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Mobile Systems for Contextual Learning
ー文脈上の学習のためのモバイルシステムー

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あらまし We reflect upon our previous works on designing interaction with educational technologies for formal and informal settings (involving interactive whiteboards and pen-tablets in the classrooms and learning activities with PDAs "in the wild"). Mobile learning is redefined as contextual learning relating to and embedded in the learners' situation. We elaborate upon this perspective to derive implications and potentials for learner-centered interaction design and present an interaction scenario for contextual learning with embedded and mobile devices.

キーワード Classroom Technologies, Mobile Learning, Informal Environments, Context, Interaction Design, Learner-Centered Design, Embedded Systems, Interaction Design Patterns

1. Introduction

For centuries education took place in classrooms. Part of the reasons was the fact that the media used for education like textbooks, blackboards and voice were easy to use in such an environment. Developing and deploying educational technologies is also much easier within controlled environments. Students may easily be observed and corrected if they deviate from the course of instruction. Influences from the outside of this secure place were considered to distract the students from their contemplation in learning processes and materials.

Even with new technologies the traditional classroom is still a form of white cube, indifferent against the students and the objectives and materials of education. E-Learning technologies and distant education applying enhanced physical facilities and a range of new communication tools like VoIP, IM, Discussion Forums, Collaborative Authoring tools do not essentially change this situation. Following this tradition schools still try to isolate the classroom from external influences, e.g. by banning mobile phones and devices.

Sharples [11] addresses the emerging conflict between personal informal learning and traditional classroom education. He points out that computing technology may become a focus in this conflict, "with schools banning powerful technologies for personal learning and social networking while struggling to provide obsolete computers running software that children don't want to use and that perpetuate an outdated model for content delivery and didactic teaching."

Considering developments in learning theories, including works on constructivism, collaborative learning, and situated learning on the one hand, and the availability of mobile devices on the other hand the need arises to seamlessly integrate structured learning activities with informal environments.

Problem-oriented approaches to teaching and learning combine cognitive and constructivist aspects. They suggest that self-directed and problem-oriented student activities being moderated by the teacher may not only increase students' motivation but also their understanding and memorization. Instead of focusing on the individual mind, socio-cultural theories of learning (in the tradition of Vygotsky) conceptualize learning as socially constructed and emphasize the need for support provided at the right place and time by a teacher, other students or resources. Similarly, situated learning [8] stresses the webs of meaning created through experiences.

Education becomes increasingly a question of creating an environment for students to learn from experiences that extend beyond the walls of the classroom. Teachers and technology contribute to such an environment and the process, the internet and the real world provide sources for content and exploration.

2. Supporting Classroom Interaction

Within some of our previous works [1, 2, 3] we developed software that supports the flexible creation and discussion of learning content created by students or imported from other sources. We synthesized two lines of development that have been dealt with independently so far:

(1) the development and evaluation of educational technologies to support problem-oriented and collaborative learning activities inside and outside of the classroom, and

(2) interaction design patterns as a means to document and generate design knowledge.

Primary contributions have been software prototypes for enhancing classroom interaction through interactive whiteboards and multiple clients with pen-tablets, and a basic layout of a pattern language for formal and informal learning environments [2].

Regarding whiteboards and large-screen devices spending too much time on activities which are not directly related to teaching (typing, file searching) may interrupt the dynamic flow of the lecture and distract the attention of the audience. It is therefore desirable that the teacher may perform all teaching activities on the whiteboard as the unique input and output device [1]. For these reasons we decided to implement a gesture-based system of interaction that enables users to create, import, edit, link, and delete pieces of content.

