Ubiquitous Learning Environments: Notions of Context, Application Scenarios and Reflective Stories

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Abstract: Different notions of context do not only impact system design for ubiquitous computing, but also for mobile and ubiquitous learning. Introducing and discussing different application scenarios for mobile educational technology we explore the design space of mobile learning and reflect upon the different notions of context being involved. The first scenario involves PDSs and interactive whiteboards and enables a seamless integration of learning activities inside and outside the classroom. The second scenario enables learning in natural contexts by means of augmented reality. Within the third scenario mobile students sustain their personal comfort zone by carrying along their familiar learning environment. In a final scenario students actively contribute to an emerging ecosystem of learning resources. Following a comparative discussion of existing approaches how contexts may be generated by learners, storytelling and geocaching are introduced as valuable ways to share lessons learned and to contextualize information in meaningful ways within the realm of mobile learning.

1 Introduction

Within communities of practice advanced learners become natural teachers, and lessons they learned become lectures and stories to be told to following generations. Within the field of mobile learning has been described as “learning across contexts” (Walker, 2006); but the situated potentials for learning in different contexts, and resulting requirements for learner-centered system design have rarely been considered. Moreover, the notion of context itself, which Dourish (2004) identifies as a central issue for HCI, remains unclear. Within this paper we discuss design challenges and new opportunities of portable technologies to support learning activities inside the classroom and outside across various contexts. A scenario approach allows us to think through different setups of educational technology for mobile learners and to compare the different notions of context being involved. Coming from an utilization of context to situate and enrich learning opportunities we move on to the notion of learner-generated context and storytelling as a technique to establish context and communicate educational content. An ubiquitous learning scenario is introduced to exemplify this approach. It enables mobile learners to share their insights and reflections upon cultural ways to deal with earthquakes at tourist sights.

2 Related Works

Several learning theories share an understanding of learning as some kind of expansion into some kind of context, most notably situated learning and socio-cultural theory. Situated learning may be understood as an

activity engaging in a (primarily social) context, and deepening or expanding ones knowledge of that context through interaction. Under good conditions the learners' competence to act upon and impact this context will grow. Socio-cultural theories emphasize the need for mediation and support provided at the right place and time by a teacher, other students or resources, so that the learner may move into the "zone of proximal development". Within this tradition Engestroem (1987) introduced the notion of "learning by expanding", as opposed to an idea of learning by rote memorization or by storing discrete bits of information. Learners move from a problem to a context to a new activity. Within this understanding mobile systems may provide tools and opportunities to deepen learners' understanding of their contexts and to expand their potential engagement (Breuer & Matsumoto, 2008).

Portable devices have been discussed as a valuable means to support the context-dependent construction of knowledge (e.g. Jippling, Dieter, Krikker, & Sandro, 2001). Especially their ability to collect data, to work collaboratively and location awareness features are suited to create uniquely new learning opportunities (Patten, Sanchez, & Tangney, 2006). Recently the notion of learner-generated contexts (Luckin, Shurville, & Browne, 2007) has been brought up. The concept follows a constructivist tradition and was named in analogy to the concept of "user-generated content". As such it stresses the fact that learners may not only retrieve and exchange educational materials through technology, but contribute to the co-creation of their own ecology of learning resources. However, up to now the concept is being described on rather vague and descriptive accounts and the specific nature of "context" remains unclear. Similarly emerging research on ubiquitous learning (Cope, & Kalantzis, 2009) remains declaratory in nature and indifferent against the notions to context to leverage. Oftentimes ubiquitous learning is even equated to mobile learning.

The following explorations distinguish between different notions of contexts (Winters, & Price, 2005) and their significance for the design of mobile learning experiences. Usage scenarios for mobile learning with portable devices help to exemplify different notions of context and to work out a new, contrasting scenario specifying how learner-generated contexts may be created, enriched and revised.

