Exploring How Pervasive Computing Can Support Situated Learning

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Abstract: Pervasive computing offers new ranges of possibilities when it comes to supporting learning and collaboration. The design of educational activities in these environments is a challenging task that raises the question of how pervasive computing can be used to support new modes of collaborative learning. In this paper we discuss those aspects related to the design of situated learning activities supported by pervasive computing and the collaboration modes that may emerge as a result of these activities. Additionally, we discuss how activity theory can be used as a framework for designing such educational activities. We present the results of a trial we conducted while introducing pervasive computing in an elementary school activity. In conclusion we open the discussion about the relation between the design of innovative learning activities supported by pervasive computing and new collaboration possibilities that may arise in these environments.

Keywords: collaborative learning, situated learning, pervasive computing, activity theory, ubiquitous learning environments

1 Introduction

Learning is a social process; it happens in collaboration between people and together with technology. So when introducing technology the view should be shifted from seeing it as a cognitive delivery system to considering it as means to support collaborative conversations about a topic [1]. The central notion is that learning is enculturation, the process by which learners become collaborative meaning-makers among a group defined by common practices, language, use of tools, values, beliefs, and so on [2]. The idea that new technologies will transform learning practices has not yet been fully realized, especially with regard to technology-facilitated collaboration. The task of designing effective computer support along with appropriate pedagogy and social practices is more complex than imagined. The use of advanced computing and information technology in educational settings has increased significantly during the last decade. The rapid development of these technologies combined with access to content almost everywhere and every time, allows learners to gain new experiences regarding learning in a variety of situations and not only in school settings. This latest
view on technology-enhanced learning supported by wireless technologies and pervasive computing is referred as pervasive learning. These technologies offer new possibilities for designing innovative educational activities that can be carried out indoors, outdoors, and in any place. The design of such activities is especially challenging when it comes to conceptualizing how pervasive technologies can be used to support collaborative knowledge building.

According to Hansmann and colleagues [3] the principles of pervasive computing are: decentralization, diversification, connectivity and simplicity. These principles imply that the mobility of users and the presence of heterogeneous devices with a high level of usability in the learning environment open opportunities for innovative educational practices. Thus, in the context of our efforts two main research question have been identified, How can pervasive technologies be used to support new ways of learning about different educational subject matters, and how can these technologies support groups of learners when they, collectively, share their understanding of such a material?

In this paper we discuss those aspects related to the design of novel educational activities supported by pervasive technologies and the collaboration modes that may emerge as a result of learning in these environments. The paper is structured as follows; section 2 discusses those ideas related to situated learning and pervasive environments while in section 3 we discuss how activity theory can be used as a framework for designing new collaborative learning activities and for understanding those collaboration modes that may arise as a consequence of these actions. In section 4 we present the results of a trial we conducted using pervasive technologies with elementary school children working together across two locations, indoor and outdoor respectively. Section 5 concludes the paper by discussing the relation between the design of innovative learning activities supported by pervasive technologies and new collaboration possibilities that may arise in these environments.

2 Situated Learning and Pervasive Environments

Situated learning [4] 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 that typically involve a problem or task, other persons, and an environment or culture. 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 [5]. But it is not the abstraction of knowledge as such that distraction learners, but that the abstractions are not illuminated with examples in context. Understanding is a product of the context and activity. 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 [1]. Yet an authentic context alone is not sufficient to support students’ learning. Situated cognition argues that learners must engage in authentic tasks as well.

Designing technology support for situated learning is a challenging task, since in many cases technology tends to shift the learning environment to a more computer based representation moving away from the core ideas of situated learning [6], [7]. However, pervasive computing opens new dimensions to avoid this diversion, by
providing means to trustfully representation of learners’ contexts by placing them back
into the authentic. Pervasive environments provide the possibilities of embedding
computational support for the learning activity in the learner’s physical and social
contexts [8]. These embeddings can offer new challenges when it comes to design
interaction models to support a variety of collaborative learning situations. Embedding
learning activities into the learner’s physical and social context is consistent with the
core ideas of situated learning. Understanding the role of context in pervasive
computing for learning is an important factor in the design and analysis of these
systems. In the next section we explore how Activity Theory can be used as a design
tool to overcome some of these problems.

