Teachers Matter: Challenges of Using a Location-Based Mobile Learning Platform

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Abstract. This paper presents the design of a learning management system for location-based mobile learning and reports on first experiences of ongoing user studies with a location-based mobile learning platform. This platform allows teachers to create location-based mobile learning units as editors that can be consumed by students using mobile devices with self-localization capabilities, such as the Global Positioning System or network positioning. We show hands-on challenges of location-based mobile learning and emphasize the role of teachers as learning unit designers. We determine five aspects relevant for the challenges of location-based mobile learning: environment, technology, teaching, learner, and teacher's spatial cognitive competences. For every aspect, predictable and non-predictable challenges may exist. We describe these five aspects and focus on the challenges encountered to enhance professionalism in the didactic use of location-based mobile learning based on related work, diaries, and interviews of initial studies with our learning platform. In this respect, our experiences with the ongoing project support the importance of teachers for the success of location-based mobile learning concepts.

Keywords: Location-based mobile learning · Location-awareness · Mobile learning management system · Context-awareness · Teaching

1 Towards Location-Based Mobile Learning

Mobile technologies are changing the way we interact with the world. The ubiquitous availability of information, combined with the contextual awareness these devices provide, enables us to learn and receive support whenever we need it and wherever we are. The potential in multi-functional and individualized learning through mobile learning applications show the limitations of traditional educational tools in classrooms, which were typically confined with regard to content, given location, and given functionality.

In our research, we focus on a particular type of mobile learning whose learning activities are performed at those places the teaching content is spatially related to (*location-based mobile learning, LBML*). In LBML, the learner interacts with the environment during contextualized learning activities by means of location-aware technologies (Patten et al. 2006).

From several previous studies with LBML applications, it is well-known that teaching place-related content at the respective location with mobile technologies can

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improve the learning effect by complementing conventional didactical methods. Mobile Virtual Campus, for instance, is a collaborative mobile learning system powered by the location-based dynamic grouping algorithm (Tan et al. 2010). This algorithm groups the learners primarily based on their location closeness but takes learners' learning profiles, learning styles, and learning interests as further grouping criteria. Environmental Detectives is a handheld augmented reality simulation game designed by Klopfer and Squire (2008). It supports learning in advanced introductory (late high school and early college) environmental science. Their goal was to understand the potential of augmented reality simulation games while also proposing the idea of a general software development platform including authoring tools for creating other handheld applications. CAERUS is a complete context-aware educational resource system for outdoor tourist sites and educational centers by Naismith et al. (2005). Their system is a working implementation of a complete context-aware educational tool for outdoor use with the goal of engaging visitors with their physical surroundings. Location-based multimedia content and activities are presented to visitors through Pocket PC handheld computers with GPS capability. Beside the handheld delivery application, CAREUS consists of a desktop administration application and provides a visual interface to add new maps, define regions of interest, and add theme-based multimedia tours. Rogers et al. (2004) presented Ambient Wood, a framework for the different forms of digital augmentation and the different processes by which they can be accessed. Using the framework, they designed an outdoor learning experience, aimed at encouraging students to carry out contextualized scientific enquiry and to reflect on their interactions. Pairs of pupils explored a woodland and were presented with different forms of digital augmentation at certain locations. This study showed that such kind of exploration promotes interpretation and reflection at a number of levels of abstraction for pupils.

In summary, teaching place-related content at the respective location with mobile technologies opens up a number of promising opportunities. However, implementing LBML in a real teaching setting comes with a number of challenges, thus impeding a broad adoption of LBML in school and university teaching. Moreover, there is a lack of platforms that support teachers in overcoming these challenges.

The success of LBML strongly depends on the context and situation during learning, which leads to a number of challenges in designing LBML management systems. Several approaches and models for supporting and evaluating learning with mobile technology have been proposed in related work. For instance, Sharples et al. (2010) observed a dialectical relationship between learning and technology and showed their convergence. Muyinda et al. (2011) developed a competence set of dimensions and sub dimensions for instantiating or evaluating mobile learning objects which are based on Khan (2001). They defined learning objects as a digital educational resource which is granulated into units that are reusable, adaptive, and can be re-purposed to different learning styles, knowledge levels and conditions. Tan et al. (2013) recommended their 5R adaptation framework concept to enhance learning in location-based learning environments by taking into consideration the factors of learner, location, time, and mobile devices.

