Chapter 8
Location-Based Environments for Formal and Informal Learning: Context-Aware Mobile Learning

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8.1 Introduction

With the rapid development of information and communication technology (ICT), new learning technologies and approaches can be widely found and adapted in learning environments for different forms of learning. In this chapter, we discuss location-based environments for formal, nonformal, and informal learning and focus on mobile learning.

At the dawn of the twenty-first century, mobile devices have been commonly used in people's everyday life. Currently, mobile devices i.e., smartphones have been used not only for voice telecommunication but as powerful data communication tools as well, which are greatly changing our daily lives including learning processes and learning capabilities in the Digital Age. Because of their mobility, portability, and data communication ability, many educational technology researchers, educational professionals, students, and mobile phone users have started to realize the great potential of using mobile devices for learning (Huang et al. 2011; Liu 2007; Liu et al. 2003). Gradually, using a mobile phone to conduct learning is considered an effective way for learning anytime and anywhere. Location-based services are one of the fundamental components in the cellular wireless communication network. Using mobile phones' location awareness into mobile applications has become a new trend, which has attracted great attentions among consumers, technology developers, and academic researchers (Paucher and Turk 2010; Tan et al. 2009; Hermann et al. 2007). Mobile devices allow mobile applications to have strong interactive capabilities with the environment by sensing and reacting to their locations and contexts. Therefore, in a mobile learning setting, learners do use por-

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table handheld mobile browsers not only to get learning contents but also to conduct their learning in context-aware and, more specifically (for the purpose of this chapter), in location-based environments.

8.1.1 Location-Based Environments

In this chapter, we focus on mobile devices with built-in GPS receivers, webcams with 3G data, and Wi-Fi communication capabilities (such as iOS, Android, RIM or Windows smartphones, and iPad, Galaxy, Xoom, PlayBook tablets). While people are usually using mobile devices in their daily life, this kind of devices is also used in education as the providers of an appropriate platform to conduct teaching and learning (e.g., Huang et al. 2011; Liu 2007; Liu et al. 2009). Access to learning content through a mobile device has started to become a rapidly developing learning setting. Because of the advanced wireless telecommunication infrastructure, for example, 4G cellular networks and enlarged mobile computational capacities, mobile devices have much stronger capability to implement client–server-based mobile learning applications. Furthermore, the upgraded mobile operating systems and enhanced mobile device middleware and native features may provide learners with authentic learning activities. The wide cellular network coverage, mobility, and portability of mobile devices have set the framework for ubiquitous and asynchronous learning (Chu et al. 2010; El-Bishouty et al. 2007). The unique characteristic of mobile devices is their location awareness that enables the development of mobile learning applications with strong interaction capability. The advanced functions of mobile devices enable mobile learning applications to sense location and to identify learners' learning environments. Thus, in mobile learning settings, learners are able to interact with learning environments by means of mobile learning application's interactive functions.

Within location-based environments for formal, nonformal, and informal learning, real-world objects and scenes are used as learning objects, while learners' mobile devices can sense and react to particular setting or environments. In location-based environments, real-world objects can be integrated and associated with learning content as particular learning objectives, providing pervasive and seamless learning environments. These kinds of environments have the potential to offer tremendous opportunities to support formal and informal learning, especially nonformal learning (a comparison of these two terms will be presented later in this chapter).

In 2006, Yang proposed context-aware ubiquitous learning environments that provided contextual information to support peer-to-peer collaborative learning. He indicated that with context-awareness learning, it can occur in the right place at the right time, when location-based learning environments have been considered (Yang 2006). While mobile devices are used as the location-aware interactive learning devices, location-based environments are considered as learning resources that include contextual information. Learning resources can be provided to dynamically adapt to different learners based on substantial advances in pedagogical theories and knowledge models (Tetchueng et al. 2008; Tan et al. 2011; Burkle 2010). In practice, real-world objects are combined with other learning materials based on learning objectives and then turned into location-based learning contents. Location-based environments associated to learning contents are integrated into "learning management systems (LMS)" and stored in learning repository databases with identification attributes tagged with the location information. When learning takes place, location-based environments associated to learning contents will be retrieved from the LMS using acquired mobile devices' current location information and other contextual information. Then, the information will be landed on learners' mobile devices for the learners to learn or act on accordingly. Many mobile learning applications have been developed and implemented to conduct location-based learning.

From what we have mentioned above, location-based learning environments could facilitate learners' interaction with the real world. Through accessing and experiencing real-world learning objects, learners can connect and associate the information and knowledge learned on books with the actual world to enhance their learning. Location-based environments aim to contextualize learning activities by enabling the learners to interact appropriately with their environment (Patten et al. 2006). Therefore, vivid location-based environments could greatly impact formal, nonformal, and informal learning.

8.1.2 Formal and Informal Learning

In this chapter, we discuss location-based environments for formal and informal learning. Because of the variation of the definition with regard to forms of learning, it is helpful to clarify at this point what we mean by these terms in the context of this chapter.

Ainnsworth and Eaton outlined and summarized notions of formal, nonformal, and informal learning in the framework of learning in the sciences (Ainnisworth & Eaton, 2010). These practices are described as:

- Formal learning—A type of learning that is intentional, organized, and structured. Institutions usually arrange formal learning opportunities. Often, a curriculum guides this type of learning.
- Nonformal learning—An institution may or may not arrange this type of learning intentionally. It takes place outside the formal learning system but is usually organized in some way, even if it is loosely organized. This kind of learning does not follow a formal accreditation processes.
- Informal learning—This type of learning is never organized. Rather than being guided by a rigid curriculum, it is often thought of as experiential and spontaneous.

Koole (2009) builds a model to analyze the impact of mobile technologies for both formal and informal learning processes. In her FRAME—Framework for the Rational Analysis of Mobile Education—model, Koole describes the role of mobile technologies in the provision of a learning platform to support formal access to learning (content provided by a higher education institution) and informal learning (knowledge exchange between technology users). Formal learning addresses knowledge, memory, and context, while informal learning deals with learner's emotions and motivations.

