

Mobile learning and content creation for location-based learning applications

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Using mobile devices to enable new ways of learning has been a big area of interest in research for quite some time. Mobile devices have the opportunity to foster free movement and enable structured context-aware learning activities regardless of time and location restrictions. The increased amount of mobile devices and advances in mobile technologies has made creating these new learning applications a reality. This thesis discusses the possibilities mobile learning offers to the field of education and the type of actions that must be taken in order to support the adoption of m-learning.

Mobile learning is discussed by first looking at the history of technology enhanced education and the special affordances that mobile devices have to offer. In order to create applications that can provide meaningful learning experiences and go beyond the novelty factor of using mobile devices, supportive pedagogies must be developed and integrated into tools that can be used in designing learning content for these applications. The main concepts and pedagogies for mobile learning are discussed by looking at some example applications and previous research.

The main challenge for adopting m-learning in practice is to develop generic and easy to use tools for the educators to author the learning content to be used. This thesis focuses especially on content creation for location-based mobile learning applications and presents some examples of existing solutions. As a result from the constructive part of this thesis this kind of tool was also developed as a part of the Seek'N'Share platform for location-based mobile learning.

Keywords: Mobile learning, m-learning, location-based mobile learning, creating location-based content, learning objects, learning pedagogies.

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1. Introduction

The amount of smartphones and other mobile devices has been increasing massively in the past few years. This has enabled and created a demand for developing new kind of applications and pedagogies for learning. Mobile technologies have evolved a lot in the recent years. Data communication possibilities have increased and they are getting better all the time. High speed access to the Web is constantly available through mobile (3G/4G) and Wi-Fi networks [Song et al., 2011]. Also position detection has become more accurate. These technologies are the foundation for creating location-based applications that use the user's location to provide in situ information and new real-world learning experiences. Modern mobile devices also enable the capturing of user-generated content e.g. by taking photos and recording video and audio [Heimonen et al., 2013]. In order to fully take advantage of using mobile devices in education, we must understand all these new affordances they have to offer, and develop new supportive pedagogies and tools that can be used to create new type of learning assignments.

The objective of this thesis is to research how mobile devices can be utilized in education, and what kind of tools are needed to support creating content for these mobile learning applications in order for them to be used in practice, focusing mainly on location-based learning applications. The main research questions are:

- *How can mobile learning in general be used to enhance learning results and improve motivation towards learning?*
- *How to create content for mobile learning applications, especially in a location-based learning context?*

To answer these questions, this thesis combines explorative and constructive research. The discussion starts with a literature review on the area of mobile learning in general, and continues with a main focus on location-based learning applications and content for them. The constructive part of the research consists of the design and implementation of a web editor that can be used to create location-based learning assignments for Seek'N'Share, a platform for location-based collaborative mobile learning.

The assignment editor is a web-based tool designed for teachers, not developers or expert users, which makes usability and user experience an important part in the application design. The goal is to make an application that makes creating content easy and fun for the teachers, not to give yet another program that they have to learn how to use, or that makes their job even harder. The author of this thesis took part in the designing of the user interfaces for both the mobile application and the web editor, and

had the main responsibility of the actual development process of the content authoring tool.

The thesis is constructed as follows. First in Chapter 2 the concept of mobile learning is discussed by looking at the history of mobile learning and the use of mobile devices in education. Some of the main concepts and the supportive pedagogies used in the research of mobile learning are also presented. This is followed by a summary of the main technologies used in the development of location-based learning applications and some examples of the work that has been done in the area of location-based mobile learning applications and content creation for them.

After the literature review, in Chapter 4 there is an introduction of Seek'N'Share, a platform for location-based collaborative mobile learning. The rest of the thesis consists of the results for the constructive part of the research. Design and implementation of the assignment editor for Seek'N'Share are discussed in Chapter 5, and testing and evaluation of the editor in Chapter 6. Lastly there is a discussion about future work and conclusion.