3 Three Scenarios and Notions of Context

Exploring the design space for mobile learning the following three scenarios of mobile learning differ with respect to their notion of context. They help learners to collect, project, and maintain context while being on the move.

3.1 Mobile Pattern Collector

The first scenario was actually implemented in software for interactive whiteboards, pen-tablets, and mobile devices (Breuer et al., 2007). We assume the teacher prepared an initial presentation introducing the field and pointing out some problem, like the conflict between the planning of a static structure and the inhabitants' appropriation of that space, which may be defined in terms of usage patterns. Afterwards, students are asked to collect examples of best practices in the city regarding an illustrating topic such as "entrances and exits". Students then explore their neighborhoods, taking pictures of felicitous examples of door design, with the functional and aesthetic context of the door, the door itself and its component details. Subsequently, they may comment upon what they see using the pattern format and adding extra (e.g. online) material and references at home. In case of doubt if a certain appropriation of space represents a usage pattern, they may connect to other students in their group debating their point of views.

Communication functionalities and a shared view on the handheld provide a common anchor for reference. Back in the classroom, the groups send their findings to the interactive whiteboard and discussions continue. Moderated by the teacher, students evaluate their propositions and discuss the hierarchy, its distinctive levels, and the relations between the patterns they intend to work with in order to collaboratively create their own pattern language. Design and architecture students would then go on to apply their own patterns by building models that represent ideal representations of these patterns and pattern languages for a specific context. In the end, they will not only have learned how to extract and work with patterns, but will have also addressed critical issues and trade-offs in the specific field.

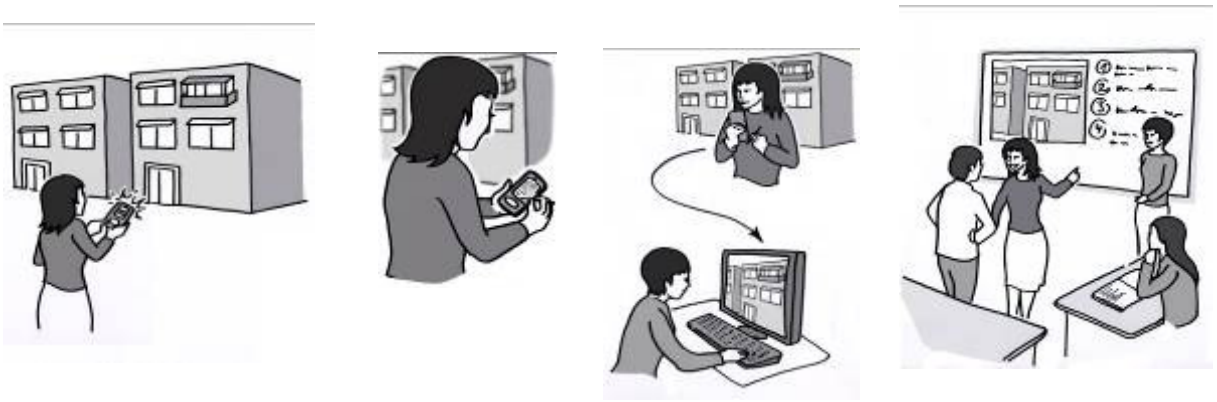

Figure 1. Pattern Collector to import natural environments into the classroom

3.2 Contextual Projection

The second scenario resulted from a futures workshop on mobile broadband applications. A mobile screen (of a handset, or even a window of a vehicle) is used to enrich empirical objects and sights in natural settings with learner-centered visual and / or audio information on places and objects you see or target with your mobile device. Its basic technology for visual search is being developed by companies like Google (http://www.google.com/mobile/goggles). One mode may be a "timemachine", with which a user can visually travel back and forward in time to access documented material about his or her surroundings or to get information about upcoming events. A metadata visualizer adds content provided by others, e.g. on what is happening inside a building. Interactive online games mix the real and the digital world.