In the context of this chapter, we focus on location-based environments for formal and informal learning. In order to be precise with the type of learning analyzed in our research, we have combined both terms as understood by Ainnsworth and Eaton into one learning type: formal learning and alter informal learning. Hence, the following discussion in this chapter will refer to the definition of learning type as:

- Formal learning: This type of learning takes place inside or outside the school environment. It is conducted within teacher–student relationships. It is arranged by education institutions and guided by a curriculum. It aims to achieve a particular course's learning objectives.
- Informal learning: The type of learning that is never organized but still intentional. Rather than being guided by a rigid curriculum, it is often built on experience, and it is always spontaneous. It does serve for learner's overall learning objectives.

In the following section, we will explore location-based environments in the two learning forms. Next, we will introduce research related to location-based environment for learning. Then, we will introduce mobile applications and research for location-based environments. Finally, we will conclude this chapter on the location-based environments for formal and informal learning topic.

8.2 Location-Based Environments for Learning

Location-based environments for learning have become a hot topic with the significant growth of mobile learning devices in recent years in context-aware ubiquitous learning. Since mobile learning can take place at anytime and in anywhere, there is an advantage to integrate the real-world objects into learning contents. With regard to location-based learning environments, we need to examine the differences between formal and informal learning in practices to identify their advantages and limitations.

8.2.1 Location-Based Environments for Formal Learning

It is not very common to include real-world objects and scenes—such as historic places, geographically and geologically interesting spots, interesting architectures, landmark buildings, and museums—into a course delivery framework as learning objects. Learning with location-based environments can be found through arranged field trips, outdoor education, environmental studies, and field-worker training. It is important to know that in this framework, learning is still guided by curriculum, and it is conducted by the instructor or teacher to fulfill the course learning objectives. In this type of learning, that is, formal learning, location-based environments are used as learning objects. Usually, teachers assign learning tasks associated with location-based environments to students and provide them learning materials or tools as well as instructional documents to directly or indirectly lead them to complete the learning tasks on-site or to work on the tasks on their own. In this case, students' learning achievements are often evaluated through assignments or reports or presentations or examination.

In this chapter, location-based mobile learning is considered an organized and structured method of learning internal or external to the formal learning environment. It complements classroom learning by engaging students in location-based environments. Learning contents associated with the location-based environment are predeveloped and stored in the learning contents repository so that students can retrieve them through mobile devices when they are in the location. Many researchers have demonstrated that mobile learning has the great advantage of incorporating location-based environments for learning (Peng et al. 2009; Chu et al. 2008).

With advanced wireless telecommunication networks and mobile technologies, the integration of location-based environments for formal learning through mobile devices has become much more effective and efficient. Applying mobile device's location-awareness features, context-aware mobile learning has unique and remarkable strength in implementing location-based environments for formal learning.

In recent years, there have been several interesting and innovative location-based applications, such as location-based grouping—Mobile Virtual Campus (Tan et al. 2010), Environmental Detectives (Klopfer and Squire 2008), Butterfly Watching (Chen et al. 2005), CAERUS (Naismith et al. 2005), Ambient Wood (Rogers et al. 2004), Savannah (Facer et al. 2004), and Riot! 1831(Reid et al. 2004)—that could be used in the context of formal and/or informal learning environments.

As an example of using mobile learning applications in location-based environments for formal learning, we introduce the Mobile Virtual Campus system that is used to develop mobile-technology-guided field trip activities for the Athabasca University *Geography 266* course for distance education in physical geography. Figure 8.1 shows the conceptual architecture of the field trip.

The course instructor describes the content of the course in her own words:

> In this course, students study the internal structure of the Earth, the rocks that compose it and the forces within the Earth that act to deform both its internal and surface structural composition, thus creating relief. Students also learn about the denudation processes that unceasingly act at the Earth's surface to shape landforms and reduce relief, thus covering the topics of weathering, mass movement, erosion, transportation, and deposition by the geomorphic agents of water, waves, wind, and ice. The fieldtrip consists of a visit to the area around the Crowsnest River Valley and Turtle Mountain in the Canadian Rockies of southwest Alberta, famous for being the site of the deadliest rockslide in Canadian history. This event is known as the Frank Slide because it destroyed the southern end of the town of Frank in 1903. The fieldtrip is expected to be undertaken by students, individually or as a

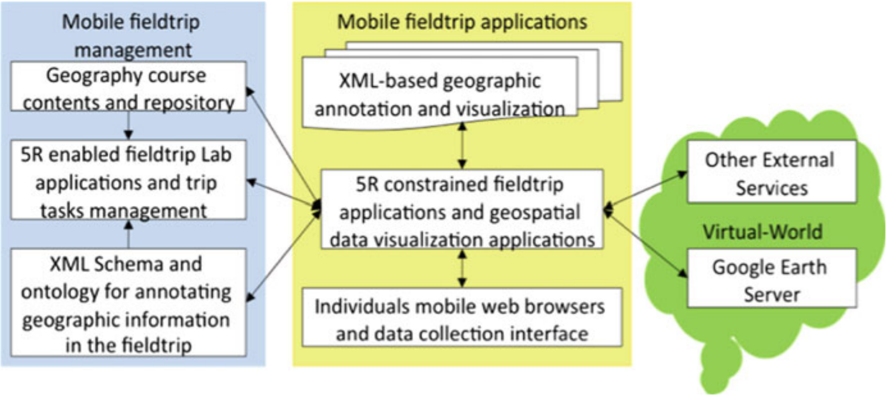

Fig. 8.1 The conceptual architecture of the location-based mobile field trip (Tan et al. 2011)

group, in the absence of direct supervision from an assigned instructor. Instead, it is facilitated by a mobile device that acts as a guide by drawing students' attention to geographical features of interest. The mobile device also delivers a list of tasks and reflective questions to students as they undertake the field trip. Finally, it enables data collection and annotation in the field (Pivot 2012).

