using the IM functions. The final mission was to go back to the location where the game started and to listen a story of valuable coins found there some centuries ago. The indoor group needed to answer how much the treasure would be worth today. In order to accomplish this task the children in the museum needed to communicate with the outdoor group while this could be performed using instant messaging.

3.3 Pedagogical Aspects

One of the main pedagogical challenges of this game-based activity was to design learning tasks that fostered children's collaborative problem solving skills within the same subgroup and with their peers. In order to add more realism to the game an adult performing as a blacksmith from past centuries provided some historical background, enabling the children in the square to share this information with those at the museum using pictures, thus giving a new contextual dimension to this information.

During the different stages of these trials, children needed also to use their mathematical (number conversion/decoding), historical (state of main square through history), and geographical/navigational (self navigation and historical map reading) skills. Strong negotiation skills were needed for the successful accomplishment of the tasks that were part of the quest. In addition, group discussions and interactions, as well as collaboration were also activities that enriched the learning experience. The integration of all these different features into a realistic scenario offered children a challenging learning environment.

3.4 Technical Aspects and Implementation

In order to provide technological support for the activities described in the section above, we developed and implemented several solutions that are illustrated in figure 4. The activities for the outdoor subgroup in the mobile environment (see left side of figure 4) were supported by 4 smart phones used as tools for collaboration, communication and for creating and receiving content. The first smartphone has been utilized to support communication between the subgroups using a mobile instant messaging application. The second smartpone has been used as semacode reader. The semacode application running in the phone served for reading the semacode tags and for triggering the events (based on a specific location) and actions to be conducted by the outdoor subgroup. The third smartpone was used as a mobile server for coordination of the other phones and the generated content. The last smartphone was used as a device for generating content related to the specific tasks and activities that children needed to perform. In the mobile environment, two of the smartphones were running the Nokia Raccoon[2] software that enables mobile communication via instant messages. The mobile phone leveled with the number 1 in figure 4 (running the first instance of Nokia Racoon) was used for mobile instant text messaging.

The mobile phone leveled with the number 2 in figure 4 (running the second instance of Nokia Racoon) was held

[2] Application developed by Nokia Research Center which makes it possible to run an web server on Symbian phones http://research.nokia.com/research/projects/mobile-web-server/

by the adult supervising the children, and it was used to link the photos taken by a particular subgroup to the correspondent group activity. This specific group number was automatically added (in the form of metadata) to the photos taking by the children. This action was performed using a python application we developed. This feature was enabled with PHP-scripts on the server to keep track of all the communication that happened during the trial. All the content generated by the children contained contextual information such a group number, activity type and additional information and it was stored in our repository.

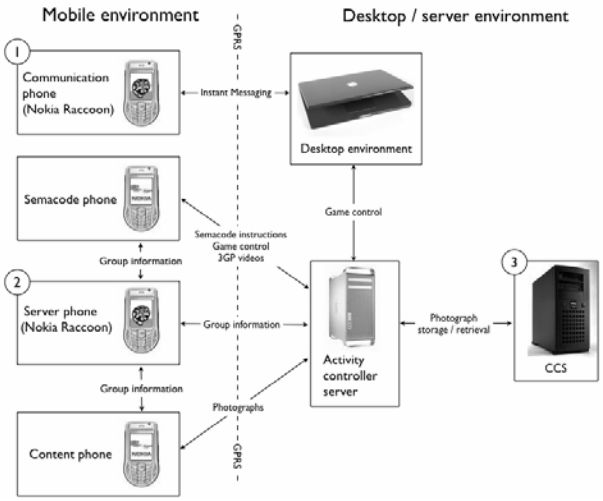

Fig. 4. *An overview of the technical implementation*

The indoor subgroup located at the museum was equipped with a desktop computer with internet access and the children in this subgroup participated in the game utilizing a customized web based application we developed using AJAX. The game activities in our trials that required collaboration between the students in the museum and the students in the field have been mediated through the Activity Controller Server (ACS) as illustrated in the right side of figure 4. The ACS had a direct connection to our content repository (number 3 in figure 4) that stored the content generated during the trials. The content repository is referred to CSS (Collect, Convert and Send) and it was used to collect content generated by the different subgroups and to deliver content to the mobile phones upon request. The digital content (prepared previous to the activities) delivered to the mobile phones was also stored in the same repository.

4. Assessment

The main goals of our assessment were twofold; firstly, to explore how children experience these ubiquitous learning activities, secondly, to look at usability aspects related to the use of ubiquitous computing in educational contexts. For evaluating the technology we used questionnaires that were distributed to all the students after the trials. For reviewing the learning experiences we conducted deep interviews with several children and both teachers. From the 29 children participating in the trial, 18 of them described the activities as *"very fun"* while 11 described them as *"fun"*. Interesting to mention is the fact that none of the respondents described the activities as boring or uninteresting When asked if the collaboration worked well among them 22 of them answered with *"very good"* while 6 of them with *"good"* ; one child did not answer this question. When asked about the collaboration with the complementary subgroup, 9 of them describe it as *"very good"*, 15 as *"good"*, 3 as *"not so good"* and one as *"bad"*. Also in this case one child didn't answer this question.