2. Mobile learning

Mobile devices and wireless connections have evolved a lot in the last decade. Mobile phones with fast internet connections and location-detection capabilities have become ubiquitous. This has also brought new possibilities and gained a lot of interest in the field of research and education. Since mobile learning, or m-learning, is a relatively new concept, there is still no single definition for it. The definitions are mainly focused around four central constructs: learning pedagogies, technological devices, context, and social interactions [Crompton, 2013]. A definition presented by Crompton [2013] incorporates these constructs by defining m-learning as “learning across multiple context, through social and content interactions, using personal electronic devices”.

In this chapter, first there is a short look at the history of mobile learning and the pedagogical changes that have happened during the years. In Sections 2.2 and 2.3 the focus is in the advantages and key challenges that using mobile devices has brought to the field of education. After that a few examples of how m-learning could be incorporated into existing learning platforms are presented as one solution to help with the adoption of mobile devices in education. Lastly the main concepts and suggested pedagogies for m-learning are discussed.

2.1. History of mobile learning and learning pedagogies

Technology enhanced learning dates back to the 1920's when the first testing machine was developed to help students test and practice their knowledge independently [E-learning, 2014]. Today e-learning and Massive Open Online Courses (MOOC) have become very popular, with almost every school using some sort of Learning Management System (LMS), like the popular open source solution Moodle. Now we are moving from these e-learning solutions towards mobile learning (m-learning) and context-aware ubiquitous learning (u-learning) [Shih et al., 2011]. Not only have the technologies that we use changed a lot, but so has the used pedagogies and the way we learn. Crompton [2013] states that pedagogies have been influenced by social behaviour, expectations, and values throughout history, but learning itself has always been essential. She also reminds that the essence of technology assisted learning is in the marriage between the technology and learning, not just one or the other. By looking at the history, it can be seen that technology has been very much connected to learning from a very early stage, and maintained interest during the changes in popular pedagogies. In the next sections the most important advances in technology enhanced learning are discussed based on the overview by Crompton [2013].

2.1.1. 1970s

In the 1970s a movement called discovery learning had emerged, with a focus on how knowledge can be acquired, retained and recalled. At that time there was no World Wide Web (WWW) or internet access available, which would have supported the concept of discovery learning. Even then there were already a few schools that utilized behaviouristic computer-assisted learning programs. During the 70s the e-learning systems started to evolve from information delivery to more interactive systems [E-learning, 2014].

The 1970s was also the decade of the invention of the first mobile phone. At that time the concept model for Dynabook, a handheld multimedia computer for learning, was created by Alan Kay. Even though the device was never created, the description was much like the modern mobile devices of today. According to Crompton [2013], one of the reasons that the Dynabook was never actualized was the lack of technological advances and the drive to incorporate desktop computers in teaching at the time.

2.1.2. 1980s

The 1980s was the time of constructivist learning, with a belief that knowledge acquisition develops through interactions with the environment. At that time multimedia personal computers were considered to be able to enable this interactive way of learning. From constructivist learning was then developed constructionism, with an added component where “students learned best when they were actively involved in constructing social objects” [Crompton, 2013]. This would bring the student in the tutor position, where s/he would be teaching the computer how to do things, e.g. how to draw a picture.

The 1980s was also the time for the arrival of the first handheld computers and personal mobile phones. These devices were still far away from the concept of Dynabook, and they were mainly targeted for business purposes. As a way to connect with the learner-centered pedagogies, classroom response systems (CRSs) were introduced in the late 1980s, but these did not gain wider usage until the late 1990s.

2.1.3. 1990s

Problem-based learning emerged in schools in the 1990s. It is based on learning by working on tasks and activities in authentic environments. In this model the teacher has the role of a guide in the learning process, but it requires critical thinking and creativity for the students to solve the presented problems. In this decade many schools were already using computer-assisted instruction (CAI) and computer-based training (CBT) programs. The problem with desktop computers at the time was that they could not easily be moved around to be used in real situations, unlike the mobile devices today.

