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Abstract

In this paper, we analyse how contextualised media can be used to support learning. Additionally, the advantages of contextualised learning and the types of learning that are fit to be supported are discussed. Our focus throughout the paper will be on lifelong learning, and the integration of formal and informal learning therein. However, we think, to this date, most of the research concerning contextualised and mobile learning has been focusing on technological issues. Therefore, as an attempt to shift the discussion to a more educational perspective, a generic technical framework is presented. The technical framework is based on a reference model that came about as the result of a literature analysis in a previous paper. The reference model should provide a foundation that leads to a flexible and generic technical framework that can be used in a range of different learning scenarios. Moreover, a generic technical approach should aim at an easier integration of contextualised learning appliances into current learning.

Keywords:
Contextualised learning, Mobile learning, Mobile social software, Technical framework, Ubiquitous computing

Introduction

Lifelong learning takes place anywhere and anytime and across multiple learning contexts. Some of the learning opportunities take place in a formal context, while others happen in an informal setting. Therefore, e-learning infrastructures that focus on lifelong learning should integrate both formal and informal learning support. Koper & Tattersall (Koper & Tattersall, 2004) present an integrated model for lifelong learning called a “learning network”, which tries to exploit the strengths of a heterogeneous community of self-directed learners. The importance of such communities to support a lifelong learning process has often been stressed in educational research. In this respect, research has been done specifically considering the strengths of embedding learning support in authentic learning contexts and communities of practice (Wenger & Lave, 1991). Additionally, lifelong learning emphasises the responsibility of the self-directed learner to create and structure the learning content himself (Koper & Tattersall, 2004).

In a lifelong learning scenario, a learner can be involved in several learning activities in different contexts at the same time. In this sense, a great deal of learning is informal and therefore highly unstructured (Livingstone, 2001). Mobile devices offer possibilities to make use of these spontaneous, unstructured learning situations. In addition, mobile technology should be seen as a mediating artefact (Sharples, 2007) that (1) can be used to give more structure to informal learning and (2) integrate informal learning into blended learning scenarios. Koper & Tattersall (Koper & Tattersall, 2004) support the potential of mobile devices for learning, by arguing that mobile devices offer new opportunities “to create flexible, rich and interactive learning environments”. Moreover, they specifically identify the potential of mobile information access for lifelong learning as being able to reach anyone, anywhere. Furthermore, mobile access to personalised content provides an instant way of accessing and collecting personal memories. More specifically, mobile access to, for instance, educational blogs (Oravec, 2002) would provide the learner with a way to instantly collect personal information and learning experiences, in that way offering simple tools for supporting long-term informal learning processes embedded in authentic contexts (Trafford, 2005).

Next to on-spot creation and delivery of content, mobile devices offer several ways of acquiring information about the learner. On the one hand, mobile technology is often personal and therefore offers means for personalisation, for example using calendar information to find appropriate moments for learning. On the other hand, by using sensor technology, information about the environment of the learner, the learner’s context, can be acquired. In context-aware computing a variety of notions of context and automatic possibilities for context detection have already been discussed (Abowd & Mynatt, 2000; Dey & Abowd, 1999). More particularly, the combination of context-aware computing with ubiquitous and pervasive techniques leads to systems that are able to adapt to the user’s identity, preferences, location, environment and time (Gross & Specht, 2001; Specht & Kravcik, 2006; Zimmermann, Lorenz, & Specht, 2005). Lifelong learning, supported by these techniques, could provide a high level of personalisation and furthermore provide the learner with suitable learning content at a suitable place and on a suitable moment. A detailed review of the current state-of-the-art in mobile and contextualised learning solutions has been given in (De Jong, Specht, & Koper, to appear).

However, several challenges in contextualised learning can be still identified. First, contextualised learning support needs an infrastructure for contextualisation with a strong technological foundation in the area of context-aware systems (Zimmermann, Lorenz, & Specht, 2005). Second, methods for analysing and designing specific tools tailored to one situation are necessary (Specht, 2007). Third, seen from a human computer interaction perspective, new methods of interacting with ubiquitous and contextualised media and learning experiences need to be researched (Terrenghi, Specht, & Moritz, 2004). Last, and most important, the pedagogical models behind contextualised learning have to be better specified, best practices in applying them have to be developed further (Stone et al., 2002; Tatar et al., 2002), and new ways of integrating contextualised media in already existing learning scenarios have to be found. To provide a generalised way to tackle these challenges, we will propose a framework for contextualised learner support in the following paper.

The paper is laid out as follows. In section two, we will give a short overview of contextualised media for learning and discuss how contextualised media can be used to support learning on-the-spot. After that, section three will describe a reference model for contextualised learning that forms the foundation for the technical framework in section four. In section five, we will describe examples of how the technical framework can be applied in practice. Last, section six gives a summary of the paper and provides an outlook to further research.

Contextualised Media for Learning

Current learning management systems mostly make available their learning content to distance learners via the World Wide Web, and hence could also be accessed by using mobile devices with internet access. Conversely, lifelong learning in a mobile society requires new ways of accessing, structuring, and connecting digital resources to be accessible anywhere and anytime. The dramatic changes in the usage of digital media and the resulting consequences are interestingly discussed in a recent study of Demos (Green & Hannon, 2007). The shift towards a new tradition of online learning is also described by Herrington et. al. (Herrington et al., 2002). However, often current learning content is not suitable to be used with these devices and additionally the following problems with current e-learning systems have recently become clear:

- *De-contextualisation of learning activities*: often learners have been confronted with course information without a real application context and there was often a gap in transferring knowledge to performance that could not be filled instantly by the learners. Furthermore, learning in every-day life is taking place in many occasions, only some of them formal and focused on a clear learning goal with a specified outcome.