3 Activity Theory as a Framework for Supporting Situated
Learning with Pervasive Technologies

Activity Theory (AT) is a philosophical framework that allows the study of different
forms of human practice [10]. Activity Theory can also be used to provide a broad
conceptual framework in order to describe the structure, development and context of
tasks that are supported by a computerized system. It is the authors’ belief that this can
provide a model for the design and evaluation of interactive learning environments
can promote educational change because, according to activity theory, artifacts mediate
human activity. Activity Theory has been used successfully in designing human-
computer interactions for learning activities [10] and more recently used in the design
of mobile learning [12], [13].

The reason to use AT is that it has a simple form to represent concepts such as role,
rules, and tools, which have important impacts on learners’ activities. Moreover, AT
also maps the relationships amongst the elements that are identified as having
influence on human activity. In our particular case, we applied AT for guiding the
design of an interactive learning environment that used pervasive technologies to
support a number of indoor and outdoor educational activities that were performed by
different groups of children.

Each of the indoor and outdoor groups can be regarded as a semi-independent
activity system that was a subset of larger activity system that encompassed these two
groups. This larger activity system required the indoor and outdoor groups to
collaborate in order to accomplish a specific learning task (See figure 1). Using this
model expanded from Engeström’s activity system [12] provided us with a tool for
design and a foundation for later evaluations giving us insight and record of the history
of actions between the different groups. The division of labor was a key point of for
how we explored new interaction modes to promote collaboration. In the coming
section we describe a specific educational scenario based on the ideas presented in the
former sections together with the technologies we used for its implementation.
4 Bridging Indoor and Outdoor Educational Activities Using Pervasive Technologies

4.1 Educational Activities

Thirty 5\textsuperscript{th} 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 this activity 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 kids. Additionally, each group was divided in two subgroups of five kids each, where one subgroup was working indoors in the museum while the other group was outdoors. Only one group was conducting this activity at a time, therefore this activity had three sessions. The outdoor subgroup was equipped with three smartphones (Nokia 6630) for content delivery, content generation, instant messaging and decoding visual semacode\textsuperscript{1} tags. The indoor subgroup was equipped with a laptop computer equipped with a GPRS connection and a mobile handset for still photography. Each group was supervised by a couple of adults (in our case, teacher candidates from our university). 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 pervasive technologies in a variety of ways.

Together with the teachers and our designers, we developed a set of activities conceived 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. The activities were

\textsuperscript{1} Is a 2D barcode tag for embedding URLs to specific location (source: http://www.semacode.org/). Semacode tags can be read by a camera-enabled mobile phone.
designed containing challenging problems to be solved by the children where they needed to apply problem-solving strategies, to understand the rules, and to collaborate. Figure 2 illustrates some of the activities conducted by the different groups. One of the main pedagogical challenges of such game-based activity was to design learning activities that fostered children’s collaborative problem solving skills within the same subgroup across the different locations.

Figure 2 Bridging indoor and outdoor activities.

During the different stages of these trials, children needed to use their mathematical (number conversion/decoding), historical (state of main square through history), and geographical/navigational (self navigation and historical map reading) skills, as well as negotiation abilities 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.