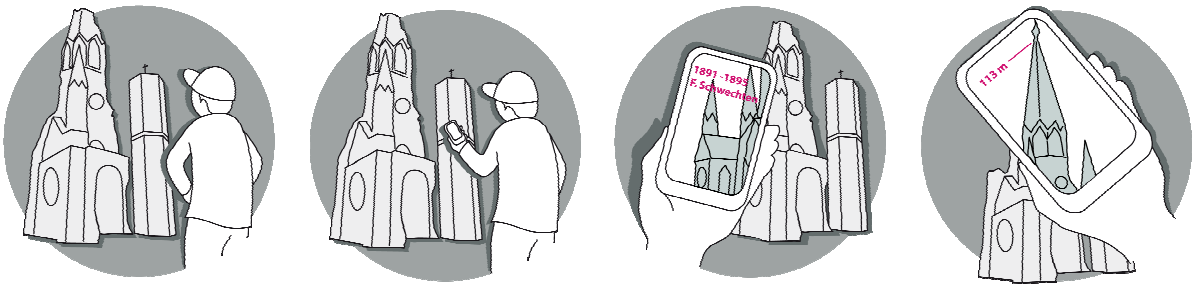

Figure 2. Enabling situated learning with an augmented tourguide

3.3 Personal Library

The third scenario resulted from ethnographic user research combined with a futures workshop with design students. It preserves aspects of formal learning environments within mobile settings and intends to support self-directed learning activities during commuting times. It utilizes tablet computers with camera and gyro sensor in order to create a personal or shared space for learning.

Current obstacles and utopian futures of mobile learning laid the grounds for envisioning new systems to support mobile learning for public transport. A "comfort zone" was identified as a neglected requirement for mobile learners. During commuting times people often find themselves in stressful states, coming across crowds of people, alternating between natural and artificial daylight when using the metro, potentially encountering loud noises and malodors. If a certain limit of sensory information is exceeded awkward sensations result. Many people cope with this stimulus overload by secluding themselves, blending out the environmental changes, e.g. by wearing earphones. Another way to restore comfort might be to provide familiar cues associated with a

relaxed context. Thus, the envisioned system provides a personal library with spaces, books, desks to sit down and write and read on, staff to ask how to advance, and other rich resources organized by physical location. A gesture-based handling of tablet computers was proposed in order to create an adaptable and comfortable personal learning environment with individually adaptable and familiar modules. Moving the tablet or pad to one side yields access to books whereas a horizontal posture provides for a desk with notebooks, pens and brushes. Work materials are still accessible and they do not need to be rearranged to adapt to the new environment.

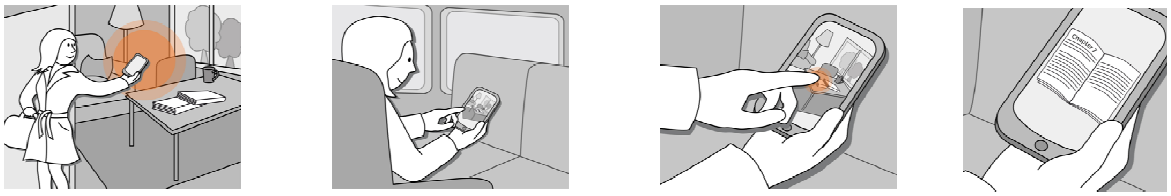

Figure 3. Sustaining your own context by carrying a personal library

3.4 From Educational Settings towards Learner-driven Scenarios

Reviewing these three scenarios different notions of context and ways to deal with it appear. Within the pattern collector scenario portable devices allowed an *import of natural environments* and a detachment of learning activities from formal settings of education. By collecting data out in the field findings from natural environments were brought into the classroom, and – as in the case of the pattern collector prototype – data exchange enabled an integration of the formerly separated learning environments of the classroom, the home, and informal settings. Accordingly, the unique ability of portable devices to collect data (Patten et al., 2006) may be exploited. Location awareness features may be used to enhance situated learning activities. Due to the portability of devices and communication features also new forms of collaborative learning and sharing of learning resources may be utilized. The proposed sensory and communicative features do not even require "intelligent" information processing. "Context" is basically everything outside of the white cube of the classroom appropriated through portable devices to be imported into the formal setting.