- *No support for distributed learning activities and distributed notifications*: especially, in a more activity-oriented learning paradigm the flexible and mobile support for learning activities becomes essential. Activities in this sense are combined in blended learning scenarios, which combine traditional with new technology-based learning media, and can range from reading documents, working on assessments on a PC screen, listening to a pod cast, or collecting pictures on a field trip. Moreover, notifications or process reminders could be more broadly used to structure learning and draw attention to important events in the learning network or interesting aspects of the user's environment.

- *No Integration of Personalised and Contextualised Support for Lifelong Learning:* informal learning, in its broadest sense, takes place everywhere, anytime and in a context or situation that is often not known beforehand. Also, it heavily depends on the learner's individual situation: his preferences, his interests, his working situation, his spare-time to study. In a lifelong learning scenario, personalised and contextualised learning should ideally be combined and tightly integrated. An integration of both personalisation and contextualisation of learning could tailor learning material to the learner's preferences and his current context at the same time.

- *No Continuous Support and Integration of Formal and Informal learning*: In the literature formal and informal learning are mostly distinguished in the sense:

    - Formal education takes place "when a teacher has the authority to determine that people designated as requiring knowledge effectively learn a curriculum taken from a pre-established body of knowledge … whether in the form of age-graded and bureaucratic modern school systems or elders initiating youths into traditional bodies of knowledge"(Livingstone, 2001).

    - Informal learning is "any activity involving the pursuit of understanding, knowledge or skill which occurs without the presence of externally imposed curricular criteria. Informal learning may occur in any context outside the pre-established curricula of educative institutions" (Livingstone, 2001).

  Current research stresses more and more the role of supporting informal learning activities and integrating them with formal and lifelong learning approaches in learning networks (Koper, 2005). From our point of view, the role of continuous and ubiquitous support for learning activities in learning networks is essential to embed learning into every-day living, working, and learning and to support situated and informal learning in learning networks.

Because of these problems in on-the-spot learning, important opportunities to learn might pass. In our opinion, many of such situated learning opportunities could be very useful to support learning on-the-spot and integrate informal learning in a lifelong learning practice. More specifically, the importance of contextualising learning has been directly or indirectly emphasised by research in the field of educational and instructional psychology. Out of this research, we see a new quality for contextualised learning in connecting media with real-world contexts, rooted in different argumentations for learning.

Constructivist theory (Bruner, 1966), for instance, brings forward learning as an active process, in which learners should construct new ideas or concepts based on their current knowledge. Learning has to take into account experiences and contexts that make the student willing and able to learn. Bruner (Bruner, 1996) additionally states that learning should include social and cultural aspects. Similarly, Piaget (Paiget,

1970) emphasises that learning should take place with activities or in situations that engage the learners and require adaptation. Teaching methods should be used that actively involve students and present challenges to the learner. Other research, especially in the field of knowledge management, describes the process of eliciting tacit knowledge (Nonaka & Takeuchi, 1995) by contextualisation and de-contextualisation for abstraction and generalisation of knowledge. Several examples of eliciting expert's knowledge, carried out in a work context during or shortly after the actual action performed, are given by (Schön, 1983; Schön, 1987). Additionally, in the sense of cognitive apprenticeship (Collins, Brown, & Newman, 1989) the learner is guided towards appropriate levels of knowledge by a constant process of contextualisation and de-contextualisation of knowledge. Cognitive apprenticeship furthermore assumes this guidance takes place in an authentic learning situation.

Additionally, according to Cognitive Flexibility Theory (Spiro et al., 1992; Spiro & Jehng, 1990), learning activities must provide multiple representations of content and support context-dependent knowledge. Especially, the theory identifies the importance of using interactive technology to support the learner in the learning process. Multiple representations can also be found in various opinions of different learners. In this sense, 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 a community of practice must not only be structured by a curriculum, but also, should use authentic tasks and learning situations, i.e., settings and applications that would normally involve the knowledge learned. Additionally, it should involve 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-contextualised. Sticht (Sticht, 1975), shares emphasis with situated learning in addressing the need to make learning relevant for the work context. Moreover, he states that the assessment of learning requires a context/content specific measurement.

Thus, from the perspective of constructivist learning theory, situated learning theory in specific, several requirements for new learning tools can be given; they should enable active construction of knowledge, use authentic problems, allow for multiple perspectives in learning, enable learning by social interaction within communities, and allow for reflection about own knowledge. Mobile and contextualised media offer unique chances to address these requirements; using context-aware techniques the learning content can be adapted to a certain learning moment, allow for flexible creation of media and related context information, and make the learner aware of possible situations of interest by using notifications (Dey & Abowd, 1999; Oppermann & Specht, 2006).

More specifically, Ogata & Yano (Ogata & Yano, 2004a, 2004b) identified five characteristics of contextualised/ubiquitous learning, that made it suitable for learning. First, contextualised learning offers *permanency*; learning processes are recorded continuously which allows for later reflection of learning about knowledge. Second, learning content is *accessible* anywhere, and third, *immediate* access to content allows learners to store and retrieve learning content at anytime. The accessibility and immediacy of content access makes it possible to use content in authentic situations, and to tailor it to the current need of the learner. In this sense, also the fourth characteristic, *interactivity*, and the fifth, the *situating of instructional activities*, allow for a better adaptation to the learner's current situation and for a more active learning situation. Additionally, contextualised/ubiquitous technology should be as non-intrusive as possible by being as invisible as possible, which should result in a user interaction as natural as possible (Weiser, 1991). This non-intrusiveness would also prevent mobile technology from interrupting learning scenarios (Sharples, 2003). Moreover, a blended learning scenario that integrates contextualised learning combines de-contextualisation and contextualisation of knowledge, and could be used for tacit knowledge elicitation.