Even though the origin of the term e-learning is under debate, some believe it was not until 1999 when the term was first introduced in a CBT systems seminar [E-learning, 2014]. This was also the decade for the invention of the digital camera, Web browser, graphic calculators, the Palm Pilot personal digital assistants (PDAs) and the emergence of Learning Management Systems (LMS).

In the late 1990s the research on using mobile devices in education was already starting to emerge. One of the first attempts to implement mobile learning was The Handheld Learning Resource (HandLeR) project. HandLeR was an attempt to utilize mobile devices and to recreate the Dynabook. The project aimed to study how mobile devices could be used to aid lifelong learning with the means of experimental and collaborative learning by bridging formal and informal learning contexts. A paper by Sharples et al. [2002] presenting the results of the developed mobile application concluded with the statement that further evaluations should be delayed until technology has developed enough to make the use easy and more intuitive.

Problem-based learning often included students to work in small groups to gather knowledge and solve problems. This trend has led to a sociocultural revolution in education with more focus on out-of-school learning through social interaction, called socio-constructivist learning. This was also the start of the emergence of non-education related social-networking sites that today include services like Facebook, LinkedIn and Twitter.

2.1.4. 2000s – Present

The 2000s bring us finally to the concept of m-learning. Even though the use of mobile devices in education has been a point of interest for quite some time, it appears that the term m-learning became a recognized term only in the year 2005 [Crompton, 2013]. It has been considered as the next step of digital learning, or an advanced model of e-learning [Shih et al., 2011]. In a pedagogical sense, a lot has changed since the 1930s when autonomy and self-direction in learners was not encouraged [Crompton, 2013]. Today students are expected to have an active role in their own learning, and self-thinking is promoted. Knowledge is gathered by interaction with the environment and society, not delivered as plain facts by the teacher.

According to Crompton [2013] e-learning and m-learning have arisen from the adaptation of a learner-centered pedagogy that is personalized, contextualized and cooperative, and the technologies that enable putting the learner at the heart of learning, by supporting flexibility, accessibility and convenience. In her research paper Crompton [2013] recognizes five key affordances that mobile devices offer to extend the learner-centered pedagogies: (1) contingent learning, where learners can directly respond and react to changes in the learning environment and different experiences; (2) situated learning, where learning takes place in real-world settings applicable to the learning; (3)

authentic learning, where learning activities are directly related to the set learning goals; (4) context-aware learning, in which learning activities are adapted based on the history of the learner and the environment; and (5) personalized learning, where content and activities are customized to support the preferences and abilities of every learner.

The development of mobile devices and wireless technologies has been very rapid, and the interest of PDAs has since decreased, and tablet PCs are starting to replace the more traditional m-learning devices [Huang et al., 2014]. Devices have become smaller, but at the same time power, speed, memory, and functionality have increased. The modern smartphones and tablet computers have the same capabilities as a laptop or a PC, with the added mobile-phone functionalities. Since the adoption of touch screens the trend has been towards increasing the devices' screen size to make interactions easier, but still making the device as lightweight as possible, so it can be carried around at all times.

The 2000s is also the decade for the emergence of ubiquitous learning (u-learning), one of the offshoots of m-learning [Crompton, 2013]. According to Sampson et al. [2013] the difference of u-learning is that it has a higher degree of embeddedness compared to m-learning and it offers more seamless and adaptive services with context-aware abilities embedded in everyday objects, not just the mobile devices of the users. Crompton [2013] states that this direction of u-learning literally embodies the concepts of learner-centered education by making learning omnipresent to the learner.

Both m-learning and u-learning are still very much evolving and waiting for the development of actual tools that enable the utilization of these concepts in real educational context. Future trends are developing based on mobile devices and new sensing technology. In the book edited by Huang et al. [2013] four main categories of emerging trends are presented: (1) the application of cloud based technology, social networking sites and sensing technology to e-learning, (2) immersive environments, (3) augmented reality (AR), and (4) mobile AR environments.