While these examples demonstrate the breadth of mobile learning pointing in particular to the importance of the learner, we recognize missing literature on the evaluation and challenges of LBML management systems on the one hand, and literature focusing on the editor (teacher) on the other hand. We argue that—by focusing on the learner—the importance of teachers' abilities in the field of LBML is often underestimated. Technological, didactical, and spatial cognitive competences of teachers are diverse and have a major impact on the result of the design in the field of LBML. Further the teachers' understanding of the physical environment and the individual learners depends also of that design. In conclusion, teachers matter in view of successful implementations of LBML.

The rest of this paper is structured as follows: we describe the design of a LBML management system (OMLETH) in Sect. 2 and systematically report on challenges that occur in teaching with LBML in Sect. 3. Our list of challenges may serve as a guideline for teachers planning to use LBML in their courses, as well as for system developers responsible for LBML platforms. Future research on LBML may also be motivated by these challenges.

2 OMLETH: A Location-Based Mobile Learning Management System

OMLETH[1] is a prototype implementation of a LBML management system (Sailer et al. 2015a). It allows teachers to create LBML units as editors that can be consumed by students using mobile devices with self-localization capabilities, such as the Global Positioning System (GPS) or network positioning (IP address, WiFi, GSM/CDMA cell IDs).

Figure 1 provides a schematic overview of our prototypical platform. Editors (teachers) use the system through a map-based web application which can be accessed with conventional desktop browsers. The system enables the teacher to create and publish *learning modules*, where each module consists of one or (usually) several learning units – a concept known from common learning management systems. The teacher draws the spatial footprint of each learning unit, i.e., the zone in which it will be triggered on the students' phone, in an interface based on scalable web maps (Fig. 2a). Learning units are categorized by the type of learning activity they involve, similar to those found in common learning management systems. Examples of such activities include: consuming context information by text or photo, solving tasks by text input, multiple choice, voice or video recording, distance estimation tasks, or activities that involve the interaction with, learning from, and comparison of current and historical maps. These activities can be combined flexibly depending on the curriculum, learning goals, as well as didactical approaches. Teachers can save the module for self-testing and later publish it, thus making the module accessible in the students' mobile app.

Learners (students) access the learning module on their mobile devices by a mobile web application (right in Figures 1 and 2b). By pressing the "Locate me" button, students can trigger the localization and visualize their location on the map. Spatial

[1] Location-Based Mobile Learning at ETH Zurich (German: *Ortsbezogenes Mobiles Lernen an der ETH Zürich*, OMLETH).