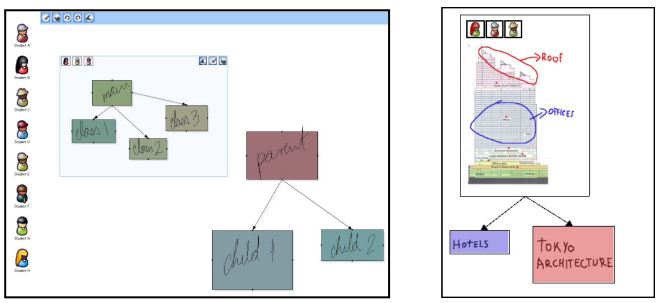
Our DeepBoard and the related software for the pen-tablets also implement a gesture-based interaction paradigm and a hierarchical semantic to store and retrieve learning created on the flight by free-hand writing. Drawing or performing gestures on the board may result in a flexible creation, structuring, presentation and documentation of various learning materials. The DeepBoard therefore supplies “depth” to the interaction with interactive whiteboards. Several pen-tablets may interact in the same space within an application program in one PC [3].

3. Bringing the World into the Classroom

We expanded the approach to be used on mobile devices. Mobile devices have already been recognized as a powerful tool for supporting formal learning in classroom situations and informal learning outside the classroom. Handhelds have been described as 'flexible tools that can be adapted to suit the needs of a variety of teaching and learning styles' [4]. In [9] authors provide a review of existing work in a number of areas which suggest possibilities for the future of research on mobile learning in informal science settings. However, like Scanlon et al. [9], we also believe that it is necessary to take an integrative perspective on orchestrating technology enhanced educational scenarios. Our work is directly aimed at proposing such an environment.

In order to support a seamless transition between the learning environments, we aimed for a consistent interaction design across all devices. To support collaborative learning with PDAs we developed a system that enables face-to-face collaborative sketches using handheld devices equipped for spontaneous wireless peer-to-peer networking. It may be used by students inside or outside the classroom to exchange ideas through sketches on empty sheets or over a recently taken photograph of the object being worked on, in a brainstorming-like working style. Pen-based designed human-computer interaction is the key to supporting collaborative work.

The design principles applied for developing the system reduce the problems associated with having a small size screen to interact with. On small-screen devices like handhelds, menus and widgets consume precious working space and tapping them with a stylus is tedious. Other than on desktop applications, no right mouse-click is available to provide context-dependent popup-menus. In order to facilitate the focus of attention, it is desirable to keep user input and system response in the same space. The human-handheld interaction is therefore based in gestures and freehand writing, avoiding the need of widgets and virtual keyboards. The content of the generated documents are organized as concept maps, which gives more flexibility to reorganize and merge the contributions of the meeting attendees. The system is based on handhelds connected to an ad-hoc wireless network. This application has a module which allows using an electronic board in order to have a common display to show the content being produced during the working session.



(Figure 1: The left image presents a screenshot of the whiteboard after the teacher and students have created some rectangular node objects for creating or importing content, and connected them by drawing from one node to the other. The right picture shows a sketch of the PDA interface designed according to the same interaction design patterns.)

When creating the first blank page, the user may create different nodes within that page (entering the node level below) or create a new page on the same level. The following gestures are implemented to flip between pages, create and edit content:

(1) Flipping to next/previous slide: Moving the stylus from one vertical edge of the handhelds screen to the other the user flips between different pages.

(2) Creating a node: By drawing half a rectangle the user creates a node. Handwritten or other content within the rectangle will be included and stored within that node. These nodes are by default private but may be shared with other students' handhelds or shown on the interactive whiteboard.

(3) Deleting a node: A node may be deleted by drawing an "x" in one stroke across its boundaries.

(4) Sharing a node: The content of a node may be shared with other students or the teacher. This is done by dragging the node to the icon of a single participant or a group of participants. Dragging the node to an icon of the whiteboard sends the node to the whiteboard. Sharing content in a shared-screen mode is essential to support collaborative activities and discussion when the students are outside of the classroom.