A technical framework for contextualised media for learning should take into account the requirements identified from different theoretical backgrounds. Furthermore, the flexible combination of learning content and context information into pedagogical models used for learning in blended or authentic learning settings should be enabled by a flexible infrastructure supporting contextualised media for learning.

For us, contextualised media enables the user to create, retrieve, and use digital media in a relevant real-world context for notification, documentation, problem solving, reflection, communication and a variety of other learning activities. An infrastructure for enabling such contextualised media needs to be flexible to configure and map properties of digital media and learning contexts for different pedagogical models. In the following sections, we will first analyse the state-of-the-art of contextualised learning applications and introduce a theoretical framework out of a literature analysis we have described in detail in an earlier publication (De Jong, Specht, & Koper, to appear).

Already available solutions in current state-of-the-art

In the current state-of-the-art in mobile and contextualised learning already some research has been done in addressing the problems above. Several projects have looked at how to contextualise learning content by using contextual metadata (Equator Project, 2003; Specht & Kravcik, 2006). Also, the MOBILearn project (Bo, 2002) combines multimedia content creation, content delivery and stores context metadata about that content. Most interesting, new approaches in context-aware systems see the main strength in combining different context parameters for user support. In the MACE project, the combination of various types of content, usage, social and contextual metadata enables users to develop multiple perspectives and navigation paths that effectively lead to experience multiplication for the learner (Stefaner et al., 2007). PhotoStudy (Joseph, Binsted, & Suthers, 2005) is an example that annotates learning content with images or audio recorded on mobile devices for a better contextualisation. Moreover, QueryLens (Konomi, 2002) focuses on information sharing using smart objects that can be enriched with learning content. Moop (Mattila & Fordel, 2005) couples a GPS location to observations/information gathered in the field for later analysis in the classroom. However, one of the most interesting projects, the KLIV project (Brandt et al., 2002; Brandt & Hillgren, 2003), delivered contextualised video content to PDAs used by nurses to learn how to operate medical devices; the video content had been recorded by more experienced colleagues.

Already also a couple of blended learning scenarios, incorporating distributed learning activities, have been investigated. Environmental Detectives (Klopfer, Squire, & Jenkins, 2002) is an example that combines a field trip with formal learning in a classroom; students take pictures in an outside setting to enhance the learning experience in remote participation. A similar approach was taken in the RAFT project, which demonstrated effects on classroom engagement and participation with the integration of authentic learning materials from remote field trips (Bergin et al., 2007). (Mattila & Fordel, 2005; Paredes et al., 2005) also discuss a system aimed at field trips combined with a classroom discussion about the results of the field trip afterwards. Additionally, a number of systems provide distributed notifications. For example, in (Eagle & Pentland, 2005) notifications are used to introduce people with similar interests to each other to highlight a learning opportunity. Moreover, the more standard form of notification systems (Berger et al., 2003; Liu et al., 2005; Silander, Sutinen, & Tarhio, 2004) want the user to react on or learn about some peer activity being performed.

An interesting attempt to integrate personalised and contextualised learning support has already been given in (Ogata & Yano, 2004b) who present CLUE, a system for learning English in real-world situations. CLUE uses (1) a learner profile to adapt the learning content to the learner's interest and (2) location information to link objects/locations to suitable English expressions, i.e. appropriate learning content. Likewise, MOBILearn (Bo, 2002) combines a user profile and user position, to facilitate personalised and location-based information delivery. A slightly different approach is presented in (Jansen et al., 2005) that delivers content on a public display board called SynchroBoard; most of the information on the board is public information, but the information is adapted to individual users based on Bluetooth information from their mobile phones; this enables personal perspectives on public content objects.

Examples of the continuous support and integration of formal and informal learning are harder to be found. The Musex system (Yatani, Sugimoto, & Kusunoki, 2004) is one appealing example. The system focuses on enkindling face-to-face discussion by using PDAs to inform two paired learners about the correctness of their answers to a certain question; hence, it integrates formal learning content with an informal discussion. KLeOS (Vavoula & Sharples, 2002) is designed to support lifelong learning by managing and organising their learning processes, and is accessible on a number of different platforms for continuous learner support. Furthermore, a number of learning management systems are integrating support for mobile devices for a greater accessibility of learning content (Bo, 2002; Houser & Thornton, 2005; Mitchell et al., 2006; Raymond et al., 2005) .

However, we feel the identified problems have not been addressed enough. Current solutions mostly focus on one specific sub-problem and often do not provide integrated solutions for lifelong learning. More specifically, current research seems to aim mostly at mobile technology and frequently the educational part plays only a minor role. In our opinion, a generalised technical framework for contextualised media, with a strong technical foundation in context-aware systems and offering flexible ways of designing learning scenarios, could change the focus. Therefore, in the next section we will present a reference model that provides a way to classify and analyse existing contextualised media for learning. Moreover, based on the characteristics of contextualised media contained in the reference model, we will present a number of extensions for current systems for contextualised media.

A reference model for Contextualised Media

In (De Jong, Specht, & Koper, to appear) the authors present a review of current systems for mobile contextualised learning support and a reference model that is used to classify the current research. The reference model is also used to identify limitations of current applications and to discuss new solutions and challenges for contextualised learning support. Table 1 shows the reference model that is comprised of five dimensions: content, context, information flow, purpose, and pedagogical model. For each dimension, the possible values are given in the column below.