The notion of learning as expansion into context (Engestroem, 1987) suggests that learning may not only be achieved by bringing representations of the world into the classroom. Instead it may also be supported through learning in the natural context of the respective contents itself. In line with this, the second scenario shows how technology can empower meaning-making practices of learners without reducing context to environmental data or to making system behavior transparent and modifiable to a user. Within the augmentation scenario context is also outside of the classroom and within the learner's proximity, and could be defined in line with socio-cultural theories as his or her "zone of expansion" (Breuer & Matsumoto, 2008). Socio-cultural theories emphasize the need for mediation and support provided at the right place and time by a teacher, other students or other resources such as the ones described in the scenario for an augmented tourguide.

Developing this scenario information processing is indispensable for mobile educational technologies. On the one hand learner models are required in order to enable scaffolding. On the other hand technologies like visual search and visual or auditory pattern recognition are needed in order to augment aspects of the natural environment. The contextual tourguide exemplifies this scenario, supporting locally *situated learning* and enabling increased participation within the real environment. Aspects of the environment are identified and matched with context-dependant information in order to provide for educationally relevant content.

The mobile library works with the insight that learners physically arrange their immediate environment to fulfill learning needs. The scenario tries to preserve key aspects of these arrangements for mobile situations. The personal *comfort zone* is extended into the outside world, sustaining a personal context for learners on the move, but learners are detached from their real environments trying to maintain their focus on a topic.

All scenarios imply unique benefits associated with their respective contexts. Importing natural environments into the classroom as has been implemented by the mobile pattern collector draws students' attention to the practical relevance of learning contents and makes otherwise abstract content more vivid.

Context-dependant learning within one's natural environment as specified by the augmented tourguide situates the acquisition of knowledge and enhances memorability (Mandler, 1984; Mandler & Johnson, 1977). Finally, sustaining a familiar context as suggested within the third scenario enables learning in situations that would otherwise not meet essential prerequisites such as an opportunity to concentrate. Still, all three scenarios share the one common characteristic that learners appropriate information instead of creating it, and are instructed in doing so.

4 Ubiquitous Learning

In contrast, constructivist approaches to teaching and learning stress the active role of learners not only coming up with their own insights but also exploring content and creating the tools they need in a self-directed manner. Applying this tradition to our discussion of different notions of context, a new perspective for system design may be developed. For user-centered design concepts participation of users in the design of application has been extended from external knowledge sources supporting professional new product development to the notions of user-generated contents and user-driven innovation. Within the realm of education Luckin (2008) understands learner-generated context as ecologies of resources, that is "a set of inter-related resource elements, including people and objects, the interactions between which provide a particular context" (Luckin, 2008, 452). After a brief overview of initiatives on learner-generated content and open education (4.1) we exemplify and specify this notion and present a scenario for learner-generated context (4.2). We discuss storytelling and reflective journals as didactical approach (4.3) and derive basic technical requirements for an implementation of the scenario (4.4).

4.1 Learner-Generated Content and Open Education

Several initiatives foster knowledge sharing between peers for educational purposes including Mozillas "School of Webcraft", Youtubes service "edu" for educational films, and Apples instructional films. "Academic Earth" provides free university lectures, the MITs "Open Course Ware" and "Flat World Knowledge" offer professional textbooks for free, "Lingorilla" supports collaborative language learning.