2.2. The affordances of mobile learning

There are many reasons why mobile phones are considered to be an excellent addition to the way we learn. One of the main benefits of mobile learning is that it enables taking the students out of the classroom and fosters free movement and exploration of the environment, where new skills and knowledge can be immediately applied through informal learning activities [Sampson et al., 2013]. On the other hand, mobile devices can also be used to enhance classroom learning [Santos, 2013]. A personal mobile device can support individual learning styles and provide the right educational content in the right context in a seamless learning environment. These different possibilities that mobile devices can offer are called affordances.

Klopfer et al. [2002] list five main educational affordances that should be taken into account to take full advantage of mobile devices. These are: (1) portability – mobile devices can be easily taken to different locations, and the user can move around to perform in situ learning tasks; (2) social interactivity – enables users to exchange data and collaborate with other people face to face or over a network connection; (3) context sensitivity – mobile devices can gather data and provide content based on the learning context, including real and simulated data; (4) connectivity – ability to connect to other devices and services; (5) individuality – possibility to offer unique scaffolding based on the learners behavior and goals. These are topics that occur frequently in the area of research [Santos, 2013; Sampson et al., 2013].

Mobile learning can have the ability to engage students to experiment in situ, without place, time, and device restrictions [Sampson et al., 2013]. Students today are used to working interactively with digital information, performing multiple tasks simultaneously, and using mobile solutions to communicate with each other [Huizenga et al., 2009]. Because of this major change in the way we operate in everyday life, also the learning paradigms and methods should be updated to match the abilities and interests of the learners. Since games are now played more than in previous generations, Huizenga et al. [2009] propose that game-based learning could be a solution to address the way young people learn today, and engage them more successfully by promoting intrinsic motivation through six factors: challenge, curiosity, control, fantasy, cooperation and recognition.

Mobile devices have the ability to provide a seamless learning environment, where learning activities can be carried out across different contexts regardless of the device or the location of the users [Song, 2014]. Students can continue learning activities through anytime and anywhere access to learning materials and constant interaction and communication possibilities with other students, teachers and even other communities [Sampson et al., 2013]. Push notifications can even be used to motivate and remind students to study, which has proven to result in more effective learning [Houser and Thornton, 2005].

Research has shown that using mobile technologies can really engage the learners and create positive learning results [Ako-Nai and Tan, 2013; Huizenga et al., 2009; Huang et al., 2010]. It seems that especially students from lower and medium ability levels benefit from m-learning the most [Huizenga et al., 2009; Shih et al., 2011; Huang et al., 2014]. While traditional learning is usually restricted to print-based textbooks and other scattered resources, multimedia devices bring access to a wider variety of learning resources that students can access anytime [Huizenga et al., 2009]. The variety of learning resources and the availability of applications like text-to-speech, speech recognition and e-reader offer a range of new possibilities for students with learning

disabilities and e.g. young students that have not yet learned how to read [Fayed et al., 2013].

Despite all of the affordances and positive effects on learning results, there are also some negative effects of m-learning that have been reported. Chu [2014] points out that compared to traditional instruction or web-based learning, these new learning scenarios can be more complex if not properly designed, and can even have a negative effect on learning achievements, due to the heavy cognitive load that is caused by having to simultaneously deal with learning materials in both the real world and the digital world.

Mobile devices and network connections can also bring a set of technical difficulties, which can have a negative effect to student motivation [Huizenga et al., 2009]. Huang et al. [2010] list the five main drawbacks presented by previous research: (1) problems integrating the software; (2) performance issues with the mobile devices web browser; (3) text input is difficult on mobile devices; (4) too small screen size; and (5) the limited battery life. It must be taken into account that since in situ learning activities can take much more time than regular classroom teaching [Huizenga et al., 2009], especially the battery life of mobile devices is a big concern. This problem was also brought up by the teachers testing the Seek’N’Share platform presented in Chapter 4 [Yrjänäinen, 2013].