8.2.2 Location-Based Environments for Informal Learning

In contrast to formal learning, location-based environments for informal learning are usually found as casual and self-motivated learning. Learners can learn with location-based environments without waiting to receive instructions from the teacher or course guide. Informal learning with location-based environments could happen in the context of experience, and even if it is spontaneous, it is still intentional. It does serve for the learner's overall learning objective.

Mobile applications can provide learners great interactive ability with location-based environments for informal learning through mobile devices. Mobile learners can learn anytime and anywhere by using location-based environments in their everyday life. Many fascinating mobile applications can be employed to assist learners for informal learning. Some examples of these are iCollaborator, an iPhone application that was developed at Athabasca University to provide multimedia mobile meeting and interactive virtual whiteboard in which participants can effectively communicate and exchange ideas in a real-time manner with location-aware aspects (Lo and Tan 2010). Figure 8.2 shows screen shots from iCollaborator. With the iCollaborator, learners can have real-time communication and exchange ideas with others to assist their learning from their everyday life.

Below is a quote from an iCollaborator user:

> As a scenario Jason, a visiting student learns Chinese in China. When he is in a Chinese restaurant, he may run iCollaborator on his iPhone to communicate and share the menu in

Fig. 8.2 The iCollaborator's interfaces and whiteboard (Lo and Tan 2010)

> Chinese through the whiteboard with his buddy, Wei Tao to ask him to help for his order. At the same time, he could learn Chinese on the menu, which eventually helps his Chinese learning.

Another example of mobile application for informal learning is Word Lens. This application translates instantly printed words from one language to another. It can be used as a great tool for language learning in location-based environments (Quest Visual Inc. 2010). There are also some location-based mobile applications that enable informal learning in location-based environments, such as "Geocaching" software and location-based games.

Indeed, using location awareness of mobile devices gives mobile learning applications a distinguishing ability for facilitating mobile learning, either formal or informal, and to interact with the location-based environments. Enabling the context-aware feature makes mobile devices stand out as a learning media and motivates the development and innovation. It provides tremendous opportunities for integrating location-based environments for formal and informal learning.

8.3 Location-Based Environments Issues and Opportunities

The integration of location-based environments into the context-aware mobile learning systems opens great opportunities for teaching, learning, learning content management and delivery, and educational administration. At the same time, many theoretic, pedagogical, and technical issues and challenges need to be examined and solved in order to successfully implement location-based environments for learning. A research framework was proposed for research on location-based adaptive mobile learning by Tan et al. 2009. As the research on this issue progresses, research topics and issues are respectively categorized into four aspects: technology, application, pedagogy, and education.

8.3.1 Technology Issues

Location-based environments for learning are based on the advancement of technologies, especially mobile technology and location-based technologies. The research issues and topics in the technology layer focus on studying the technical solutions to find the optimal answer for the integration of location-based environments for learning.

1. Mobile device issues:
   (a) *Mobile computing:* how to optimally use the mobile device's computation capacity and to utilize mobile devices' native hardware and software functionalities
   (b) Human–machine interaction: how to identify effective human–mobile device interface and to apply the cutting-edge mobile technologies to enhance the interaction among humans, mobile devices, and location-based environments
2. Location-based environment issues:
   (a) *Location-based technologies* to study and apply positioning solutions for indoor and outdoor location identification and navigation
   (b) *Wireless sensor network and sensors:* how to tag the real-world objects indoor and outdoor and to study effective sensors and sensory technology-based mobile devices' interactive capacity
3. Learning management system's server application issues:
   (a) *Location awareness and contextual information* to study algorithms and system architectures for location-based learning management systems to effectively process acquired contextual information and to provide location-based adaptive learning contents
   (b) *Artificial intelligence and natural language processing:* how to use AI to design and build more intelligence in learning systems to continuously upgrade and calibrate location information for improving positioning accuracy and efficiency and system performances
   (c) *Data mining and data analytics* to track learners' learning behaviors and to build learners' profile for enhancing personalized learning
   (d) *Fuzzy logic and set theory* to quantify the contextual information and descriptive measurements for calculation in order for the learning management systems to be able to automatically make decisions and evaluations
   (e) *Imaging processing* to effectively process images captured by mobile devices that will allow interaction with location-based environments via mobile devices' built-in webcams
4. Learning management system infrastructure issues:
   (a) *Cloud computing* to study and develop robust networking infrastructure, learning application platforms, and learning application software for easily and effectively accessing learning resources and to develop CASS (Computer-Assisted Social Services) learning content delivery model
   (b) *Robot telepresence* to study and develop online remote labs and to allow online learners to interact with location-based lab environments through robot avatars

8.3.2 Application Issues

Location-based mobile learning applications are the means of utilizing location-based environments for learning. The location awareness of mobile devices offers great opportunities to develop innovative and effective location-based applications to facilitate and enhance location-based learning and teaching. The main goals of the location-based applications are to provide collaborative, adaptive, and interactive learning platforms.

- *Location-based collaboration* to study and develop mobile applications that enable learners to learn collaboratively through location-based environments
- *Location-based adaptation* to study and develop mobile applications that are able to provide learning content adapted to contextual information, especially location information corresponding to location-based environments
- *Location-based instruction* to study and develop mobile applications that allow instructors to give lectures or instructions according to location-based environments
- *Location-based assignment and problem solving* to study and develop mobile applications that are capable of allocating location-based assignments and to ensure that problems are solved in the designated locations
- *Location-based augmented reality* to study and develop mobile augmented reality applications that enable learners to use the augmented reality technique to interact with location-based environments
- *Location-based learning content delivery* to study and develop mobile applications that can sense and react to location-based environments and deliver learning contents based on the location-based environment

8.3.3 Pedagogy Issues

Pedagogy issues in location-based environments for learning address the transferring of educational needs, ideas, methodologies, and practices into technological solutions for design and development of learning applications. By studying these issues, it aims to assist technological solution providers to create and develop applicable and helpful learning applications for educational use.