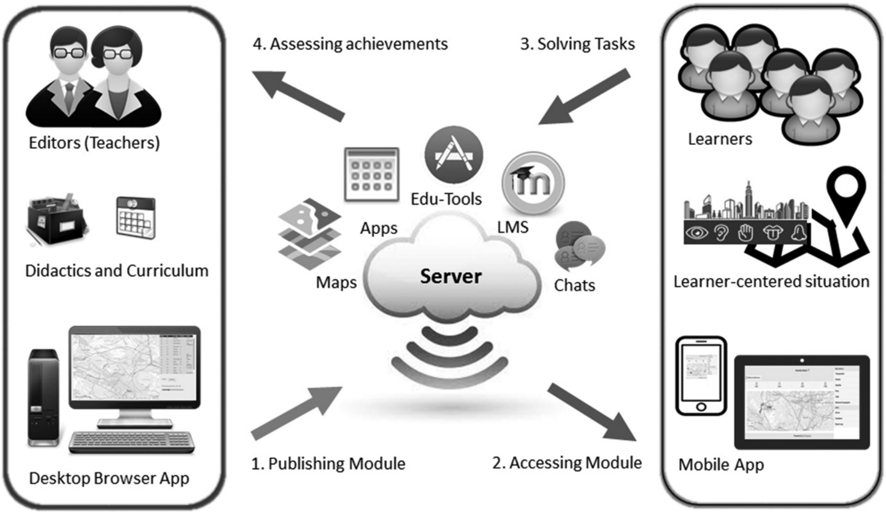

Fig. 1. Overview of OMLETH, a location-based mobile learning management system

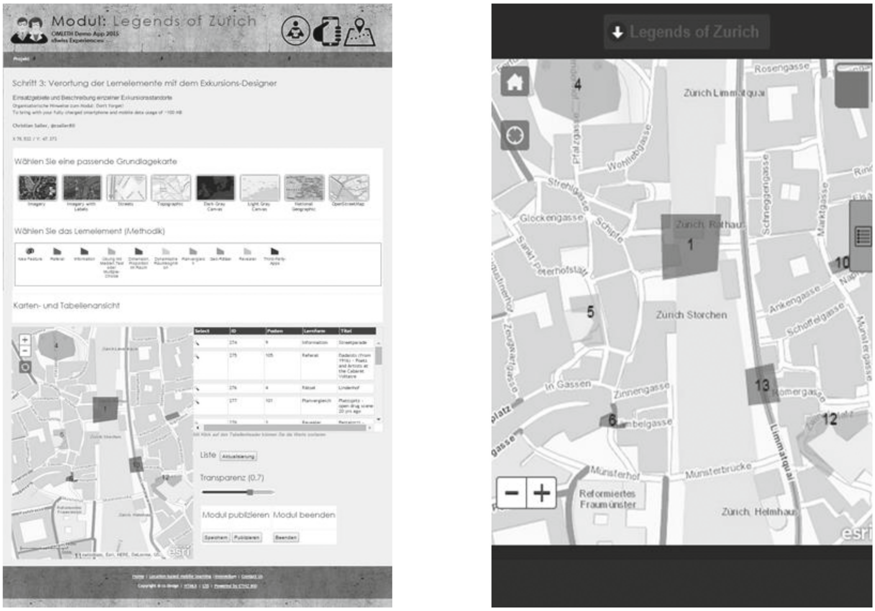

Fig. 2. (a) Editor App of OMLETH. (b) Learner App of OMLETH

footprints of learning units are visualized as polygons on the map, where the color-coding is based on the type of learning activity. As soon as the current location of the mobile device is inside the footprint (area) of a learning unit, the associated content is retrieved from the server and appears on the screen. The learner is asked to solve the unit, where the required activity depends on the type of learning unit (as explained above).

The teacher can follow and supervise the students' activities in two ways: during the execution of OMLETH learning modules, as well as after students have finished. The trackable students' data include the solutions to learning activities, students' feedback, as well as spatio-temporal trajectories. The latter can be visualized and aggregated in a second map-based interface and may be particularly useful for evaluating the design of the learning module. For instance, learners' speed and trajectories can be analyzed, and transportation mode as well as wayfinding problems can be detected through visual analysis of individual and aggregated student trajectories (Sailer et al. 2015b). Afterwards, the teacher can adapt the methodology of the learning module and dose or enhance the educational content.

In addition, a chat functionality enables teacher and students to communicate while the student is using the mobile app. Teachers can send instructions, hints or abruptly important notifications, whereas students can ask for help, immediate feedback or interesting findings.

3 Challenges of Location-Based Mobile Learning and Teaching

Our classification of challenges is inspired by the context model of Brimicombe and Li (2009): we determine five aspects relevant for the challenges of LBML: environment, technology, teaching, learner, and teacher's spatial cognitive competences. For every aspect, predictable and non-predictable challenges may exist (see Table 1). We describe in the following the five aspects and focus on the challenges encountered to enhance professionalism in the didactic use of LBML based on related work, diaries, and interviews of initial studies with OMLETH.

3.1 Physical Environment

In the following, we emphasize the environmental factors where mostly physical factors, such as weather, light, sound, and accessibility affect the planning of LBML activities.

3.1.1 Weather Conditions, Comfort

The planning of an outdoor LBML unit requires a diverse preparation and a confident handling of environmental factors, such as the season, and the actual weather conditions at a given time and location in order to recommend a suitable equipment (e.g., clothing, water-proof phone case) for the learning session.

Our experiences with OMLETH have shown that the weather is highly important: learners evaluate the conditions as good in dry weather, and rather bad in rainy weather. If the weather is bad, the motivation for solving the LBML unit conscientiously is low and thus the achievements are scarce. First experiences have shown that

Table 1. Challenges in LBML, structured by their predictability and the context aspect they relate to.