While Wikipedia remains a crucial reference for the notion of user-generated content, Wikiversity may develop into a major reference for learner-generated context. Wikipedia enables user-generated contents that are evaluated against clear-cut criteria, correctness being the one of capital importance. In contrast, authors point out that "wikiversity has a broader mandate to explore how to use wiki technology to promote learning" (see http://en.wikiversity.org/wiki/Introduction_for_teachers). Strong emphasis is placed on the concept of experiential learning (e.g. Kolb, 1984). In line with this, Wikiversity encourages students and teachers to share their ideas and experiences regarding learning activities. However, borders become blurred since everyone may take on the role of being a teacher, student, or tutor regardless of his or her real life status. Everyone may provide, use and evaluate self-study or teaching materials such as lectures, quizzes and presentations. By sharing materials that have been tried out, Wikiversity aims at an improvement of teaching practice. The utility of the proposed tools is mainly determined by users' subjective experiences with their practical application.

But not only pieces of content and single resources may be embedded unobtrusively into everyday settings. Whole lessons, courses, time schedules, curricula or even development programs may be seamlessly integrated into real world settings. When this stage is succeeded context is no longer something external to be represented internally by some computational model, nor is it the real world context into which a self-directed learner strives to expand his or her participation (Breuer & Matsumoto, 2008). Instead, context becomes the learning environment itself as it emerges from the joint engagement of the community of learners. Nevertheless, current approaches still lack a seamless integration of learning resources with situated experiences and therefore fail to exploit the potentials of mobile learning across contexts.

4.2 Scenario for Learner-Generated Context

A very popular treasure hunting game called geocaching inspired the development of the subsequent scenario. Geocaching integrates online functionalities and real-life experiences. However, there is a strong focus on the latter. Geocachers actively interact with their environment leaving traces, interlinking locations, sharing their experience or even working collaboratively, e.g. to make a so-called "travel-bug" travel across continents as fast as possible. A common feature of geocaching and the subsequent mobile learning scenario is the playful character of searching for answers by following traces and interlinking real life locations to investigate a common theme.

On top of that, the following scenario provides ubiquitous learning opportunities drawing on a context unifying academic and real world contents. As an educational topic it assumes cultural ways to deal with earthquakes (Baloian, Breuer, Matsumoto 2006) and to prevent their disastrous impact e.g. by constructing earthquake-proof buildings, holding mock disaster drills to instruct citizen on appropriate behavior, or exploring wireless sensor networks to sustain communication infrastructures after an earthquake has occurred.

During a course about architecture students are supposed to acquire a thorough understanding of earthquake-safe static as an example. Several exercises may then be created. First, students are asked to analyze the structure of a nearby pagoda that has resisted several earthquakes. Thus, they go out to inspect how the pagoda in their hometown has been build, taking photographs, taking measures for drawing a ground plan, and discussing their ideas regarding its static. Then, they may visit the construction site of the new Tokyo Skytree that will be unveiled in the spring of 2012 as the world's tallest stand-alone communications tower. It is being constructed to resist even strong tremor in one of the most earthquake prone areas worldwide.

By comparing the architecture of the new Skytree with their pagoda they may come up with new insights. For example, similar structures may be found drawing students' attention to very essential safety-critical features. As a matter of fact the structural system of the Skytree is supposed to recreate the five-story damping system of Japanese pagodas as they resisted several earthquakes. The core of the tower is loosely attached to the body, where each floor is independent with a central pillar at the core, so that tremor is minimized by the interaction between the floors (http://www.tokyo-skytree.jp/english/design). At the base roots branch out into the earth underneath. On the other hand differential structures may point out new techniques or more advanced solutions. Whatever insights students gained they may leave their documents such as drawings, photographs or sketches, videos or audio comments at the Skytree for others to discuss or they may study the information left by others.