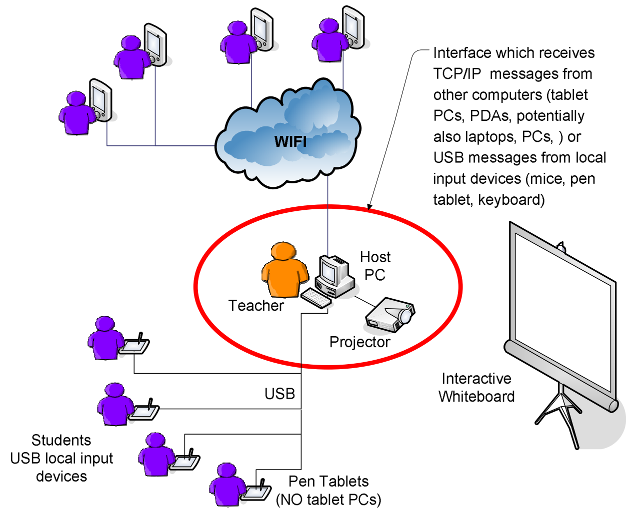
(5) Linking nodes: Two nodes may be linked by drawing a straight line from one node to another. In this way, a network of nodes may be created.

(6) Saving structured content: By moving the stylus from the top edge of the handheld screen to the bottom edge, the network of nodes is saved. The content of the generated documents is organized as a concept map, which gives more flexibility to reorganize and merge individual nodes.

In addition to these gestures, we implemented the following interface elements:

(7) Active participant representation: Participants synchronously present in the system are shown as icons at the top of the screen. The teacher may assign individual participants to groups.

(8) Showing a node as a page: Clicking on a button underneath the node brings it up as a page. Here we experimented with various solutions. Informal user tests showed that double-clicking was often performed unintentionally when users did not want to open a page. For the same reason, we abandoned the idea of drawing from outside of the node on the page to the inside.



(Figure 2: General architecture of the platform: Mobile users on a WiFi network communicate amongst one another and with the server controlling the interactive electronic whiteboard. Tablet users use USB connections to the server. The teacher uses an interactive whiteboard as input and presentation device.)

An integrated environment emerges. It facilitates both performing and documenting learning experiences outside the classroom and bringing them into more formal settings for discussion and further development. It supports collaborative learning and applies the same gesture-based interaction principles as software for interactive whiteboards, enabling seamless transition between inside and outside as well as facilitating individual work, peer-to-peer interaction and group discussions. Using the PDAs elements from the real world may be brought into the classroom and used for further elaboration.

New opportunities for learning arise if the outside world is not just brought into the classroom, but itself being enhanced with interactive learning technologies. "Mobile learning is not just about learning using portable devices, but learning across contexts" [12]. In the second part of this paper we will therefore reflect upon the question how we may understand this context and transform it into a learning environment.

4. Outside the White Cube into the Wild

As already noted in the beginning today's classroom is still a kind of white cube indifferent against students and contents. Until the middle of the 20th century the "white cube" was the paradigm for exhibiting and perceiving modern works of art. The white cube was seen as being indifferent towards the "collection" inside and therefore suitable for exhibiting the various traditions and kinds of artworks. From naïve to expressionist paintings, from oil paintings to photography and even the first installations everything fit it and could be removed without leaving traces.

Modern exhibitions like the Documenta 12 in contrast apply lights, colors, carpets, walls and architectural constructions in order to create designed spaces with concrete and visual elements that relate to the artworks and contribute to creating a web of meanings that constitutes the space. The “exhibition as medium” becomes an installation in its own right. Opposing to the sterility of the white cube installation art uses various media to provoke spatial experiences that may in some cases be related to and only exist in a specific site.

For example in Japan installation art was introduced in 1954 by the Gutai group and the works of Jiro Yoshihara. His Gutai Manifesto [7] celebrates the “novel beauty to be found in works of art and architecture of the past which have changed their appearance due to the damage of time or destruction by disasters in the course of the centuries.” Like the unique site itself artistic intervention in such places is always locally and historically situated.

If we compare this development in art exhibition and consumption with the provision and reception of educational practices today’s classroom still follows the model of the white cube, indifferent towards its users and content. And the comparison provides an idea what it could mean for learners to move out of the box of this white cube and into the real world. Instead of remaining an indifferent frame for any arbitrary content, the unique quality, location and history of a site become an indispensable moment of the learning experience. The notion of context becomes essential and we may redefine mobile learning as contextual learning relating to and embedded in the learners’ situation.