	Challenges where teachers are out of influence	Predictable challenges
Environment	- Weather conditions - Comfort - Safety risk - Accessibility of locations - Traffic	- Seasonal conditions of the climate - Safety risk - Environmental Noise, Light and Odor
Technology	- Hardware (Screen size, Battery, Accuracy of Positioning Sensors, Screen Reflection, Temperature and Humidity Extrema) -Software (Correctness, Usability / Learnability, Integrity, Reliability, Efficiency, Security, Safety)	- Hardware (Network) - Software (Security)
Teaching	- Curriculum - Learning success - Interaction between learners	- Group size and members - Learning goals and their integration into the curriculum - Time
Spatial cognitive competences	- Spatial knowledge - Spatial concepts	
Learner	- Character - Motivation	- Aims - Individual communication - Empathy - Age

learners do not like to rest too long at one learning unit when temperatures are below approx. 10°C whereas temperatures over approx. 25°C get learners tired and impatient. LBML becomes even more uncomfortable if extreme weather events like thunderstorms, vertical solar radiation, or heavy winds occur. Fortunately, predictions' reliability increased during the last years.

In summary, weather forecasts and uncertainties must be taken into consideration when planning an LBML unit. One option for dealing with weather uncertainties consists in preparing a second learning unit as a fallback solution in which learners, for instance, cover a shorter route or are less exposed to the weather.

3.1.2 Physical Accessibility

In OMLETH LBML units, learners usually have to visit learning units successively in a pre-defined order. The allocation of these learning units is based on the teacher's opinion of an ideal path. Although the teacher explores this path at least once while planning the LBML unit, circumstances are – especially in urban areas – changing on a daily basis, and direct access to an object might not be possible any longer. Construction sites, traffic jams, or barriers could intersect the learners' walk and force them to do a detour. OMLETH studies have shown that traffic can distract learners and render accessing a certain location effectively impossible: the learning module then fails because information about further procedure is lacking.

In conclusion, the physical accessibility of the learning units becomes more relevant for LBML than for general mobile learning, since the learning content is bound to specific locations.

3.1.3 Environmental Noise, Light and Odor

Environmental factors are manifold and have different effects on the perception by human senses. In the field of LBML, learners cannot turn off their ears, thus sound perception is always on and must be filtered based on the importance of the content (Schwartz 2003). Findings, how far sounds have a benefiting or obstructive influence on learning, are controversial. Personally preferred music tends to have a neutral effect on learning whereas environment noise is mainly perceived as neutral to obstructive (Reinhardt and Rötter 2013). Therefore, teachers can foster effective learning by the avoidance of areas with obstructive environmental noise.

Environmental ambient light changes during the day. Therefore, features in the environment appear differently depending on the time of day, and readability of mobile displays will also vary.

Our experiences from pilot studies with OMLETH indicate that the influence of some odorants on human behavior is highly affective. Teachers can integrate specific location-based odors in a LBML unit. Unique odors support the learners' long-term memorizing. However, extremely unpleasant odors can distract learners.

In summary, sound, light and odor are often underestimated factors in LBML designs. Teachers need to reflect about these factors during the planning of the LBML units.

3.2 Technology

Mobile technology plays a central role in LBLM. The fast growing mobile development and the change of hardware (mobile devices) and software solutions (platform and apps) poses ongoing challenges for LBML designers. Smartphones are convergent devices which empower users with internet access, music, audio and video playback and recording, navigation and communication capabilities (Sharples 2013, Brown et al. 2010, Vavoula and Sharples 2009).

When learners use their own mobile devices many technological factors are out of the teacher's control. This technology section is divided into two parts – hardware and software – each subsuming relevant issues and related work for technology usage where teachers have some influence in providing learning activities and where teachers are out of control.

3.2.1 Hardware

Although the development of hardware technology is a fast growing industry, mobile device users are still struggling with several issues. In the following we summarize challenges we were facing in studies with OMLETH.

Screen Size

LBML is based on handheld technology for the delivery of learning objects. Churchill and Hedberg (2008) found the key limitations of this kind of technology are the small screens. Meanwhile, a variety of screen sizes for mobile devices is available on the market, labelled as Smartphones, Phablets or Tablets. Studies with OMLETH and others (e.g., Bartoschek et al. (2013) have shown that devices with larger screens are preferred for map reading and navigation. However, not every learner may have access to a tablet, therefore screen size remains a challenge.

Battery

Larger screens, fast processors, frequent use of the positioning sensor and internet connectivity, and generally growing functionality come with the requirement for higher battery capacity to support operation throughout the learning session. Display use, processing power, feature-sets and sensors are bottlenecked by battery life, where the typical battery capacity of smartphones today is barely above 1500 mAh. Ferreira et al. (2011) presented solutions to allow users for longer smartphones battery life.