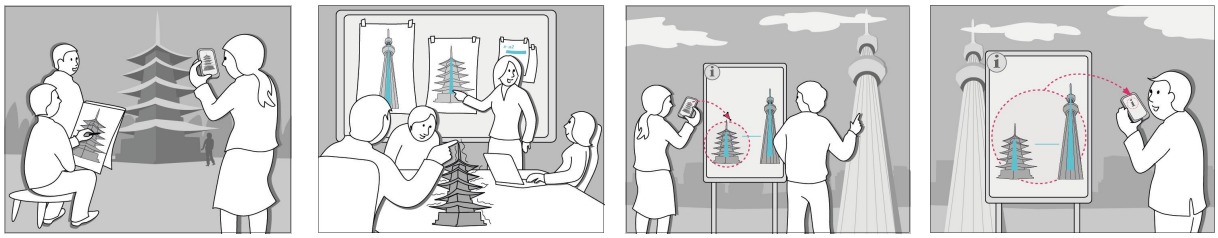

Figure 4. Learners deal with architectural topics & provide lessons learned as learner-generated context

Within traditional learning environments students are usually follow standardized instructions provided by the teacher. In contrast, within the mobile learning scenarios outlined, learners are provided with a broad scope of action to interact with their environment more closely. They may act upon their own learning environment, selecting and co-creating their own learning contents. Due to the learners' active involvement these learning contents are much more personally relevant than contents selected by a teacher. According to the self-determination theory developed by Deci and Ryan (1985, c.f. http://www.psych.rochester.edu/SDT/theory.php) this should be associated with significant advantages. Deci and Ryan (1985) argue that individuals strive for fulfilling three basic needs, namely a sense of 1) autonomy 2) competence and 3) relatedness or social involvement. All three psychological needs are addressed by the mobile learning scenarios and should contribute to a positive learning experience. In particular, a sense of autonomy and self-determination is considered to be essential for developing an intrinsic learning motivation. Intrinsically

motivated individuals consider learning contents as interesting and challenging, they are willing to invest high efforts and to elaborate issues thoroughly. Similarly, developing an identified motivation should be facilitated, referring to individuals who learn in order to accomplish personally relevant goals. Both motivational concepts are considered important for dealing with complex problems successfully that require persistence despite barriers and obstacles. In contrast, extrinsically motivated individuals learn to gain awards or to avoid punishments. They try to meet predetermined objectives by investing just as much effort as necessary and consequently, they may fail more easily. Thus, the motivational advantage of learners who are encouraged to decide upon their learning contents and procedures by themselves may result in performance benefits.

4.3 Ubiquitous Learning and Educational Storytelling: A Mobile Reflective Learning Journal

Many authors stress the importance of reflection and reflective writing to mediate between experiences respectively practice, and theoretical understanding. Within user research activities methods like user diaries and cultural probes have matured as means of self-observation providing insights into the conscious lives of people. Techniques to structure and analyze such empirical data may be transferred to structure, design and utilize what we could all "heureka journals" of students as learner-generated content for others. Within such journals students would reflect upon their own situated insights and preconditions for understanding in order to make their own insights accessible peers.

Journaling is a "means for recording personal thoughts, daily experiences, and evolving insights" (Hiemstra, 2001, 19; Moon 1999). A reflective learning diary should support students to record insights and reflections on their individual learning experience. Students review, consolidate or evaluate the results, and plan for future learning activities. Thus, they take charge of their own learning. Leveraging potentials of portable devices to support mobile learners the application scenario above allows documenting, reviewing, consolidating learning activities. Once written, a journal's content may be reviewed again in order to focus on critical issues and progress in understanding, and to distil learning stories to be shared with others (using the infrastructure developed in the first work package). Thus, the journal not only serves as a means for reflection and setting up anonymous learning contents into individual contexts of matter but, the other way around, also to abstract from individual moments of insights and learning experiences towards clues to be provided for other learners.

Digital storytelling may be particularly apt to edit and share such individual learning experiences. By creating their own stories learners may convey their own insights and understanding (heureka moments) to others and contextualize information in meaningful ways. For digital storytelling content is presented using pictures, videos (visual storytelling) or acoustics, original sounds and music. Furthermore, an emotional stance, the authors' subjective perspective, and a limited duration of less than eight minutes are considered as characteristic. Specific suggestions for realizing digital storytelling have been proposed by the Center of Digital Storytelling in Berkeley, California (www.storycenter.org) and may be adopted for mobile learning scenarios.