- *Location-based environments in course development* to study how to integrate these into course design in order to make the integration better serve for the entire learning objectives and to ensure the integration to be implementable and practical in learning
- *Implementation of location-based environments in different forms of learning* to study implementation of location-based environments in different learning forms and to explore the best practice based on difference between educational methodologies and environments and to identify differences in applying location-based environments in formal and informal learning

8.3.4 Education Issues

The final goal of implementing location-based environments for learning is to enhance teaching and learning. Therefore, we need to evaluate their effectiveness and to identify the best practice of location-based environments for learning from an educational point of view. We also need to use educational research methodology to analyze the learners' behaviors and patterns in location-based environments, to understand the strength and weaknesses of location-based environments for learning in order to provide possible solutions and suggestions. It is therefore very important to study the technology impact and explore the trends associated with location-based environments for learning.

- *Location-based technologies for learning* to study the rationale behind location-based technologies for learning and the effectiveness and application areas of location-based technologies for learning
- *Effectiveness of location-based environments: strength and weakness* to study the effectiveness and to identify the strong possibilities and challenges of location-based environments for learning from technology and pedagogy perspectives
- *Learners' behaviors in location-based environments* to study mobile learners' activities and actions and to find the learning patterns in order to build learning models and to develop effective learning systems

Despite many challenges and unsolved issues of location-based environments for learning, there are great opportunities in applying location-based technologies to create innovative and effective learning applications for academic researchers, application developers, technical educational solution providers, as well as teachers and students. Through advanced technological means, the effective implementation of location-based environments for learning has become a possibility and a reality in education.

8.4 Location-Based Mobile Applications for Learning

In this section, we will present and discuss mobile learning applications that have integrated location-based environments as contextual information. From the literature review, we found that there are some recent research papers introducing location-based environments for learning, such as Clough's "Geolearners: Location-based informal learning with mobile and social technologies" (Clough 2010) (Clough *et al.* 2009).

Elizabeth Brown edited a report in which a collection of contextual and location-based mobile learning researches and applications is presented (Brown 2011). Later in this section, we will introduce location-based mobile learning academic researches and application system development that we have directly involved to address the research, development, and implementation of location-based environments for learning.

8.4.1 Location-Based 5R (Right Time, Right Location, Right Device, Right Content, Right Learner) Adaptation Framework

With the goal of providing a solution and a standard structure for implementing wider-ranging adaptation for location-based environments for mobile learning, this research is still ongoing at Athabasca University (Tan et al. 2011).

The 5R adaptation concept for location-based mobile learning is stated as "at the right time, in the right location, through the right device, providing the right contents to the right learner." This adaptation concept aims to enhance learning in location-based learning environments by taking the factors of learner, location, time, and mobile devices into consideration. The 5R adaptation framework imposes the adaptation of constraints through the 5R adaptation mechanism to generate the 5R adaptive learning contents. The 5R constraints can be semantically presented and accessed during the automatic decision-making process for generating personalized learning content "filter." The framework provides learners with adaptive learning contents based on their learning profiles and learning styles, additionally to adapt to learners' current locations, times, and devices. Figure 8.3 illustrates the concept of the 5R adaptation framework.

The 5 "Rs" that integrate the model and their dynamics interrelations are crucial in the definition of the learner's system and in the provision of location-based environments. These interrelations are explained by the authors as follows:

- *The right time:* The time in the adaptation framework indicates two factors, the date–time and the learning progress sequence. The learning contents associated with the location-based environments are with date–time constraint that reflects time and date when the location-based environments are accessible, such as a lab, library, or museum. Learner's learning progress sequence is also considered as a time factor. Since mobile learning takes place anytime, by including the time constraint, the mobile learning system is able to provide the learning contents at the right time.
- *The right location:* The location in the adaptation framework indicates a learner's current geographic location. Location awareness of the learner's mobile device is used to sense the learner's current geographic location. When the mobile learner is physically at or near particular location-based environment, the learner could be assigned to conduct location-based learning activities to complete learning tasks at the location. Since mobile learning takes place anywhere, by including the location constraint, the mobile learning system can provide the learning contents in the right location. Location-based environments for learning have the unique ability to provide the location adaptation.
- *The right device:* The device in the adaptation framework refers to the learner's mobile device that is used to conduct mobile learning. The device adaptation is also the distinctive feature of mobile learning compared with other computer-assisted learning scenarios. From its nature, mobile devices are heterogeneous,

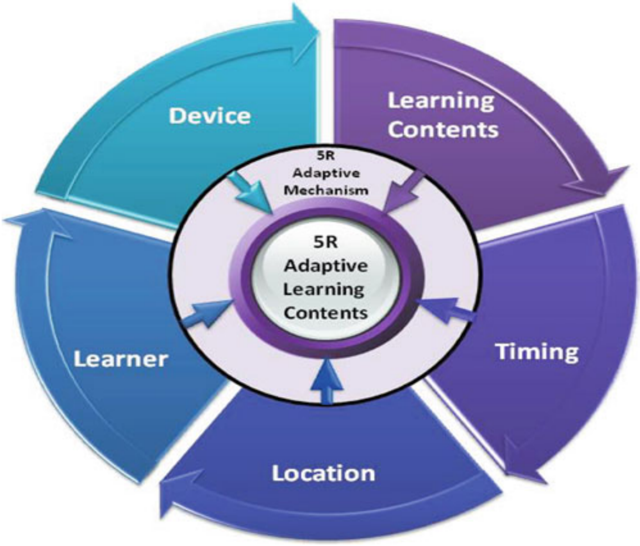

Fig. 8.3 The 5R adaptation framework concept diagram (Tan et al. 2011)

and therefore, it is essential to provide the right format of learning contents to the right mobile device. The device adaptation can provide learners the best possible learning experience in terms of the use of a particular mobile device.