Table 1 A reference model for mobile social software

Content	Context	Information flow	Pedagogical model	Purpose
Annotations Documents Messages Notifications	Individuality Context Time Context Locations Context Environment or Activity Context Relations context	One-to-one One-to-many Many-to-one Many-to-many	Behaviourist Cognitive Constructivist Social Constructivist	Sharing Content and Knowledge Facilitate Discussion and Brainstorming Social Awareness Guide Communication Engagement and Immersion

The five dimensions and corresponding values describe the following aspects of contextualised media for learning:

- The content dimension describes the artefacts exchanged and shared by users. In an analysis of the literature the main types of artefacts found were: annotations, documents, messages, and notifications.
- The context dimension describes the context parameters taken into account for learning support. The five values for the context dimension are based on an operational definition of context (Zimmermann, Lorenz, & Oppermann, 2007).
- The information flow classifies applications according to the number of entities in the systems involved in information flows and information distribution.
- The pedagogical paradigms and instructional models describe the main paradigm leading the design of contextualised media and the integration of media in real-world contexts.
- The purpose describes applications according to the goals and methods of the system for enabling learning.

Thus, on the one hand, the reference model describes the manipulated knowledge resources, the context in which they are used, and the different flows of information. On the other hand, the higher level concepts of pedagogical model and purpose define how the content, context, and information flows are used and combined. Hence, by combining different values for each dimension, various forms of contextualised software can be created for different purposes and with different pedagogical underpinnings. For example, a system with a main purpose of *sharing content and knowledge* between its users, can be described by using *documents* from the content dimension, *relations context* to describe social relations between the users, and a many-to-many information flow. Another example is a location-based information system like RAFT (RAFT, 2003), which combines (1) the creation and delivery of documents with (2) locations context, (3) a one-to-many information flow to provide (4) a social constructivist approach for increased (5) engagement and immersion.

In (De Jong, Specht, & Koper, to appear) the authors have already explored a lot of other combinations in the state-of-the-art in mobile social software. During this exploration also some limitations of mobile contextualised learning solutions have become clear. Summarising the following extensions to current state-of-the-art can brought forward based on these limitations:

- provide more integrated systems with a range of functionality,
- better and wider use of metadata,
- more advanced and wider use of notification techniques,

- an improved adaptation to the user's personal preferences and learning environment or situation by using more kinds of context information than location and identity alone, and use of techniques to derive more detailed or higher level context information by a combination of different context parameters,
- more attention to systems aiming at informal and lifelong learning.

With the reference model and the extensions as guidelines, a generalised technical framework will be developed in the next section.

A Technical Framework for Contextualised Learning

To address the extensions given in the previous section, we propose a generic technical framework for contextualised media for learning. The wide range of possible contextualised learning scenarios requires a flexible technical framework. The framework should offer support for on-the-spot content creation and delivery and should make it possible to combine content and context information in addition. Therefore, we propose a framework that consists of a context management part and an independent part, handling different types of contents on an abstract level. The context management part will be based on already existing infrastructures for context management. Zimmermann, Lorenz, and Specht (Zimmermann, Lorenz, & Specht, 2005) suggest a standard architecture for context management that semantically enriches contextual data step by step in successive layers, which will be used as our main guideline.

The system should integrate the use of content with the use of metadata, make it possible to combine different kinds of context information into higher level information, and enable the design of higher level processes based on this context information and the available content. Additionally, the technical framework should take into account the reference model presented earlier. Figure 1 shows an overview of the technical framework comprised of a multi-column model with four layers.

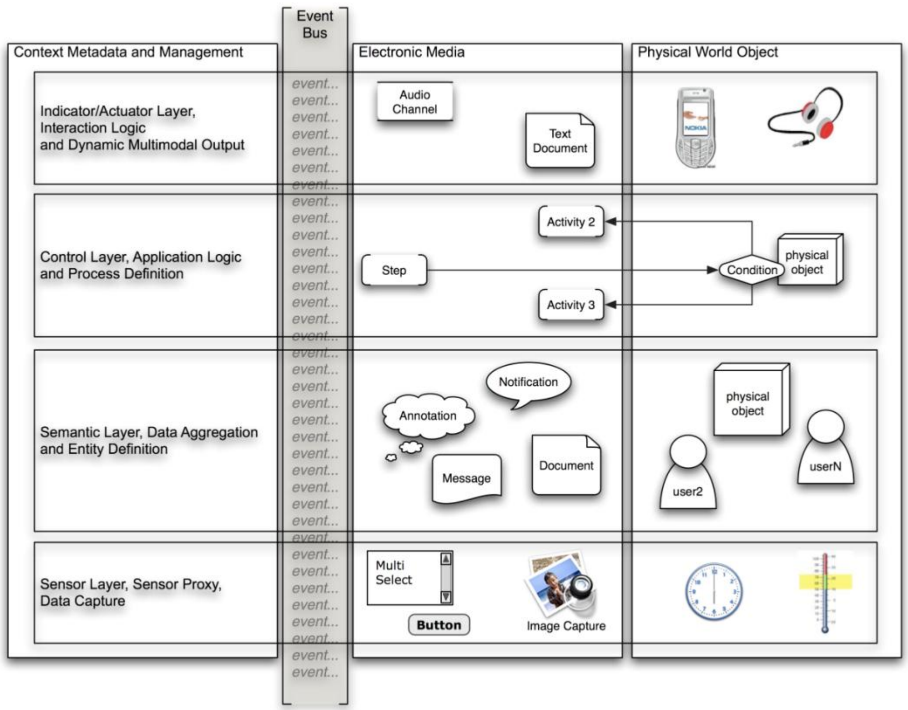

Figure 1: The contextualised media framework, its layers and entities.