4.2 Technical Aspects and Implementation

In order to provide technological support for the activities described in the section above, we developed and implemented the solutions that are illustrated in figure 3. The activities for the outdoor subgroup in the mobile environment (see left side of figure 3) were supported by 4 smart phones used as tools for collaboration, communication and for creating, receiving content, and controlling the activity. The first smartphone has been utilized to support communication between the subgroups using a mobile instant messaging application. The second smartphone has been used as semacode reader, for reading the tags and for triggering the events (based on a specific location) and actions to be conducted by the outdoor subgroup. The third smartphone was used as a mobile server for coordination of the other phones and for generated content. The last smartphone was used as a device for controlling the content related to the specific tasks and activities. The indoor subgroup located at the museum was equipped with a desktop computer with Internet access and a mobile handset for still photography. The
children in this subgroup participated in the game utilizing a customized web based application we developed. The game activities 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 3. The ACS had a direct connection to our content repository (number 3 in figure 3) 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.

Figure 3 The technical solutions used for supporting the activities

4.3 Educational Activities, Pervasive Technologies and Collaboration Modes

As already mentioned, most of the activities in this game were designed in such way to impose the division of labor, thus forcing the subgroups to collaborate. Moreover, in order to add more realism to the game an adult performing as a blacksmith from past centuries provided some historical background, so that the children in the square needed to share this information using pictures with the children at the museum, thus giving a new contextual dimension to this information. Table 1 describes the entire activity flow of the trials. The activities are classified into those that happened outdoors and indoors and they are linked by the collaboration mode used by the children in order to bridge these situations.
Table 1. Collaboration modes for bridging indoor and outdoor activities in our trial

<table>
<thead>
<tr>
<th>Outdoor Activity</th>
<th>Collaboration Mode</th>
<th>Indoor Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying the object and taking pictures of roman numbers</td>
<td>Communication and negotiation using pictures and instant text messaging (IM)</td>
<td>Decipher roman numerals</td>
</tr>
<tr>
<td>Interpretation of audio content</td>
<td>Communication using instant text messaging (IM)</td>
<td>Understanding historic audio content</td>
</tr>
<tr>
<td>Taking pictures of buildings in the main square</td>
<td>Collaboration using instant text messaging and pictures</td>
<td>Comparing pictures with an old picture of the square for identification</td>
</tr>
<tr>
<td>Meeting the blacksmith</td>
<td>Collaboration with the museum to identify the tool that does not belong to the picture. Communication using pictures and instant text messaging (IM).</td>
<td>Identifying the tool that does not belong to the picture from the blacksmith table</td>
</tr>
<tr>
<td>Back in history in the cooper plate to hear the story of found coins</td>
<td>Communication between the subgroups using instant text messaging (IM).</td>
<td>Calculating how much the treasure is worth today</td>
</tr>
</tbody>
</table>

In this way, this particular activity offered children the possibility to:

- Learn and to explore a topic in authentic settings
- Collaborate in order to construct common knowledge
- Reason and to argument in order to come to the solution of a problem
- Reflect upon things and to support abstract thinking

According to Jonassen and colleagues [8] meaningful learning will take place when learners are engaged in the type of activities described above.

5 Discussion and Future Efforts

Situated learning as a theory for knowledge acquisition is based on the idea that learning activities should be embedded in authentic contexts. Traditional computer-based applications can be seen as moving real life situations a step further away from the authentic, thus pushing situated learning opportunities out [6][7]. Pervasive technologies can provide the necessary means to promote situated learning, as they allow enhancing the learners’ context by the creation of embedded ubiquitous environments in realistic settings. In the case we have illustrated, pervasive technologies served as a bridge to connect children working with the same activity context in distinctly different locations, as well as they served also as a tool to support collaborative activities.

From a design perspective, Activity Theory can function as a useful instrument to guide the design process of innovative educational activities. In our trial, the subjects were children placed at two locations that needed to communicate and to collaborate.
through an object to fulfill a specific task. The division of labor promoted the collaboration between children in order to achieve the game objectives. Our future efforts will include the evaluation of our concepts and technologies, both from a technical and a pedagogical perspective. During the rest of 2007 we will conduct several on site trials with different classes from our local schools. We will asses the usability and usefulness of this kind of pervasive learning environments with a special focus on collaborative learning, so we can learn in more depth which concepts can be integrated into school activities and which aspects demand further exploration.

6 References