- *The right content:* The content in the adaptation framework includes learning objects, learning activities, and leaning instructional materials. Learning content can be constructed or retrieved based on the learning objectives, pedagogy, and academic structure. The right learning content will suite the learner's learning objectives and learning style at any particular time and in association with location and the particular mobile device used.
- *The right learner:* The learner in the adaptation framework is the individual who conducts learning through a mobile device in the location-based learning environment. A learner's learning profile and learning style have been taken into account in order for the learning system to identify the learner's individuality and personality compared to that of other learners. The learner's profile information contains the learner's learning objectives, learning progress, learning behaviors, and learning assessment results. The right learner means that the learner receives the learning contents provided by the learning management system matching with the learner's learning profile information.

The learning system is required to track down where the learner is, and which location-based environments are near to the learner, and if they are accessible at the time where the learner is located in that particular environment. Thus, the system has the capability to automatically alert the learner when the learner is approaching to or is at a particular location and then to provide the learner the right learning contents. Within the 5R adaptation framework, the learning system provides

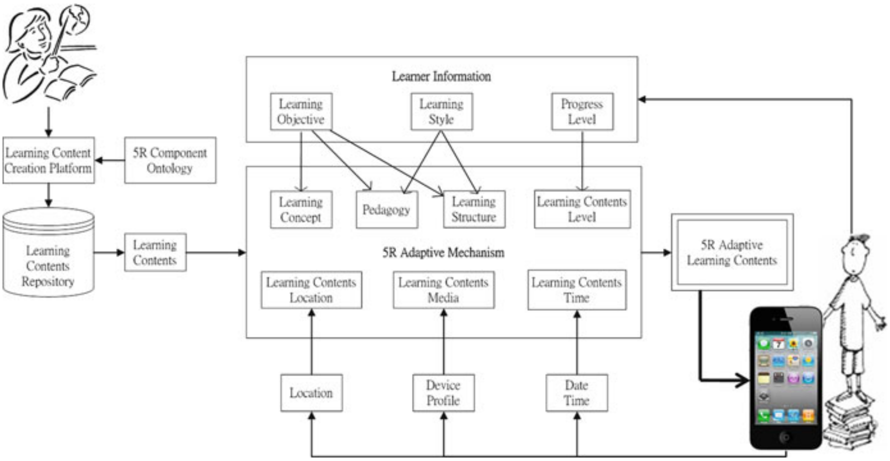

Fig. 8.4 The 5R adaptation mobile learning system architecture (Tan et al. 2011)

adaptive learning contents that not only have personalized adaptation but also have location, time, and device adaptation. Figure 8.4 describes the dynamic process of the 5R model interaction.

Location-based learning application system architecture is proposed based on the 5R adaptation framework shown in Fig. 8.4. The 5R adaptive mechanism is the core engine to process the adaptation constrains and to generate the 5R adaptive learning contents for learners. In the system architecture, a location-based learning content creation platform is designed for instructors or content developers to build and integrate location-based learning content. The platform is designed based on the 5R input ontology that ensures all the learning content developed to be used by the 5R adaptation mechanism. Moreover, the 5R adaptation mechanism could be viewed as a meta-architecture for the application system architecture in which different design or implementation strategies could be applied as long as the architecture and functions of mobile learning application comply with the 5R adaptation constraints and key relation models.

8.4.2 Mobile Natural-Science Learning

The research on mobile natural-science learning was conducted in Taiwan to study designing mobile natural-science learning activities that rest on the 5E Learning Cycle. The project was built on the examination of the effects of learning activities on students' performances when learning about aquatic plants and exploring students' perceptions toward these learning activities (Liu et al. 2009). The study identifies two positive effects in the learning process: students' engaging in "mobile-technology-supported" *observation* during their scientific inquiry and students' engaging in "mobile-technology-supported" *manipulation* during their scientific inquiry. The 5E Learning Cycle phases are described as the follows:

- *Engagement phase (E1):* The main task of this phase for the teacher is to assess students' prior knowledge and motivate the students to engage in learning a new concept. With the teacher's assistance, students are also encouraged to connect their prior knowledge to present learning and to organize their thoughts about the learning outcomes of current activities.
- *Exploration phase (E2):* The main task of this phase for the teacher is to provide students with a common base of activities that reflect concepts, processes, and skills. In this phase, students are encouraged to complete activities by using their prior knowledge to generate new ideas, to explore questions, and to conduct a preliminary investigation.
- *Explanation phase (E3):* The main task of this phase for the teacher is to let students focus on specific aspects of their "engagement" and "exploration" experiences and to provide students with the opportunities to demonstrate their understanding or skills. The teacher can assist the students to have deeper understanding of a specific concept by using direct instruction and guidance.
- *Elaboration phase (E4):* The main task of this phase for the teacher is to challenge and extend students' conceptual understanding and skills. Through the above three phases, students are expected to develop broader and deeper understanding and skills.
- *Evaluation phase (E5):* The main task of this phase for the teacher is to evaluate students' progress toward achieving the instructional goals. Students are encouraged to try to assess their understanding and abilities.

This study took place in an elementary school in Taiwan, which had been constructing an ecological pool for years. The school planned to establish a location-based mobile learning environment devoted to natural-science instruction on aquatic plants. In order to advance students' learning of aquatic plants, the project was designed, developed, and implemented including mobile learning activities. In order to examine the effects of learning activities and possible factors underlying these effects, the researchers collected and analyzed data on students' performances, perspectives, reflections, and opinions about the instruction.