The interviews with the children were conducted some days after the activities. The focus of the interviews was on four questions exploring issues related to how the technology worked; the collaboration process and the overall learning experience. The first question we asked was, *"What did you learn during the activity?"* The main denominator of their answers was that they believed they learned about what happened with the main square during the different time periods in history but when reflecting together with them about when things happened in time; it appeared that children had problems to differentiate between different historical events. All the children were very satisfied with the activities although they main remark was that the weather was cold and rainy, especially for the outdoors subgroups.

The second question we asked was, "*Which missions do you remember from that day?"* It appears that the children remembered more the missions with real characters (like the blacksmith) rather than missions in which the content was sent to them via animations in the mobile phone. According to the children, the most interesting part of this activity was to guess what the new mission will be. The third question was, *"What do you remember from the animations and movies that were sent to your mobile?"* From the children's answers it appears that they did not remember very clear the content of the stories from the movies sent to their phones. However, when they got a small hint about it they have been able to recall the events that happened in the stories. The final question focused on *"Do you think that was an interesting and enjoyable day and do you want to join a similar activity in future?"* All of them said that they are positive to participate in similar activities with different missions in the future and they would like to see more activities of this kind integrated into the school daily activities. The collaborative

problem solving aspect of the game was one of the most appreciated and useful things during this trial.

Interviews were conducted with two teachers that participated in this trial. The teachers' general impression was that the trial was successful and they both felt that ubiquitous technologies, smartphones in this case, may help children to become more engaged in the activities. When reflecting about novel aspects of this way of learning, the teachers' main concern was that the risk of technology potentially overshadowing the learning process. The teachers thought that this game-like-scenario helped the students to focus on the tasks more than traditional learning settings and they both felt that communication and collaboration were key issues in helping the children to solve the different tasks successfully.

5. Conclusions and Future Work

In this paper we described our current work that is an evolution of our previous research efforts [8] when it comes to contextualize situated learning activities supported by ubiquitous computing. The aim of this study was to assess how learners experienced the different activities we have developed, as well as the usability of the technical solutions we implemented. The entire process was based on an iterative design cycle guided by the ideas of design-based research. In general, the outcomes of this trial indicate that children are open and positive when it comes to using mobile technology in everyday learning activities, especially when they can be used in playful ways. Another interesting indication from the analysis of our results is that the context in which the learning activity takes place impacts the way children interpret and deal with information. This particular issue was quite evident for the outdoor subgroup where the location and environmental attributes of the context affected the overall performance. From the results of our assessments, we experienced that children paid more attention to real-life situations (like the blacksmith mission) rather then computer generated content and characters.

The type of rich technical learning environment we have presented may offer potential situations where children might get overwhelmed by the technology. This indicates that innovative situated learning activities enhanced by mobile technologies should not be regarded as stand alone activities, as they should be part of a well developed educational flow that also is combined with traditional ways of teaching and learning. Complementary post-activities that may be conducted in the classroom are needed in order to allow children and teachers to reflect upon their actions and the activities and therefore promoting metacognitive skills.

The software solutions we developed for this trial allows also for supporting this kind of post-activities in classroom settings by providing access to the data logs of all activities and communication that happened during the trial. By using principles of design-based research, we plan to improve and to modify our existing activities and technical solutions in order to increase the authenticity of the learning situations, as well as providing post-activities for fostering reflection. We will also try to develop new ways for promoting collaboration, since the children and the teachers identified the issue of collaborative problem solving as one of the most appreciated things during this trial. We will continue our efforts in this direction in conjunction with our ongoing research activities that will take place during the rest of 2007.

6. References

[1] J. Lave and E. Wenger, *"Situated Learning: Legitimate Peripheral Participation"* Cambridge University Press. Cambridge, 1991

[2] J.S. Brown, A. Collins, P. Duguid, "Situated cognition and culture of learning" *Educational Researcher*, *Vol. 18(1)*, 1989, pp.32-42

[3] J. Herrington and R. Oliver, "Critical characteristics of situated learning: Implications for the instructional design of multimedia" *In J. Pearce & A. Ellis (Eds.), Learning with technology.* Parkville, Vic: University of Melbourne, 1995 pp.235-262

[4] Y. Rogers, S. Price, C. Randel, D.S Frases, M. Weal & G. Fitzpatrick, Ubi-Learning Integrates Indoor and Outdoor Experiences*, Communications of the ACM*, *18*(1), 2005, 55-59

[5] C. Hoadley, "Methodological alignment in design-based research" *Educational Psychologist, 39(4)*, 2004, pp.203-212.

[6] Design-Based Research Collective, "Design-based research: An emerging paradigm for educational inquiry" *Educational Researcher, 32(1)*, 2003, pp. 5-8.

[7] D. Edelson, "Design Research: What We Learn When We Engage in Design". *The Journal of the Learning Sciences, 11 (1)*, 2002, pp.105-121

[8] A. Kurti, M. Milrad, F. Alserin and J. Gustafsson (2006) "Designing and Implementing Ubiquitous Learning Activities Supported by Mobile and Positioning Technologies". *Proceedings of the IASTED CATE 2006*, Lima, Peru, 2006, pp. 193-199