On the one hand, the four layers represent the several forms of data used in the system; from unstructured, raw data in the lowest layer to highly structured and enriched data in the topmost layer. On the other hand, the three columns identify the different kinds of artefacts that can be used in a learning process: the context metadata identifying the learning situation, the electronic media used in the learning process (context and content in the reference model), and the physical world objects the learners interact with during that learning process. The two leftmost columns (context and content) are modelling the physical world in the rightmost column. The artefacts used and manipulated in each of the columns will be described in more detail in the subsections below. Finally, the event-bus used for communication throughout the framework is described and some suggestions for a technical implementation given.

Context Metadata and Management

The leftmost column in figure 1 will be aimed at acquiring and managing context metadata. Context information is acquired through sensors and can be further enriched to more detailed information about a learning situation. The situation will be described using context metadata in one or more of the five categories of context information of the reference model:

- Individuality context includes information about objects and users in the real world as well as information about groups and the attributes or properties the members have in common.

- Time context, this dimension ranges from simple points in time to ranges, intervals and a complete history of entities.

- Locations context is divided into quantitative and qualitative location models, which allow working with absolute and relative positions.

- Environment or Activity context reflects the entities, goals, tasks, and actions of a user.

- Relations context captures the relation an entity has established to other entities, and describes social, functional, and compositional relationships.

This contextual information can be used to describe or derive information about the user (describing for example the learner's personal preferences), information about the environment, (describing the learner's physical environment) or, information about the social context of the learner (describing the social relationships a learner is involved in and the social networks the learner is part of).

The sensor data, representing various complexities or combinations of these five categories of contextual information, is captured in the lowest layer. Each subsequent layer will enrich the sensor data more, until an action responding to the current context can be carried out. The second layer, or semantic layer, contains low level rules that combine sensor data into higher level context information. For example, using a combination of individuality context, time context and locations context, relations context can be derived, identifying which users are interacting at a specific time and place. Another example is the calculation of the user's speed by combining location and time context. After semantically enriching the sensor data, the third layer (the control layer) defines high-level application logic that can model the actions that have to be taken on the basis of the current context information. These rules define what we call *Content-Context Modelling*, which models the adaptation of learning content to context information, identifying a certain learning context. For instance, a rule giving a notification to draw attention to a location, object, or other learner can be created. The fourth layer, the indicator/actuator layer, chooses the indicator or actuator that is best suited to carry out the action from the control layer or display the learning content chosen. If, for example, the noise level is too high for people to hear an audio feedback, the layer could decide to provide visual feedback instead.

Contextualised Electronic Media

The middle column of figure 1 handles all kinds of electronic media, a combination of which can be found in most learning content. The lowest layer provides several mechanisms of media input by the learners, for example, image capture from a mobile device or text input from a web-based widget. The second layer manipulates several kinds of electronic media, based on the four types identified by the reference model: annotations, documents, messages, and notifications. Several kinds of input from the first layer can be combined to form one of these for types of content. For example, a text input together with an audio message forms a multimodal annotation. Furthermore, the second layer also stores and retrieves the electronic media in/from the content repositories.

The third layer defines activity models that define learning activities and the combination of content, information flows, and learner roles. Educational processes can be modelled on the basis of these activity models and pedagogical paradigms from the reference model. The educational scenarios will be modelled in IMS Learning Design(IMS LD) (Koper, Olivier, & Anderson, 2003). By providing an interface to the context metadata and management system, the educational scenarios are able to use context information about the learner and his environment. Thus, context information can be used to drive the modelled educational process into a specific direction. Moreover, physical world objects, real-world locations, and detailed information about the user and his social environment can be integrated to support learning. Hence, real-world situations and objects can be described using the context information and electronic media. Finally, the last layer chooses, on the basis of the electronic media that has been selected by the educational process modelling, which output channel should be chosen, i.e. the audio channel of a mobile phone or a Smartboard display to output a text document (see figure 1).

Physical world objects

The third and rightmost column is not part of the technical framework as such. However, it helps in identifying which concepts can be used in current learning processes. For example, the lowest layer describes units that can be measured by the sensors of the context metadata and management system, i.e. speed or temperature. The second layer identifies which users and which real-world objects can be used in an educational scenario. These objects can be equipped with tags that help in detecting their current context; the barcodes, RFID tags, or information from a Global Positioning System (GPS) to facilitate context-detection are described in the third layer. The tags make it possible to attach electronic media to real-world objects or locations. The fourth layer describes artefacts that can be used to mediate learning or reach the learner, like for instance a mobile phone to display content and acquire context information or a wireless head-phone to be able to stream audio content information to the learner at a specific location.

Event bus and technical implementation

For an extensible and flexible framework, we are using a service-oriented architecture, consisting of a server and several clients that provide the sensors and actuators (Rehrl et al., 2004). In addition, an event bus is used for all interlayer communication; functional components can register for events published by other components and are notified whenever such an event occurs. On notification, the component carries out an action as reaction to the event, which may result in new events being published. For instance, a sensor can post a *sensor update event* with new sensor values on the event bus, which will be picked up by other modules listening to sensor updates. The technical framework will be released under an open source licence and use existing open source software as a foundation.

An Application of Contextualised Media for Learning

The technical framework described in the previous section allows us to (1) model different educational applications based on three dimensions of content, context and information flow and (2) implement these educational applications in a standardised way with minimised effort. As one example we will describe the ContextBlogger application (De Jong et al., 2007; De Jong, Specht, & Koper, 2007), which from our view demonstrates the possibilities of the framework described above.

Contextual blogging combines social software, a weblog, with information about the context of a learner. The information in the weblog can be accessed using a mobile device, and the content can be filtered through the application of search filters based on context information. The search filters for the contextual blogging application retrieve the content either related to a specific real-world object or to a specific user location. Furthermore, the learner can also choose to create his/her own content and relate it to a real-world objects or locations. Therefore, the use of the contextual blogging application provides a basis for an investigation of the usage of physical artefacts in learning. On the one hand the combination with a physical object could provide the basis for learning, on the other, shared objects could be used to build communities of practice and couple the creation of learning networks to physical objects.

