Designing Contextualized Learning

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Introduction

Contextualized and ubiquitous learning are relatively new research areas that combine the latest developments in ubiquitous and context aware computing with pedagogical approaches relevant to structure more situated and context aware learning support. Searching for different backgrounds of mobile and contextualized learning authors have identified the relations between existing educational paradigms and new classes of mobile applications for education (Naismith, Lonsdale, Vavoula, & Sharples, 2004). Furthermore best practices of mobile learning applications have been identified and discussed in focused workshops (Stone, Alsop, Briggs, & Tompsett, 2002; Tatar, Roschelle, Vahey, & Peunel, 2002). Especially in the area of educational field trips (Equator Project, 2003; RAFT, 2003) in the last years innovative approaches for intuitive usage of contextualized mobile interfaces have been developed.

Recent research in human computer interaction describes several trends in designing new interfaces for interacting with information systems. Benford et al. (Benford et al., 2005) describe four main trends which include growing interest and relevance of sensing technologies, growing diversity in physical interfaces, increasing mobility and physical engagement in HCI, and a shift in types of applications for which innovative interfaces are designed. These developments also have a major impact on the development of new learning solutions and interfaces for explorative and situated learning support.

For building contextualized learning support on the one hand an infrastructure for contextualization is needed. This builds on research works of the area of context aware systems (Zimmermann, Lorenz, & Specht, 2005). On the other hand methods for analyzing and designing context specific appliances and tools for learning support from a human computer interaction perspective (Terrenghi, Specht, & Moritz, 2004) are necessary. Third a pedagogical framework has to be defined that sets the constraints for giving contextualized support to learners in a specific learning application.

The following paper describes the motivation and background for contextualizing learning and illustrates the implementation of a service based and flexible learning toolkit developed in the RAFT project for supporting contextualized collaborative learning support.

Contextualized Learning

Situated learning as introduced by Lave and Wenger (Wenger & Lave, 1991) states the importance of knowledge acquisition in a cultural context and the integration in a community of practice. Learning in this sense must not only be planned structured by a curriculum but also by the tasks and learning situations and the interaction with the social environment of the learner. This is often contrasted with the classroom-based learning where most knowledge is out of context and presented de-contextualized. On the one hand the process of contextualization and de-contextualization might be important for abstraction and generalization of knowledge on the other hand in the sense of cognitive apprenticeship (Collins, Brown, & Newman, 1989) it is reasonable to guide the learner towards appropriate levels and context of knowledge coming from an authentic learning situation.

From a constructivist point of view not only knowledge is always contextualized and but also the construction of knowledge, e.g. learning is always situated within its application and the community of practice (Mandl, Gruber, & Renkl, 1995). Stein defines four central elements of situated learning where the *content* emphasizes higher order thinking rather than acquisition of facts, the *context* for embedding the learning process in the social, psychological, and material environment in which the learner is situated, the *community* of practice that enables reflection and knowledge construction, and the participation in a process of reflecting, interpreting

and negotiating meaning (Stein, 1998). From the perspective of situated learning several requirements for new learning tools can be stated like: use authentic problems, allow multiple perspectives, enable learning with peers and social interaction within communities, enable active construction and reflection about knowledge. A shift towards a new tradition of online learning is described by Herrington et. al. (Herrington, Oliver, Herrington, & Sparrow, 2002).

Moreover the idea of situated learning is also closely related to the ideas of "blended learning" and "learning on demand" especially in educational systems for adults and at the workplace (Oppermann & Specht, 2006). An important point that is not taken into account by a lot of new approaches for delivering learning on demand is the aspect that the need (demand) for knowledge and learning arises in a working context with the motivation for solving specific problems or understanding problem situations. This notion of "learning on demand" in the workplace exemplifies the potential of contextualized learning in the workplace. Learners that identify a problem in a certain working situation are highly motivated for learning and acquiring knowledge for problem solving. They have a complex problem situation as a demand, which can be used for delivering learning content adapted to their situation. Furthermore not only the delivery of content into a certain context or practice is needed but also interaction facilities must be provided which allow an appropriate interaction and cooperation with educational systems.

The contextualization of the learning on demand can not only be seen from the point of view of an actual problem or learning situation but also in a longer lasting process of learning activities that are integrated. Different learning activities are combined in blended learning approaches where the preparation for a task, updates on base knowledge, then the application in an actual working situation and the documentation of problem solutions and the reflection about one's activities evaluates that process.