The location-based mobile learning environment consisted of two major components: one of them was the Ecological Pool website and the other was the tablet mobile device used by each participating student. Such a learning environment enabled the teacher and the students to use the resources of the website in any place (such as the ecological pool and the laboratory) at the school via the students' tablet mobile devices. The "Ecological Pool" website was developed in order to provide an easy delivery platform, and all the information on it echoed the instructional requests from science teachers at the school. These resources provided hands-on problem solving as well as reinforced concepts and understanding. They were used for class instruction, outdoor inquiry, lab activities, individual or small group study, and assessment, in a ready-made format for downloading.

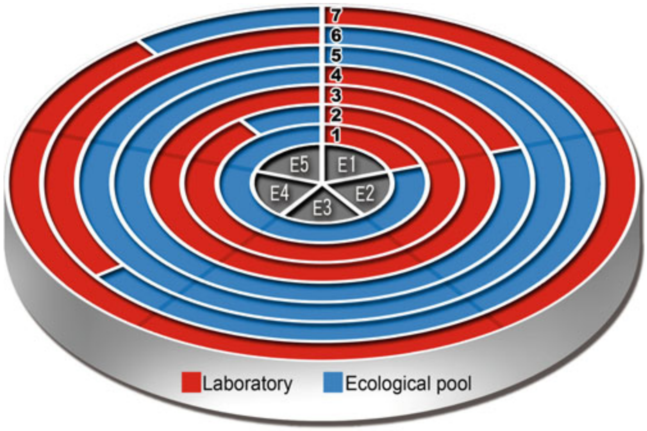

Fig. 8.5 The implementation of a mobile learning activity (Liu et al. 2009, p. 350)

Finally, in this study, seven learning activities were designed and developed based on teachers' instructional requirements, the tenets of the 5E Learning Cycle, and the school's existing learning resources. Figure 8.5 shows the implementation process of these seven learning activities. The five phases of the 5E Learning Cycle served as the foundations of the seven activities. The study involved the location-based environment, the pool, the learning devices, wireless connections, and the Ecological Pool website. At all times, and without constraints of time or location, the seven learning activities were executable and implemented.

Figure 8.6 displays specifically the implementation of activity six, which best demonstrates the use of the 5E Learning Cycle within location-based mobile learning environments. Figure 8.5 also explains the 5E Learning Cycle phases and the tasks for the teacher and the students in each phase. The instructional goals were that students should learn the specific forms and the specific habitats of the "emergent-type" aquatic plants. Besides individual learning, students also had the opportunities to conduct an inquiry with their team members. For instance, in the "Elaboration" phase of activity six, students worked in groups to complete their activity sheets via observation, the reading of materials on the website, the conduction of experiments, and sharing findings.

Finally, students were asked to browse the Ecological Pool website and to familiarize themselves with the 13 emergent-type aquatic plants. Once this activity was completed, students filled out the pre-activity sheet online. The teacher helped them connect their past and present knowledge. Students carried out their preliminary investigation of "emergent-type" aquatic plants by filling out the activity sheet via on-site observation at location-based environment (i.e., the ecological pool) and/or searched for information on the website. The teacher guided the discussion on the activity sheet and helped students locate the exact spots of these 13 emergent-type aquatic plants. Then, students refined their activity sheets through on-site observation at the pool and accessed the website. Students were encouraged to demonstrate and explained their understanding of the "emergent-type" aquatic plants.

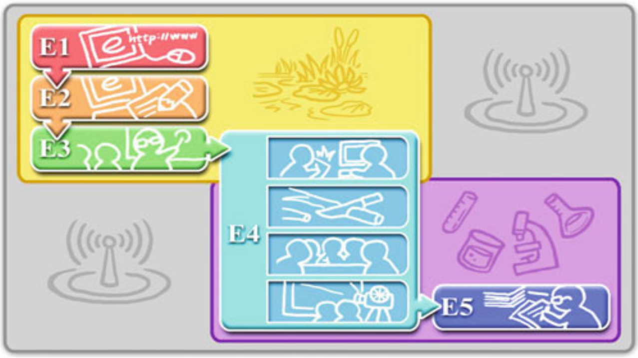

Fig. 8.6 Flow chart of the sixth learning activity (Liu et al. 2009, p. 350)

This research case study demonstrates the efficiency of using location-based environment for learning. It concludes that integrating location-based environments is an effective approach for learning. It also produced a useful guide for educational practitioners concerned with the potentials of applying location-based environment for mobile learning in school settings.

8.4.3 Location-Based Mobile Virtual Campus

In 2009, a group of researchers at the University of Athabasca in Edmonton, Canada, developed a collaborative mobile learning system called "Mobile Virtual Campus (MVC)." The campus model provided an interactive platform for online mobile learners by using the location awareness and other built-in sensory components built within mobile devices' capabilities (Tan et al. 2010). On the virtual platform, mobile learners can learn collaboratively and interactively either at a distance or face-to-face using mobile learning settings provided by the device. Furthermore, mobile learners can share learning experiences with their peers just like in a traditional classroom.

The core of the Mobile Virtual Campus application system is the location-based dynamic grouping algorithm that enables learners to be grouped primarily based on their location closeness. In addition, the grouping algorithm also takes learning factors as the grouping criteria, such as learners' learning profile, learning styles, and learning interests. The algorithm creates the default-learning group for the learners with similar learning profile and style in order to benefit them from the interaction in situations where collaborative learning is necessary. The grouping algorithm has also the option of using a learner's learning interest as the sole learning criteria in addition to the learner's location for grouping. The algorithm can create the interest-learning group for learners with similar interests to facilitate their learning in pursuing learning objectives. Furthermore, the algorithm can create a group based only on the learners' locations by social group.

The location-based dynamic grouping algorithm is a learner-centric algorithm used in order to protect online mobile learners' privacy. A learner has to initialize the grouping request. Without the request, the learner's location and other data will not be used by the algorithm and will not be shared with other learners. It is the learner's decision to join or not the group suggested by the algorithm or which group to join. Furthermore, the learner can quit grouping at anytime. The grouping algorithm is a dynamic process for the following reasons. The algorithm provides online mobile learners with instant grouping options, and the learners of an existing group may vary (i.e., learners in a group come and go according to their will). The learner's geographical location may be different to the grouping algorithm each time the learner requests for grouping.