Through applying different context filters in combination with the creation or retrieval of weblog content, we expect to achieve different educational effects:

- *Multiple perspectives on real-world objects*: by viewing the object's history, a certain category of blog entries, or using other filters people benefit through an indirect learning process (Efimova & Fiedler, 2004; Walker, 2005).
- *Community-generated content* connected to relevant real-world objects and locations: an example for the effect and importance of self-generated contents in a learning community is presented in (Brandt et al., 2002; Brandt & Hillgren, 2003) about learning to operate medical devices.
- *Community interaction* and the creation of communities of interest around certain objects and locations, supporting contextualised learning.

- *Different views about objects*, based on personal preferences. Real-world objects can also be linked electronically to create relations between those objects and to create a so-called "internet of objects" (Mattern, 2004).
- *Increase motivation through active learning*, by actively involving the learner in the learning process, the learner involvement and motivation is increased. This as opposed to passive learning in a formal classroom setting.

To achieve these educational effects, the underlying concepts of a system for contextualised blogging and the relations between them should be analysed. For instance, to create *multiple perspectives on real-world objects and locations*, a user should be able to interact with a physical object and should be able to retrieve content linked to that physical object. By using shared real-world objects, multiple users can interact with them, and create information objects related to them or view, rate and comment the content added by other people (*community-generated content)*. In that way, a community of users can evolve around these shared objects and the *community interaction* leads to different opinions and perspectives about these objects. The multitude of perspectives about a shared object, can lead to either a discussion between users with different opinions or leads to reflection about a situation by the learner; either by looking at the opinions of other users, or by adding content and reading it back later, as an opportunity to reflect back on what happened before (Schön, 1983; Schön, 1987). To prevent the user from being overwhelmed by the amount of information available in a community, contextualised search filters are used that only display the relevant information for a certain situation or context. By combining these educational effects the system addresses the lifelong learner, by providing several opportunities for the self-centred learner or a community of these learners to structure the learning process. Also the system relies on the implicit assumption of lifelong learning that responsibility for the creation and structuring of learning content resides with the self-directed learner himself (Koper & Tattersall, 2004).

Summary and Outlook

In this paper, we first gave a description of contextualised media and its applications for learning. We identified a couple of challenges for current solutions for contextualised learning support, that in our opinion could be best addressed and researched with a generalised technical framework. First, some extensions for current contextualised media were given on the basis of a reference model that was the result of earlier research in the field (De Jong, Specht, & Koper, to appear). After that, a technical framework was defined founded on the reference model and the extensions given. The technical framework is based on a context-aware system given by (Zimmermann, Lorenz, & Specht, 2005) that semantically enriches the acquired context information step by step. Similarly, the technical framework consists of four layers which represent an increasing complexity of the concepts used in those layers; sensor data and user input is collected in the first and lowest layer, more complex combinations of this lower level data are created in the second layer, process and application logic are defined in the third layer, and finally, in the fourth layer and topmost layer, actuators are chosen and actions are carried out. Moreover, the framework consists of three columns with different types of concepts: (1) context metadata and management, (2) electronic media, and (3) physical objects. Finally, an example of an application of contextualised media for learning was given, which applies the technical framework for blogging in context.

In the future, we will empirically evaluate the effects of contextualised social media in different learning applications; first of all, we will use the evaluation to validate our technical framework, and second, the experiments will be used to investigate best approaches for contextualised learning support. With each experiment new functionality will be added to the technical framework described in this paper. The first experiment will investigate the effects of contextualised content delivery on language learning and compare these to non-contextualised approaches. A second experiment will combine contextualised content delivery and creation and investigate its effects on learning. Last, a third experiment will consider ubiquitous notifications on top of the functionalities already given.

References

Abowd, G. D., & Mynatt, E. D. (2000). Charting Past, Present, and Future Research in Ubiquitous Computing. *ACM Transactions on Computer-Human Interaction, 7*(1), 29-58.

Berger, S., Mohr, R., Nösekabel, H., & Schäfer, K. J. (2003). Mobile Collaboration Tool for University Education. *Proceedings of Proceedings of the 12th IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises*.

Bergin, D. A., Anderson, A. H., Molnar, T., Baumgartner, R., Mitchell, S., Korper, S., Curley, A., & Rottmann, J. (2007). Providing remote accessible field trips (RAFT): an evaluation study. *Computers in Human Behavior, 23*(1), 192-219.

Bo, G. (2002). MOBILEARN: Project final report [Electronic Version]. Retrieved 1st July from http://www.mobilearn.org/download/results/public_deliverables/MOBIlearn_Final%20Report.zip.

Brandt, E., Björgvinsson, E., Hillgren, P.-A., Bergqvist, V., & Emilson, M. (2002). PDA´s, Barcodes and Video-films for Continuous Learning at an Intensive Care Unit. *Proceedings of NordiCHI*. October 19-23, 2002, Aarhus, Denmark.

Brandt, E., & Hillgren, P.-A. (2003). Self-produced video to augment peer-to-peer learning. *Proceedings of MLEARN 2003* (pp. 27-34). 19-20 May, London, United Kingdom: Learning and Skills Development Agency.

Bruner, J. (1966). *Toward a Theory of Instruction*. Cambridge,MA: Harvard University Press.

Bruner, J. (1996). *The Culture of Education*. Cambridge, MA: Harvard University Press.

Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive Apprenticeship: Teaching the Craft of Reading, Writing, and Mathematics. In L. B. Resnick (Ed.), *Knowing, Learning and Instruction* (pp. 453 - 494). Hillsdale N.J: Lawrence Erlbaum Associates.