Finally, teachers must be aware of learners' hardware equipment even though excursions longer than two hours may anyway be questionable in terms of learners' motivation (see Sect. 3.4).

Accuracy of Positioning Sensors

Our experiences with OMLETH have demonstrated that positioning technology on older smartphones is rather unreliable or sometimes failing. Contrary, devices from the latest generation show better results (accuracy below 10 meters). However, accuracy is also influenced by the area in which learning takes place; for instance, GPS is known to have low accuracy in urban canyons (Montillet et al. 2007). Consequently, teachers need to consider both, the available hardware and the accuracy of positioning at the locations of the learning units.

Screen Reflection

In LBML we have to deal with a wide range of ambient lighting conditions (see Sect. 3.1.3). Besides simply increasing screen brightness, a typical solution consists in using anti-reflection coatings and treatments. Ma et al. (2012) have shown that the usage of such anti-reflection coatings, together with color and intensity scale management profiles based on the ambient light sensor, can significantly improve the situation. However, since it is the learner's choice to add such components or not, the screen reflection remains a challenge for teachers in the field of LBML.

Temperature and Humidity Extrema

Temperature does not only affect the learner, but also the resilience of the mobile device. Apple[2], for instance, recommends an operating temperature between 0 and

[2] Keeping iPhone, iPad, and iPod touch within acceptable operating temperatures (https://support.apple.com/en-us/HT201678, Call date: 24.07.2015).

35 degrees Celsius for iPhones, and a humidity of 5 to 95 percent non-condensing. They recommend cold-resistant, brave users texting gloves and winter-proofing gadgets. Manufacturers argue that any temperature condition that would be unsuitable for humans is also unsuitable for smartphones, and teachers should keep this in mind when deciding on starting an LBML activity.

Network (Bandwidth Capacity/Mobile Data)

LBML affords using multimedia teaching materials, thus avoiding traditional classroom methods, such as reading long texts. Streaming multimedia requires a sufficient bandwidth from the mobile network. In the case of OMLETH, the LBML platform uses a number of different multimedia online services, including photos, video watching and map exploration. The large internet downloads necessary for streaming such multimedia content across various locations has to be taken into account when designing a learning unit, especially if a learning activity is located in an area with limited bandwidth.

3.2.2 Software

Educational software has special requirements which are in the following presented based on Sharples' theory of learning for the mobile age in relation to teachers (Sharples et al. 2010). Factors influencing software quality are discussed in the second part.

Software Requirements

The goal of using learning software consists in supporting teachers to teach more effectively. The offer of educational software and apps, however, is tremendous, and choosing the right software for a particular teaching situation is challenging.

In the field of mobile learning, Hwang and Chang (2011) have emphasized the need for well-designed learning support to improve the students' learning achievements. Sharples et al. (2010) suggest learner centered, knowledge centered, assessment and community centered approaches for effective learning. The successful development of mobile learning depends on human factors in the use of mobile and wireless technologies.

Sharples (2013) stated that the majority of mobile learning activities continues to take place on devices not designed with educational ends in mind, and that usability issues are often reported. In conclusion, a teacher centered approach is often missing. For this reason, learning units in OMLETH can be designed in other e-learning systems teachers are already experienced with, and at the same time support the teacher's freedom and creativity w.r.t. didactic choices.

The knowledge centered approach as well as the assessment centered approach are based on teacher's personal choice and experience and are linked again to a teacher's choice of e-learning system. Recent developments show also growing gamification elements in learning software applications (Kapp 2012).

With regard to the community centered approach for outdoor education, educational software in the field of LBML should support learning in pairs or groups (see Sect. 3.3). Christie (2007) discovered that middle school teachers as well as students are highly motivated to use GPS and Geocaching. The Geocaching software creates technology-rich, constructivist learning environments and supports learning in communities.

Factors for Software Quality

The challenges teachers face in their daily work with educational software may be caused by several factors. McCall et al. (1977) presented a software quality schema to assess software in a structured way: they proposed a categorization of factors that affect software quality. These software quality factors focus on three important aspects of a software product such as operational, transitional and revisional characteristics.