We elaborate upon this perspective to derive implications and potentials for learner-centered interaction design and present a scenario for contextual learning with mobile and embedded devices.

5. New Systems for Contextual Learning

Informal learning is learning in the context of ongoing activities whose primary goal is not to learn, and the first studies on informal learning have thus been conducted at the workplace.

As the Chinese philosopher Lao Tzu put it: „If you tell me I will forget, if you show me I will remember, if you let me experience I will learn”. Relating to the learners context it bears the potential to Learning experiences that relate to the context of the situation and educational technologies that support and enable such experiences have to be conceived in particular ways. As important as the mobility of devices is their context-awareness and application behaviour based on the recognized context. It needs to be enabled by appropriate localization or sensing features.

An operational definition [5] defines context as "any information that can be used to characterise the situation of entities." Context is not just location and contextual learning not just a location based service. According to [10] context related to physical environment may be structured into three categories:

（1） location (absolute position, relative position, co-location ...),

（2） infrastructure (surrounding resources for computation, communication, task performance ...), and

（3） physical conditions (noise, light, pressure ...).

While context-awareness has been explored and used in ubiquitous and wearable computing to support task-oriented users (context-aware pervasive systems), its application for learner-centered design is just in the beginning. Besides information on the user, nearby people and resources advanced personalization enabled by information on the learners’ state and goals is desirable to enable well tailored learning experiences. Various constructs of context (as socio-cultural, location, activity, content and context of user) have been explored in [13].

In order to document and exchange information on the contexts systems should enable users to record audio, visual and video material. Like the system we presented above an appropriate application should also be provided with the ability to flexibly create and edit notes, to link them to other pieces of content in order to create a web of relations between the learners’ current context and background information for further investigation and study. Supporting learning as researching in such way users also need to retrieve and import content from other resources like the internet or their personal computer via wireless connections. All these actions will allow them to collect and explore information in the contexts where it becomes relevant. And it allows them to share what they have experienced through a synchronous shared screen mode on the mobile device or on the whiteboard within the shared physical space of the classroom at a later point of time.

In order to collect and input data various channels may be used. Appropriate input channels apply haptic input (using traditional buttons and touch-screens), movement of the device (e.g. through accelerometers that are becoming popular for mobile phones now) or holding the device against data emitting sources (like visible or infrared light, or Bluetooth signal emitters). Camera input (e.g. reading QR codes) and sound analysis may be used to provide links to online resources. Speech is another option for input, but potential disturbances within the oftentimes noisy environment and the potential disturbance of the environment through the users' voice input have to be carefully considered.

Regarding the systems output channels large pieces of information are wearisome to read on a small-screen device, whereas photos or even video with short chunks of text may be appropriate. Before future generations of mobile devices with stabilized micro projectors are commonly available screen size remains a bottleneck for the presentation of text and visual information with mobile devices.

Audio appears to be suitable for output, because it allows the user to receive and interact with information in a hands-free manner. Especially for receiving background information, which heavily relies on text, audio streaming provided by headsets or (finger-) bone connection may be used if taking potential dangers into consideration. Informality as we described relates to a learning environment that is not controllable and even the primary goal of the user may not be learning-related but task-oriented. Especially audio signals from surrounding traffic still have to be understood by the user and trade-offs between situation-awareness [6] and learner-experience have to taken care of.

One way to deal with this would be the design of a "learning mode" similar to the manner mode available on mobile phones. It would either wait for explicit activation in a given situation or automatically deactivate itself, when sensing competing, potentially important audio information in the surrounding.