Latest research stresses also two other dimensions of embedding learning support into everyday life: first integration from a lifelong learning perspective and therefore second also in a community of practice. Latest research into lifelong learning integrates informal and formal learning approaches and supports access to knowledge resources, learning activities, competence development, and learning communities from a variety of clients build on service oriented architectures (Koper & Specht, 2006).

Designing Contextualized Learning Support for Field Trips: RAFT Project

In the context of the European funded project RAFT - Remotely Accessible Field Trips- the consortium created learning tools for field trips in schools. The system should support a variety of learners with different tasks either in the classroom or in the field.

RAFT envisioned to facilitate field trips for schools and to enable international collaboration of schools. Instead of managing a trip for 30 students, small groups from the RAFT partner schools went out to the field, while the other students and classes from remote schools participate interactively from their classrooms via the Internet. The groups going to the field were equipped with data gathering devices (photographic, video, audio, measuring), wireless communication and a video conferencing system for direct interaction between the field and the classroom.

Field trips are an ideal example for an established pedagogical method that can be enhanced with computer-based tools for new ways of collaboration and individual active knowledge construction. The learners in the field can collect information and contextualize it with their own experiences and in the same time work on tasks with their peers and detect new perspectives and solutions to given problems. To foster the variety of perspectives and activities in the field trip process RAFT developed tools for the focused support of different activities in the field and in the classroom. In the last years several research projects have worked on enhanced field trip solutions with mobile technology (Concord Consortium, 2003; Equator Project, 2003).

The RAFT project followed a plan of functional analysis in the field, end user requirements analysis, system and service design, interface design and implementation, and evaluation in the target group. In the following paper we would like to describe the process and some lessons learned out of RAFT for developing and implementing contextualized learning support.

Prototyping and Scenario Based Analysis

In the first year of the project the different phases and functional requirements for supporting live collaboration and information access during field trips were worked out. Field trips with school kids were held in Scotland, Slovakia, Canada and Germany in order to identify different activities in

the field and in the classroom and to draw first evaluations of critical success factors. Different types of field trips where identified including one-class field trips within one subject, cross curricular field trips within a school, interconnection of classrooms with different remote experts, comparison field trips synchronously collecting data from different remote classes, longitudinal studies comparing data from different classes in different years, and others.

Through these trials, different phases for preparing the field trip, experiencing the field trip in the classroom and in the field, and the evaluation after the field trip were identified. Therefore the RAFT applications aimed to support the users with different tools depending on his/her current phase in the field trip process in general: preparation, field trip activity, or evaluation.

Based on the experiences made in the prototyping phase of the project the implementation of different user roles and interfaces is not based on a software solution for intelligent rendering of interface components but was developed with specialized applications for the different roles and role specific devices for fulfilling the tasks in the field and in the classroom. The RAFT applications can be seen as different components in a blended learning process that is distributed in time, location, social context in the different phases of the field trip. Furthermore non functional requirements highlighted the importance of specialized devices for certain tasks to reduce complexity of handling applications and also for the possibility to split up tasks in learner groups as in most field trips the students actually worked in groups.

Workshops with end users where held to understand the handling of hardware and typical usage of devices from end users. Furthermore internal designer workshops allowed us to develop different notions of the integration of field trips into the classroom of the future.

Functional Analysis and Role Model Design

From the prototyping and usage of the RAFT applications by end users we saw the following main activities as new qualities of contextualized learning approaches:

- Cooperative task work for synchronizing activities and raising interest: The distributed work on a task focuses the interaction and communica-

tion between the learners, technology get into the background when the curiosity about the given task and its exploration in physical and knowledge space become the main interest. The context in this sense is an enabling mean that allows the learners to immerse in the learning subject at hand.

- Data Gathering for Active Construction of knowledge and learning materials: Users are much more motivated when "self made" learning material get integrated in the curriculum and they have the possibility to extend existing pre-given structures for learning.
- Instant and multimodal messaging for a lively experience: The instant exchange of multimodal messages on different service levels was identified as a core requirement to make a live field trip experience happing between the field and the classroom.

To support a wide variety of different learning activities and the usage of interfaces on different devices the user interface of the RAFT system had to be built out of single blocks that support different client technologies and interaction styles. Therefore based on the functional specification coming out of the requirements analysis phase we clustered the functionality into components and recombined those components depending on the task and the interaction device a user has available. Additionally a web-service layer was build on the basis of the ALE LCMS (Kravcik & Specht, 2004) which allowed us to give access to a wide variety of interface technologies.