Teachers' main challenges are found in the daily operation and are reflected in the following seven categories: (Table 2)

3.3 Teaching

Teaching is a complex activity that requires reflection on various levels and a thorough planning. Good and effective teaching is explained by various authors (Dubs 1995, Borich 2013, Hattie Hattie 2013) and always includes the reflection of a thorough planning process. The planning starts with a curriculum framework, from which first unit plans and then lesson plans are derived. In particular, lesson planning considers goals and objectives in the cognitive (Bloom 1956), affective (Krathwohl et al. 1964), and psychomotor (Harrow 1972) domains as well as learner's individual prerequisites and incorporates diverse teaching methods. In addition, teachers can also decide to plan a LBML unit based on a specific learning paradigm and thus use tasks and questions specified for that approach (Schito et al. 2015). In this regard, LBML is one method among many to contribute with its ability to implement different teaching strategies to diverse teaching and to lifelong learning.

3.3.1 Integrate LBML in the Curriculum

First, we focus on the question, when teachers best make use of LBML. Because LBML units require surpassing preparation time, they must be applied selectively and with care. Ideally, LBML is integrated within a topic that has a high teacher task orientation, and for which it is useful to reuse the results achieved during the LBML unit for further lessons. In this way, learner's achievements are appreciated insofar as their work becomes an essential part of the whole group's learning process. Another characteristic of LBML is its linkage to a specific place. In contrast to classroom learning, teachers choose tasks linked to a phenomenon that only occurs at a specific place. Thus, LBML crucially depends on the reliability that a phenomenon occurs satisfactorily noticeably at a specific place and time. The main teaching

Table 2. Matrix of daily software operations concerning seven categorizes

Operational Factors	Description	LBML challenges
Correctness	The software should meet all the specifications stated by the customer.	Errors in LBML software have, due to the lack of direct contact between teacher and learner, bigger impacts than in classroom learning.
Usability/Learnability	The amount of effort or time required to learn how to use the software should be small. This makes the software user-friendly even for IT-illiterate people.	E-learning tools often provide overwhelming functionalities and are not directly adapted to the user's mental model. These challenges teachers and results in terms of LBML design in different solutions.
Integrity	A quality software should not have side effects, i.e., it should not affect the functionality of other applications.	Using sensors like the positioning in OMLETH depends sometimes on third party running software and may lead to problems for some mobile web browsers.
Reliability	The software product should not have any bugs; most importantly it should not crash during execution.	Since teachers and learners in LBML are typically spatially separated, a real-time support by the teacher in case of problems with the application is not possible.
Efficiency	The software should make effective use of the available resources, efficient use of storage and processing power, obeying the desired timing requirements.	In the case of LBML, the required time for planning is a multiple of the effort for preparing e-learning or classroom lessons.
Security	The software should not have negative effects on data or hardware. Proper measures should be taken to keep data secure from external threats.	Security is a big issue in the field of LBML. Crowded systems like OMLETH and its third party apps need security regulations, in terms of privacy and geo privacy.
Safety	The software should not be hazardous to the personal context.	LBML risks higher safety issues than classroom learning (e.g., software-based positioning errors)

challenges are first to link location-based phenomena with learning, and second to integrate LBML units thematically and seamlessly into the curriculum by simultaneously considering the main goals and objectives.

3.3.2 Topics Appropriate to LBML

Teachers may question which contents and topics could best be taught with LBML. According to the statement above, LBML is not limited to geography classes. Instead, LBML is a means to an end that can be conveyed for every subject whose content is linked to a specific location. This opens opportunities for interdisciplinary learning: imagine for example an economy lesson in which learners must analyze the net production of agricultural products, map the occurrence of these products on a digital map, and suggest solutions to improve production and to foster ecosystem services. Thus, the topic should not act as a bottleneck for refusing the use of LBML. Instead, teachers are motivated to search for ideas, how a topic could be related to a specific place. Rather than aiming at completeness about a topic, regional features can be investigated exemplarily in case studies.

3.3.3 Special Characteristics of Teaching with LBML

In this section, we describe in which way teaching of LBML units differs from regular classes with regard to didactic approaches and learning. LBML is very suitable to promote constructivism and cooperation. Constructivism is fostered by an intensive confrontation with the subject matter with the aim to construct somebody's knowledge through experience. Therefore, time on task plays an important role: it should be chosen sufficiently high for learners to solve the task while operating with a device and analyzing the environment (Borich 2013). These interactions could not yield a learning effect if the time given was insufficient. However, learning progress can only occur if every learner actively participates in the learning unit. Therefore, splitting tasks into subtasks by assigning each learner a role and thus making him or her a specialist intensifies the learner's confrontation with the subject matter and increases the consciousness about a useful contribution to the final product and to the collective learning process (Borich 2013). Moreover, task splitting causes division of labor and makes learners become task specialists. In general, cooperation allows to place one's own contribution within the context of the work of others. This structure fosters the sharing of ideas and enhances the learning process based on the peer effect (Hoxby 2000).