The Mobile Virtual Campus model includes collaborative mobile learning groups that are created by the location-based dynamic grouping algorithm. Learners in a group share the closeness in geographical location and have similarity in terms of learning profile and learning styles, and/or learning interests. The MVC therefore extends the virtual campus concept into a mobile learning framework by exploiting the unique location-awareness feature of mobile devices. Figure 8.7 shows the MVC application system architecture. The MVC application system has a lot of features and functions for learning; it especially enables location-based environments for learning. While MVC provides learners grouping the opportunity to participate, it also allows instructors or learning content developers to integrate location-based environments into the system to provide learners location-based learning contents. The location-based learning objects associated with the grouping geographic coordinates will be then automatically presented to the students who can access, experience, and study the location-based learning objects within the grouping distance range together. Some MVC mobile application (iPhone version) interfaces are shown in Fig. 8.8, in which the last two shots show a group associated with location-based environments marking with numbers 1, 2, and 3 on the map.

8.4.4 Location-Based Mobile Augmented Reality Systems

Augmented reality allows the user to see virtual objects superimposed upon or merged with objects from the real world. Multi-Object Oriented Augmented Reality (MOOAR) systems for location-based environments for adaptive mobile learning (Chang and Tan 2010) are one of the ongoing research projects at Athabasca University. Mobile augmented reality systems provide the individual learner with intuitive human–computer interfaces and personalized and location-based adaptive learning contents while carrying the advantages of flexibility, portability, mobility, and context-aware instructions. Individual learners can then interact with location-based environments.

The Multi-Object Oriented Augmented Reality (MOOAR) system is a client–server-based mobile application. The server site application includes an adaptive module to implement the 5R adaptation, *at the right time, in the right location, through the right device, providing the right contents to the right learner*. For this mobile augmented reality approach, the key technical challenge is to identify the

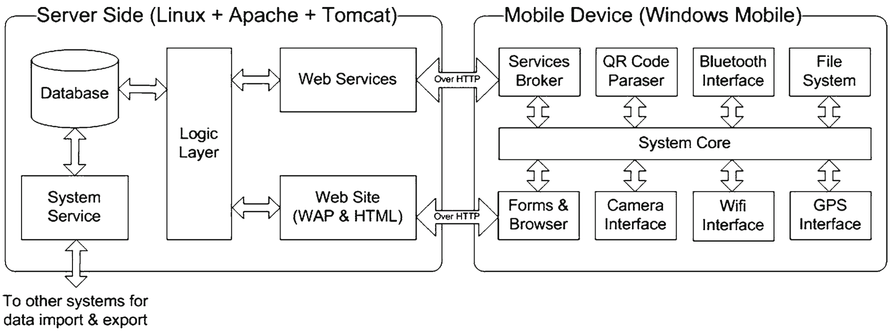

Fig. 8.7 The MVC application system architecture (Tan et al. 2010).