An instantiation of a multimodal communication channel widget is the messaging widget as one component of the RAFT interface. Depending on the input and output characteristics of the device of a user the messaging can be used with classical keyboard input on a classroom role. For example the archiver who is mainly working with a classical PC terminal and web access: As output channel he can also use the PC screen and therefore mostly has text output. On the other hand a scout in the field walking around with a mobile device cannot easily use a text input. Most virtual keyboard input possibilities were quite unusable in the field due to lighting conditions and difficult typing on a mobile device on the move. Therefore the mobile users mostly used scribbles on a notepad like widget and audio input when the environmental conditions allow for.

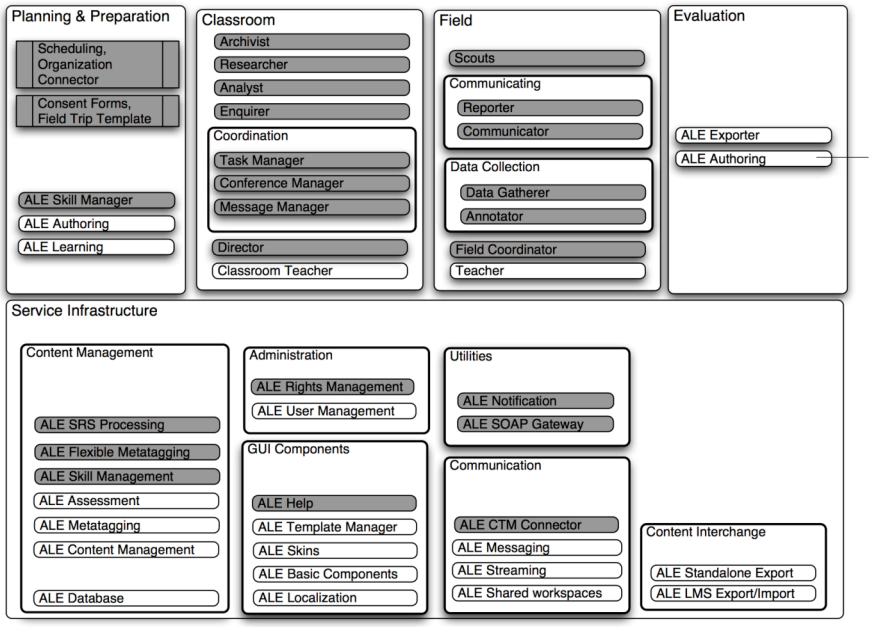

Fig. 1. The basic RAFT service infrastructure and functional clusters

The RAFT services in this sense all build on a common infrastructure with base services as content management, communications support and utilities for administrative support. Furthermore it became clear that a base library for certain interface components was necessary as field trip support applications in most cases had to be adapted to the specific field trip type.

In parallel to this functional clustering also a role model for different pedagogically motivated roles was developed. An excerpt of those is given in the table below.

Table 1 Basic functional Roles and their function with examples.

Role/Function Description	Functions	Example
Expert Interviews/ Reporter	Structure Interview, Moderate questions from the classroom	A field trip class wants to learn about a defined station in a complex production process
Datagatherer/Annotator: During the field trip the students gather data to support/disprove the	Collect Data, Annotate content with metadata, collect sensor measures,	Students go to the different phases of the chocolate production

proposed hypothesis and to find new interesting aspects. Means of data-gathering examples: video, camera, sensor data	verify concrete hypotheses	process and document the stages with photos.
Analyse: Data gained from site is analysed and discussed in the field trip, in the classroom and post field trip event.	Research online, evaluate incoming data from the field	Students look at the images taken from a biology field trip and assess the quality and if hypotheses can be verified based on the acquired materials.

Information Architecture and Use Case Analysis

Based on the role model and the non-functional requirements from the prototyping experiences a basic mapping of functionality and roles was done. Basically by defining such a matrix the focus of the role for a certain task was set and also the cooperation context for different roles was defined.

Table 2 Mapping Roles and Functional Widgets.

Role	Task Widget	Navigation Widget	Messaging Widget	Conference Widget
Field Site				
Data Gatherer	+	+	+	-
Annotator	+	-	+	-
Reporter	+	+	+	-
Communicator	+	-	-	+
Classroom				
Task Manager	+	-	+	-
Director	+	+	+	+
Analyst	+	-	+	-

On the one hand learning pairs could be defined by the roles like the Data Gatherer and Annotator pair, which have a clear split of responsibilities: while the navigator knows where to go on the map to collect certain data the annotator looks at the collected data and annotates it with the current context, both roles get their current context by agreeing on a common task. Another example is the Reporter and communicator pair, while the reporter concentrates on the verbal communication between classroom and expert and has a moderating role the communicator focuses on documenting and capturing the communication with the conferencing and recording

facilities. On the other hand in the classroom site the director has a moderating role for the whole class and therefore needs all information available on the classroom big screen, while the task manager only concentrates on managing and structuring tasks for the field trip on the fly. During the field trips in RAFT it became obvious that the roles do not always need to be split between persons but several roles can also be taken over by one person if complexity allows.