So far we have been primarily looking at the interaction with mobile devices to support learning. Their character as a personal gadget predestines them in fact to provide or trigger personalized content that is tailored to the individual interests, learning style and background knowledge. But the content or materials the learner deals with usually not depend on their provision on a small portable device. When learners leave the white cube of the classroom numerous opportunities appear to embed designed learning content in the contexts and environments where it becomes relevant. Therefore we should differentiate between learning materials available through portable devices like mobile phones and PDAs, and learning technologies embedded in the environment. The unique potential for contextual learning systems lies in the intelligent synthesis of both sides: the interaction with personal devices in self-descriptive environments.

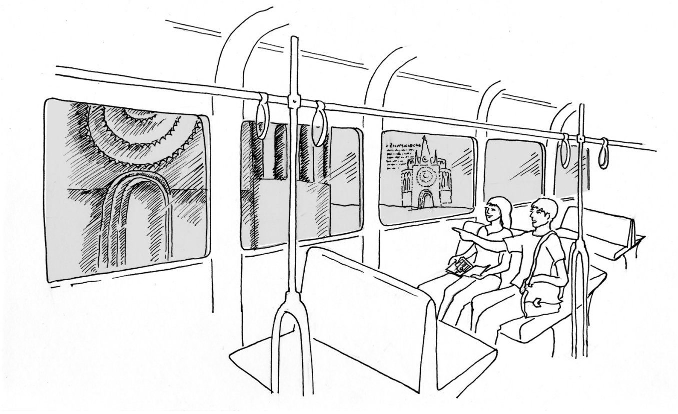
Different learning objectives like learning to learn, learning what to do, learning how to do it and learning about something also need consideration, but may not be further explored here.

6. Embedded Opportunities for Learning

In order to illustrate how learning opportunities may be embedded in the environment interacting with users and their mobile devices we present an imaginative scenario:

Travellers in trains and trams may be unobtrusively provided with contextual information on a half transparent screen in the wagon. The display screen could be implemented by an organic light-emitting display (OLED) or the Quick Response - Liquid Powder Display (QR-LPD) recently developed by the Japanese Bridgestone company. Images on the screen with silhouettes of buildings or objects would not replace the view on the real thing, but add extra, "contextual" information with local references: history of the neighborhood or building, current political issues related to it, aesthetic highlights, strange anecdotes and so on.

Via touch screen or the settings on their mobile devices travelers may select what kind of information they want. It is a form of edutainment where background information on various aspects regarding the local (historical, cultural, architectural …) context may be received. Alternatively some general information about currently popular exhibitions and events in the vicinity may be retrieved. For example travelers see the abstracted picture of the entrance to a large Berlin church as they are passing by. Listening to their handsets audio they may find out: "On the right you see "Gethsemanekirche". In the peaceful revolution of 1989 it was a central meeting point for the East German opposition protesting against the regime …" If they want to retrieve further information the handset allows them to browse related online content, that again might be shown on the public screen or saved together with an image of the scenery on the mobile device for in depth follow-up study.



(Figure 3: Drawn by Gabriele Heinzel to illustrate our scenario for mobile learning systems embedded in the environment: Windows of a train show contextual information and provide links to learning materials.)

Portability not only of end-user devices, but also of learning-related content across a range of devices that apply the same usability modules for content retrieval, creation, editing, and analysis will reduce current barriers. Connecting such systems to already existing powerful networks like social recommender systems and social networks may further contribute to reunite the separate worlds inside and outside the classroom.

7. Conclusion

Moving out of the controlled environment of the classroom is a promising yet challenging endeavour for anyone interested in providing enhanced learning experiences. We designed a system that allows students to document and discuss learning experiences "in the wild" and to bring its documentation into the classroom using their PDAs. Applying the same interaction modules like gesture-based interaction and semantic linking of nodes it is intended to allow for an integration of more and less formalized and self-directed learning activities.

We went on to reflect in more detail, what it means to move outside the box of the white cube, not only bringing representation of the world into the classroom via mobile devices, but supporting learning in the context of the learning content itself. Several properties of learning in context and requirements and options for system design could be identified. It made us differentiate between device-based and environmentally embedded features. Finally we exemplified the approach in a scenario synthesizing both.

8. Acknowledgement

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