3.3.4 LBML Unit Management

In contrast to classroom teaching, LBML does not provide an implicit classroom management. With LBML, teachers partially lose control of the learners because they are supposed to solve tasks away from school or at least outside the classroom. Even though teachers revert to technical monitoring solutions and provide communication opportunities they cannot guarantee that learners invest the maximum of time available to solve a task correctly. Instead, teachers can contribute to a pleasant atmosphere within the groups by choosing the group sizes and their members properly. Furthermore, teachers can steer by the tasks specified and the material provided the social climate between the groups, which can either be competitive or cooperative (Borich 2013). In this regard, interaction between learners can be prolonged more and intensified to increase the awareness for each other's learning. Thus, because interaction between the teacher and the learners is reduced, feedback, reinforcement, and support come mainly from peers. In this regard, teachers can only act as supporters who help the learners to reflect their own performance (Borich 2013).

3.3.5 Time

Depending on the time at which the learning takes place, the environmental effects can highly vary. Therefore it is important to determine an optimal time slot in which learners can proceed with the LBML unit and perceive the environmental effects as expected. Time is also a crucial factor since the time available for learning is often limited. Tasks should be solved within a given time frame to keep the focus straight on learning (Borich 2013). Second, especially during LBML units learners must move from one station to another which needs time again. For both, teachers must plan enough time to guarantee sufficient time on task used for learning. The teacher must also consider that the physical activity involved in LBML may lead to learners getting tired if the learning module takes too long.

3.3.6 Considering Safety Issues

Participants' well-being has the highest priority while conducting an LBML unit. In this regard, the avoidance of accidents or risky situations and the evaluation of natural hazards helps not only to increase the learning success, but also to prevent legal consequences in case teachers are responsible for the learners' health. For instance, teachers should be cautious, they must be prepared for unexpected situations, and they must recognize dangers in areas with challenging paths, steep abysses, slippery floors, potentially occurring natural hazards, obscured lighting conditions, or heavy traffic. Also, teachers must be informed if a learner needs medication, has a disease or is allergic to certain substances. Legal issues must be clarified in advance to avoid lawsuits. Keeping in mind safety issues might increase the learner's awareness of being cautious during the LBML unit. In addition, a safe environment supports carefree learning. Thus, teachers must propose solutions to any circumstances, best by following an emergency plan, in order to make learners feel safe. To prevent a learning gap, an elaborated lesson plan must contain content-related options, e.g., for tired or powerless learners.

3.3.7 Intensities of Assistance

The planning of an LBML unit opens various possibilities for the intensity of teacher's assistance. The assistance intensity depends on the formulation of the task and thus on the goals. First, a teacher can provide no assistance by refusing to set a time frame. In this regard, learners must decide by themselves how to organize their work, however, they practice self-responsibility. Second, a teacher can provide assistance selectively: at the beginning (briefing), at the beginning and at the end (debriefing) or at the beginning, at the end and in the middle (intermediate briefing). Ideally, teachers never refuse to assist the class during the beginning to explain the organization, the procedure or the goals of the LBML unit and during the end to summarize the observed phenomena. Third, teachers can provide full assistance which is not compatible with the constructivist paradigm and thus inappropriate for the use of LBML.

3.4 Learner

In this section, we focus on the learner as the protagonist to whom a teacher must draw his or her full attention. The learner is at the center of interest because teachers' actions aim at learners experiencing a noticeable learning progress. If such a learning progress did not occur, the teacher might have failed to focus on the learner's characteristics. Just like learners are unique, their learning approach and their motivation to learn also are individual. In this regard, the specific challenge lies in adapting the teaching approach according to the learner's characteristics to enhance the quality of teaching. As Borich (2013) wrote, teachers thus need empathy to foster learners of diverse characteristics.