For the different roles in the field trip the information architectures for the different appliances where inferred. One example shows the scouting application.

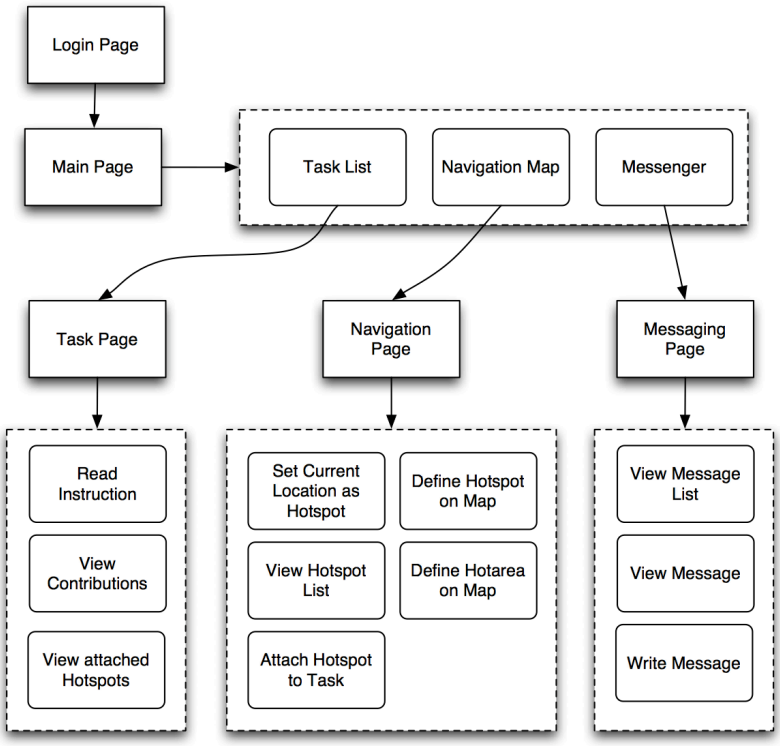

Fig. 2. The information architecture of the scouting application.

Based on this infrastructure the RAFT partners developed a variety of interface components and widgets based on different technologies like Java, Microsoft .NET, Macromedia Flash and others. Those widgets could then be easily combined in different applications, which allowed a highly fo-

cused and contextualized cooperation between different field trip participants.

The RAFT project raised a lot of technical and interaction issues relevant for the field of designing learning experiences for mobile and pervasive learning. Beside the backend technology based on an LCMS and web services that allows for the combination of different client technologies from electronic whiteboards to mobile telephones the synchronization and notification of heterogenous clients accessing a persistent and consistent learning object repository became very important.

As we found the field trip a very good example not only the synchronization between different user cooperating on a common task, but also the distribution over the different phases of the field trip (preperation, field trip activitiy, and evaluation) appear to be an important aspect of nomadic activities for learning and exploration.

Conclusions

The RAFT project implemented and evaluated a flexible set of tools for supporting field trips in schools. Basic experiences and conclusions include but are not limited to the following points:

- A flexible basic service infrastructure is necessary as client technologies change rapidly. Furthermore ubiquitous access to functionality becomes more and more important and trends like the diversification of interfaces and devices make it necessary to construct easily reusable functional components for different application scenarios.
- Restricted interaction facilities of mobile devices and new forms of sensing-based interaction make it necessary to define base contexts for cooperation and cooperative learning nevertheless the main context entities can change. In the RAFT project the tasks were the main context on which a cooperation team agrees, all members had a task widget and took this widget to set the context to which they contribute at the moment.
- Contextualization of applications and the contextualized delivery and acquisition of resources appear to have different criteria and methods relevant. For contextualized learning a pedagogical model to structure the tasks, roles, and built specialized applications seems much more

relevant than the innovative usage of contextual information for on the fly customization of applications. Nevertheless several results in RAFT showed that the contextual information delivery and automatic acquisition of contextual metadata is highly relevant for learning in context (Specht & Kravcik, 2006).

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