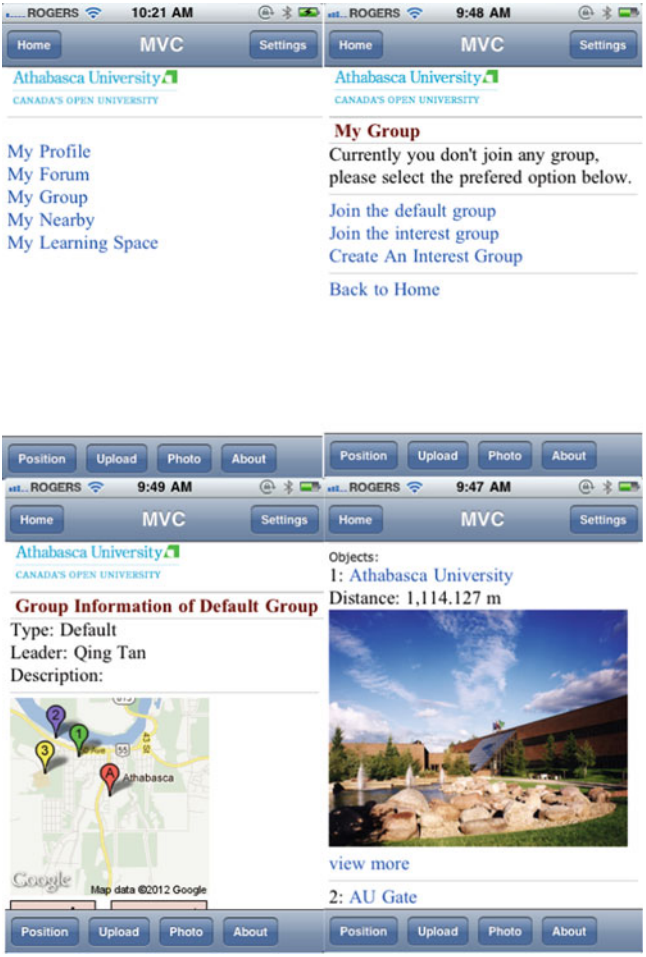

Fig. 8.8 Screenshots of the MVC mobile application interfaces

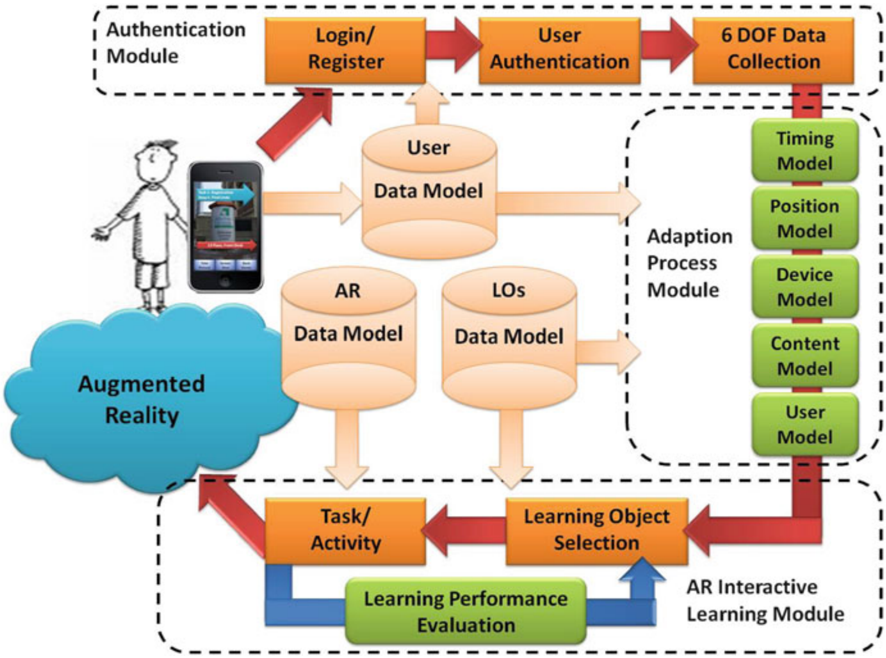

Fig. 8.9 Multi-Object Oriented Augmented Reality system architecture (Chang and Tan 2010)

real-world object or scene that the mobile camera is pointing at. Researchers in this project use GPS mobile device receivers, accelerators, and compasses to obtain geographic coordinates of the mobile device's current location and the camera orientation (i.e., the 6DOF information of the mobile device). The development of an algorithm to identify the relative position and orientation between the mobile camera and real-world object or scene is in the process of being developed by the research team. If there is a match found, the corresponding location-based learning content associated with the location-based environment will be rendered on the mobile device screen superimposing on the real-world object or scene.

The Multi-Object Oriented Augmented Reality (MOOAR) system architecture is shown in Fig. 8.9. The mock mobile device's display in implementing MOOAR system is illustrated in Fig. 8.10.

8.5 Conclusions and Future Research

In this chapter, we have discussed how context-aware mobile learning systems facilitate location-based environments for formal and informal learning. Context-aware mobile learning is indeed an efficient approach to integrate location-based environments as learning content into courses for formal learning as well as informal learn-

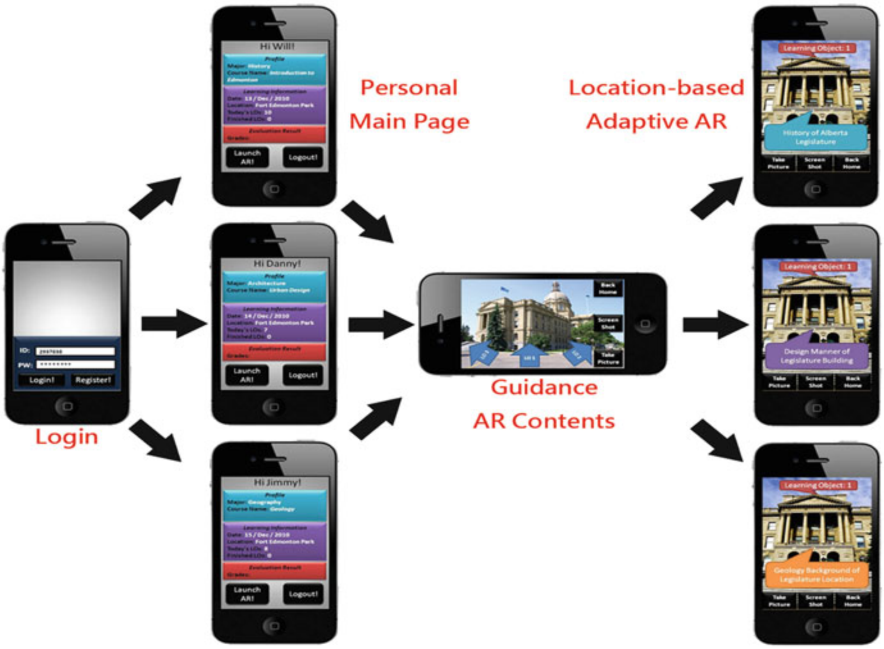

Fig. 8.10 The mock mobile device's display (Chang and Tan 2010)

ing. Usually, courses are complemented with field trips or other location-based learning activities to study real-world objects and scenes. Informal learning happens experientially and spontaneously through interacting with location-based environments in learners' daily life. Applying advanced location-based technologies to mobile devices, and mobile communication infrastructure into location-based mobile learning, is still in a very early stage. Nevertheless, we believe that it opens great opportunities in terms of providing effective and innovative learning means to engage learners interacting with location-based learning environments.

We are also aware of the fact that the application of advanced location-based technologies to mobile devices brings also many challenges in terms of learning technologies, pedagogy, and learning administration. By implementing location-based environments for learning through context-aware mobile learning, students out of their traditional classroom will be able to interact with learning objects from the real world and to connect their knowledge to it, which enlarges and extends their learning to anywhere and at anytime. Further research will need to analyze the impact of context-aware mobile learning systems in students' learning and the training needed by faculty to properly use new mobile devices as they provide access to learning objects inside and outside the classroom space.

We are aware of the great learning possibilities that context-aware mobile technologies can provide for students and instructors, but we also know the huge challenges that the use of this kind of technologies may bring to education institutions currently and in the near future. These challenges will be related not only to the technology itself but also to the development of policies to support and regulate learning innovation, to the provision of faculty training to adopt these kinds of technologies, and to the establishment of research units that will develop, observe, and adapt the use of these technologies for the better improvement of learning.

Research and development in this field has already attracted great attention by researchers and faculty members in this area, application developers, and educational professionals in recent years. In the coming years, it will promote location-based environments for formal and informal learning for the twenty-first-century learner.

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