4.4 Specification and Requirements

The notion of "learner-generated contexts" implies the provision of learning resources for others. Accordingly, an *infrastructure* supporting the learner-driven creation of educational contexts consists of at least two realms: Firstly, access and tools to enable learners to create, contribute and revise their own insights and learning experiences for others, e.g. for peers or following generations, and secondly, a system embedding educational materials and opportunities for learning within the relevant contexts, i.e. situating learning opportunities within real world settings.

To provide for a worthwhile learning experience three features are considered to be essential: Generation, location-based provision and sharing.

Generation and revision of learner-generated contents: As in Wikipedia and Wikiversity participants need ways to create and continually improve the educational content. Consequently, a didactical concept is needed in the attempt to turn students' activities, contributions, and reviews of educational materials into an instructional endeavour.

Location-based provision: In order to create contexts for others content needs to be provided in unique location-based settings, i.e. within contexts of matter. Technical options such as GPS (as used for geocaching), barcodes that are linked to online resources, or in an early stage of development, Bokodes for embedding rich information, could enable ubiquitous learning.

Sharing: Learners need to agree on a format to share their insights. This needs to support expressing one's personal view in a vivid, structured and comprehensible way to attract others' interest. Storytelling is considered to be particularly useful for conveying messages of personal relevance that have been subjected to some maturing change. Digital storytelling explicitly aims at delivering such messages and allows tracing the process of finding out more about a topic and to document and reflect upon one's heureka moments in an appealing way.

5 Conclusions regarding Ubiquitous Learning Opportunities

Different learner-centered systems imply four different notions of context:

Importing natural environments: By making use of mobile devices' portability, data collection and communication features, different learning environments such as the classroom, home and informal settings may be seamlessly integrated.

Augmenting natural environments: Mobile applications may provide for context-dependant scaffolding and situated learning which supports learners' understanding and participation.

Sustaining personal comfort zones: By means of familiar interfaces beyond the desktop mobile applications allow to take along one's favorite context.

Providing ubiquitous learning opportunities: Learners enrich their natural environment with ubiquitous learning opportunities. Thus, they construct their own ecologies of resources (Luckin, 2008) and extend existing learning contexts with joint efforts.

Additionally, a new implementation paradigm specifying the concept of learner-generated context (Luckin et al., 2007) was introduced. The scenario enables learners to create their own learning materials and to embed them in real-world settings. A thorough learning experience is gained by moving from an utilization of context, to enabling situated learning opportunities, to actively changing contents and learning environments thereby meeting the characteristics of learner-generated context. More specifically, the suggested ubiquitous learning scenario is characterized by three essential features:

Situating mobile learning experiences in relevant environments, e.g. by embedding educational materials and opportunities for learning which might be realized by application of geotagging, e.g. by means of GPS, QR codes or visible light communication through Bokodes.

Enabling learners to create and contribute their own insights and situated learning experiences for others by means of portable devices.

Sharing personal insights and heureka stories with others by making use of a storytelling format.

Whether this scenario causes advantages over traditional learning scenarios is an empirical question that needs to be investigated by implementing it and comparing its' effects with the ones observed for another group of students who learn about earthquake-safe static the traditional way (e.g. by listening to lectures). In line with previous research we might hypothesize with some confidence that students participating in the mobile learning scenario will outreach the control in terms of motivation and in the long run even in comprehension and memorability (e.g. Mandler, 1984; Mandler & Johnson, 1977)

Seen through such a system we envision a world enriched with ubiquitous learning opportunities. While ubiquitous computing promotes information and functionality for users to be seamlessly integrated into everyday life, ubiquitous learning addresses users as learners, thus developing beings. Ubiquitous learning systems should allow to easily document, collect and share short stories of insight and deepened understanding. Within communities of practice advanced learners become natural teachers, and lessons they learned become lectures and stories to be told to following generations.

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