De Jong, T., Al Takrouri, B., Specht, M., & Koper, R. (2007). Campus Memories: Learning with Contextualised Blogging *Proceedings of The 2nd TenCompetence Workshop* (pp. 59-67). January 11-12, 2007, Manchester, United Kingdom: The Institute for Educational Cybernetics, University of Bolton.

De Jong, T., Specht, M., & Koper, R. (2007). *ContextBlogger: Learning by blogging in the real world.* Paper presented at the conference ePortfolio 2007, Maastricht, The Netherlands.

De Jong, T., Specht, M., & Koper, R. (to appear). A Reference Model for Mobile Social Software for Learning. *International Journal of Continuing Engineering Education and Life-Long Learning (IJCEELL).*

Dey, A. K., & Abowd, G. D. (1999). *Towards a better understanding of Context and Context-Awareness* (GVU Technical Report No. GIT-GVU-99-22,): College of Computing, Georgia Institute of Technology.

Eagle, N., & Pentland, A. (2005). Social serendipity: mobilizing social software. *Proceedings of Pervasive Computing, IEEE* (pp. 28-34). April.

Efimova, L., & Fiedler, S. (2004). LEARNING WEBS: LEARNING IN WEBLOG NETWORKS. *Proceedings of Web-based communities*. 24-26 March 2006, Lisbon, Portugal.

Equator Project. (2003). The EQUATOR Interdisciplinary Research Collaboration. 2003, from http://www.equator.ac.uk/

Green, H., & Hannon, C. (2007). *Young people are spending their time in a space which adults find difficult to supervise or understand*. London: Demos.

Gross, T., & Specht, M. (2001). Awareness in Context-Aware Information Systems. *Proceedings of Proceedings of the Mensch und Computer - 1. Fachübergreifende Konferenz* (pp. 173-182), Bad Honnef, Germany: Teubner-Verlag.

Herrington, J., Oliver, R., Herrington, T., & Sparrow, H. (2002). Towards a new tradition of Online Instruction: Using Situated Learning Theory to Design web-Based Units. *Proceedings of 17th Annual ASCILITE Conference*, Lismore: Southern Cross University Press.

Houser, C., & Thornton, P. (2005). Poodle: a course-management system for mobile phones. *Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE '05)* (pp. 211-215).

Jansen, M., Rossmanith, P., Uzun, I., & Hoppe, U. (2005). Integrating Heterogeneous Personal Devices with Public Display-Based Information Services. *Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE '05)* (pp. 149-153).

Joseph, S., Binsted, K., & Suthers, D. (2005). PhotoStudy: Vocabulary Learning and Collaboration on Fixed and Mobile Devices. *IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE 2005)*, 206-210.

Klopfer, E., Squire, K., & Jenkins, H. (2002). Environmental Detectives: PDAs as a window into a virtual simulated world. *Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'02)* (pp. 95-98). August.

Konomi, S. I. (2002). QueryLens: Beyond ID-based information access. *Proceedings of UbiComp 2002: Ubiquitous Computing : 4th International Conference* (pp. 210-218). September 29 - October 1, 2002, Göteborg, Sweden: Springer, Berlin.

Koper, R. (2005). *TENCompetence: Building the European Network for Lifelong Competence Development* (Project Draft). Heerlen: Open Universiteit Nederland.

Koper, R., Olivier, B., & Anderson, T. (2003). *IMS Learning Design Information Model*: IMS Global Learning Consortium.

Koper, R., & Tattersall, C. (2004). New directions for lifelong learning using network technologies. *British Journal of Educational Technology, 35*(6), 689–700.

Liu, C. C., Tao, S. Y., Nee, J. N., Liu, B. J., Chen, G. D., Hsu, C. C., & Horng, J. T. (2005). Supporting Activity Awareness for Teams-Games-Tournaments with GSM Network. *Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE '05)* (pp. 238-242).

Livingstone, D. W. (2001). Adults' Informal Learning: Definitions, Findings, Gaps and Future Research. Working paper. from http://www.oise.utoronto.ca/depts/sese/csew/nall/res/21adultsifnormallearning.htm

Mattern, F. (2004). Wireless Future: Ubiquitous Computing. *Proceedings of Wireless Congress*. November 2004, Munich, Germany.

Mattila, P., & Fordel, T. (2005). *MOOP - Using m-learning environment in primary schools.* Paper presented at the conference MLEARN 2005. 25-28 October, Cape Town, South Africa.

Mitchell, K., Race, N. J. P., McCaffery, D., Bryson, M., & Cai, Z. (2006). Unified and Personalized Messaging to Support E-Learning. *Proceedings of Fourth IEEE International Workshop on Wireless, Mobile and Ubiquitous Technology in Education (WMTE '06)* (pp. 164-168).

Nonaka, I., & Takeuchi, H. (1995). *The Knowledge Creating Company*: Oxford University Press, USA.

Ogata, H., & Yano, Y. (2004a). Context-aware support for computer-supported ubiquitous learning. *The 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE '04)*, 27-34.

Ogata, H., & Yano, Y. (2004b). Knowledge awareness map for computer-supported ubiquitous language-learning. *Proceedings of The 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE '04)* (pp. 19-26).

Oppermann, R., & Specht, M. (2006). Situated Learning in the Process of Work. In D. Hung & M. S. Khine (Eds.), *Engaged Learning with Emerging Technologies* (pp. 69-89). Berlin: Springer Verlag.

Oravec, J. (2002). Bookmarking the World: weblog applications in education. *Journal of Adloescent and Adult Literacy, 45*(7), 616-621.

Paiget, J. (1970). *The Science of Education and the Psychology of the Child*. New York: Grossman.