Because motivation is a key factor of learning success, teachers should respond to the learner's character, background knowledge, social heritage, and age to motivate them to improve their skills. As premise, learners must be respected; otherwise they do not feel to be taken seriously and thus doubt the purpose of learning. Without the learner's participation or interest, teaching becomes senseless. Furthermore, power imbalance or age differences between teachers and learners inhibit open communication and enhance learners' distrust of teachers. Instead, learning from peers rates high because especially adolescents do not want to rank behind their peers (Hoxby 2000). If somebody has understood a subject matter, peers are also motivated to reconstitute the thoughts in order to prove mastery. In contrast, for the learner that has understood the matter, explaining the fact to peers deepens his or her understanding and enhances his or her social skills. Thus, teachers can benefit from these facts by planning tasks in a way that group members must cooperate and share knowledge to solve a task completely.

Beside the learner's characteristics, the reflective integration of knowledge, and the cooperative work in groups, Sharples et al. (2005) propose assessments to crucially contribute to learning success. Assessments offer diagnosis and formative guidance so that learners recognize a purpose behind learning. Such purpose can comprise mastery or competitive goals (Ames and Archer 1987). Furthermore, assessments allow students to calibrate their knowledge to a grade scale (Nicholls 1984). As teachers respond to learner's individual characteristics and encourage them individually to invest time for their learning process, chances are also high that learners will be motivated to do so.

3.5 Environmental Spatial Ability

While the concept of mobile learning mainly propagates to use mobile devices in general for teaching units, the concept of location based learning relates to a notion of teaching which aims at working on a topic at a concrete spatial location. Because in LBML knowledge is built in situ, it is embedded into a concrete context and in a real situation respectively (Brown et al. 2010).

Spatial ability is the capacity to understand and remember the spatial relations among objects, whose choice of an appropriate location to conduct a LBML unit, is crucial (Montello and Raubal 2013). OMLETH requires different spatial concepts for the LBML design. Furthermore, the map-based design of the LBML units needs also spatial knowledge of the real world.

3.5.1 Spatial Knowledge

Spatial knowledge is commonly defined as the ability of modeling the spatial environment in an intrinsic mental model. Planning learning units in OMLETH and simultaneously differ between different spatial objects, needs an excellent mental model known as mental maps. A teacher's mental map is based trough in situ or map-based exploring and experience. OMLETH shows that in situ exploration as well as map study such as the understanding of the topography are essential to design a well-constructed learning module.

3.5.2 Spatial Concepts

Spatial concepts consist of the orientation skills, spatial contexts, spatial proportions like angle or distance estimation. Experiences with OMLETH have shown that distance estimation is difficult and that teachers often underestimate the time needed to move from one station to the next (see 3.1.4). Thus, teachers should be motivated to allocate the stations close to each other to maximize the time on task and at best to keep the learner's motivation high.

Teachers' spatial knowledge and skills not only facilitate the design of LBML activities, but are highly relevant to plan them in a meaningful and beneficial way. Hegarty et al. (2002) developed a standardized self-report scale of environmental spatial ability, called the Santa Barbara Sense of Direction Scale (SBSOD). OMLETH could demand minimal environmental spatial abilities from teachers where this self-report could be used for evaluation purposes.

4 Conclusion

LBML is ideal to complement a given topic in the circumstances that a specific content can only be learned at a determined location. However, the planning of reflective LBML units is highly complex because the volatile challenges environment, technology, teaching, learners, and environmental spatial abilities must be considered. In this planning process, teachers play a key role because they can contribute to a successful LBML unit by their knowledge, skills, and by their decisions made to equally integrate the five volatile challenges and to optimally assist learners. In this respect, our experiences with the ongoing OMLETH project support the importance of teachers.

However, evidence from research in LBML with OMLETH should be treated with caution because LBML is a relatively new and rapidly growing research field and most studies concerning the effectiveness of LBML are less than ten years old. Moreover, research with OMLETH has not investigated privacy issues concerning the conduction, purpose and analysis of monitoring learner's behavior yet.

On the basis of the rapid development of mobile technology, growing user experience, and enhanced didactic research of LBML, the software development of OMLETH will continuously be adapted and extended. According to Sharples (2013) and Tan et al. (2013), we propose on the one hand to use diaries to record teacher's and learner's experience, whereas on the other hand, we propose data mining and data analysis to track learners' behaviors and to build learner profiles for enhancing personalized learning. In order to improve the technical understanding and handling, learners should be motivated to learn with their own device. These records help to evaluate the design, structure, and popularity of LBML and return essential insights to solve challenges in future work.

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