Paredes, R. G. J., Ogata, H., Saito, N. A., Yin, C., Yano, Y., Oishi, Y., & Ueda, T. (2005). LOCH: Supporting Informal Language Learning Outside the Classroom with Handhelds. *Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE '05)* (pp. 182-186).

RAFT. (2003). RAFT Project Website. 2003, from http://www.raft-project.net

Raymond, D., Mauad, C. E., Baudin-Thomas, V., Gayraud, T., Kanenishi, K., Matsuura, K., Diaz, M., & Yano, Y. (2005). Bringing Mobility to Synchronous Collaborative Activities: Recent Enhancements of the" Platine" Platform. *Proceedings of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE '05)* (pp. 59-61).

Rehrl, K., Bortenschlager, M., Reich, S., Rieser, H., & Westenthaler, R. (2004). Towards a Service-Oriented Architecture for Mobile Information Systems. *Proceedings of IFIP TC8 Working Conference on Mobile Information Systems (MOBIS)*. 15-17 September 2004, Oslo, Norway.

Schön, D. A. (1983). *The Reflective Practitioner: How Professionals think in Action*. London: Maurice Temple Smith.

Schön, D. A. (1987). *Educating the Reflective Practitioner*. San Francisco: Jossey-Bass.

Sharples, M. (2003). Disruptive Devices: Mobile Technology for Conversational Learning. *International Journal of Continuing Engineering Education and Lifelong Learning, 5/6*(12), 504-520.

Sharples, M. (2007). *Big Issues in Mobile Learning: Report of a workshop by the Kaleidoscope Network of Excellence Mobile Learning Initiative*: Learning Sciences Research Institute, University of Nottingham.

Silander, P., Sutinen, E., & Tarhio, J. (2004). Mobile collaborative concept mapping-combining classroom activity with simultaneous field exploration. *Proceedings of The 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE '04)* (pp. 114-118).

Specht, M. (2007). Contextualized Learning Support. In H. Adelsberger, Kinshuk, J. Pawlowski & D. Sampson (Eds.), *International Handbook on Information Technologies for Education and Training*. Heidelberg: Springer.

Specht, M., & Kravcik, M. (2006). Authoring of Learning Objects in Context. *International Journal on E-Learning, 5*(1), 25-33.

Spiro, R. J., Feltovich, P. J., Jacobson, M. J., & Coulson, R. L. (1992). Cognitive flexibility, constructivism and hypertext: Random access instruction for advanced knowledge acquisition in ill-structured domains. In T. Duffy & D. Jonassen (Eds.), *Constructivism and the Technology of Instruction* Hillsdale, NJ: Erlbaum.

Spiro, R. J., & Jehng, J. (1990). Cognitive flexibility and hypertext: Theory and technology for the non-linear and multidimensional traversal of complex subject matter In D. Nix & R. Spiro (Eds.), *Cognition, Education, and Multimedia*. Hillsdale, NJ: Erlbaum.

Stefaner, M., Dalla Vecchia, E., Condotta, M., Wolpers, M., Specht, M., Apelt, M., & Duval, E. (2007). MACE – Enriching Architectural Learning Objects for Experience Multiplication. *Proceedings of 2nd European Conference on Technology Enhanced Learning EC-TEL* (pp. 322-336): Springer.

Sticht, T. G. (1975). Applications of the audread model to reading evaluation and instruction. In L. Resnick & P. Weaver (Eds.), *Theory and Practice of Early Reading* (Vol. 1). Hillsdale, NJ: Erlbaum.

Stone, A., Alsop, G., Briggs, J., & Tompsett, C. (2002). M-Learning and E-Learning: a Review of Work Undertaken by the Learning Technology Research Group, Kingston University, UK. *Proceedings of Proceedings of the Europeain Workshop on Mobile and Contextual Learning* (pp. 71). 20-21st June, 2002, The University of Birmingham, England: The University of Birmingham, England.

Tatar, D., Roschelle, D., Vahey, P., & Peunel, W., R. (2002). Handhelds go to School: Lessons Learned.

Terrenghi, L., Specht, M., & Moritz, S. (2004). Design of an Interface for Technology Supported Collaborative Learning - the RAFT Approach. *Proceedings of International Conference on Entertainment Computing* (pp. 522-525), Eindhoven, The Netherlands: Springer Berlin / Heidelberg.

Trafford, P. (2005). Mobile Blogs, Personal Reflections and Learning Environments. *ARIADNE, Web magazine for information professionals in archives, libraries and museums*(44).

Vavoula, G. N., & Sharples, M. (2002). KLeOS: a personal, mobile, knowledge and learning organisation system. *Proceedings of IEEE International Workshop on Wireless and Mobile Technologies (WMTE '02)* (pp. 152-156).

Walker, J. (2005). Weblogs: Learning in Public. *On the Horizon, 13*(2), 112-118.

Weiser, M. (1991). The Computer for the 21st Century. *Scientific American, 3*(265), 94-104.

Wenger, E., & Lave, J. (1991). *Situated Learning: Legitimate peripheral participation*. Cambridge, New York: Cambridge University Press.

Yatani, K., Sugimoto, M., & Kusunoki, F. (2004). Musex: a system for supporting children's collaborative learning in a museum with PDAs. *Proceedings of The 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE '04)* (pp. 109-113).

Zimmermann, A., Lorenz, A., & Oppermann, R. (2007). An Operational Definition of Context. *Proceedings of Context 07*.

Zimmermann, A., Lorenz, A., & Specht, M. (2005). Personalization and Context-Management. *User Modeling and User Adaptive Interaction (UMUAI), Special Issue on User Modeling in Ubiquitous Computing, 15*(3-4), 275-302.