While waiting for advances in technology, these aspects should be taken into account when designing new mobile learning applications. As discussed in Section 4.1, in the Seek’N’Share platform the issues with network connections and limited battery life have been addressed by making it possible to use the mobile application in the field without a network connection available. This is done by downloading all the needed material right after selecting an assignment, which can be done at school, before moving to the field for the actual learning experience.

Even though with the reported positive learning results connected to mobile learning, according to Song [2014], after the novelty of m-learning has worn of, the enthusiasm and level of engagement might also reduce. For this not to happen, proper pedagogies must be adopted to foster meaningful learning [Song, 2014]. Suggested pedagogies will be discussed in detail in Section 2.3.

2.3. Key challenges associated with implementing m-learning

When an institution or a single teacher wants to implement m-learning, there are many things to consider beforehand. One major thing is which technology and devices to choose, and how to make sure that they are available for all the students. Bring Your Own Device (BYOD) is a program that is relying on students using their own mobile devices for educational purposes in and outside the classroom. Because mobile usage is so wide spread, this would seem like a very good solution for taking advantage of the m-learning possibilities and reduce the costs by using technology that is already

available, instead of the institution providing new devices for the students [Santos, 2013].

If the school decides to provide mobile devices for all the students, there are of course also positive sides to it. For example when everyone is using the same type of device, this could alleviate some of the issues related to m-learning, like the amount of needed IT support and equity issues. The city of Espoo is planning to do exactly that by buying tablet devices for all the students from elementary to high school level [Torvinen, 2015]. It is still unclear if the devices are left to the students after they leave the school, or do the students return them to the school. On the other hand, because technology in the area of mobile devices is developing so fast, it might be useless to recycle the devices. This would mean that the schools have to buy new devices for the new students every year. For the city of Espoo, this is estimated to cost 3.3–6 million euros yearly [Torvinen, 2015].

Regardless the chosen approach, there are some considerations and challenges that must be addressed before bringing mobile devices into the schools. The five main concerns discussed by Santos [2013] are: (1) network infrastructure, (2) network security, (3) IT support, (4) equity, and (5) possible disruption of mobile devices in the classroom. These concerns are discussed in the next subsections based on the paper by Santos [2013].

2.3.1. Network infrastructure

Mobile learning usually requires a wireless internet connection. When a lot of mobile devices are added to the same network at the same time, it can create a lot of strain on the network and can cause slow connections. This is something that the institution must consider beforehand, since it might be required to upgrade the current wireless network, and this could mean increase in financial costs [Santos, 2013]. It is very important that a poor network does not interfere with the other possible positive effects of mobile learning. Previous research states that connection issues can cause a lot of difficulties in e-learning, and therefore have a negative effect on learning results and attitudes [Santos, 2013].

2.3.2. Network security

Connecting personal devices to the institution's network can cause security risks, like exposing sensitive information to outsiders. This could be caused by losing an unprotected mobile device that can have revealing information about the owner of the device or corporate data stored, or by connecting to an unprotected public network while connected to the institution's private network and allowing unprotected access to it.

Students and faculty should be educated about good security practices and network policies. To support safe usage of the network, content access management from the access points might be a solution to block inappropriate and possibly harmful content from young users [Panagos, 2013]. Another suggestion to making the network more secure is making the users register their devices. This way the institution can monitor traffic by using the device's Mac address.

2.3.3. IT support

If mobile devices are used in education, this creates also a demand for IT support as well. The problem with BYOD is that the range of different models and operating systems can be very wide, and supporting them is way more difficult than for a set of devices maintained by the IT staff. On the other hand, because students can use their own devices that they are already familiar with, it might be that they need less support than with devices provided by the school for learning purposes only.

There has also been a lot of discussion about whether or not institutions are obliged to offer support for every type of device or just concerning the network and other services provided by the institutions themselves. For example in an m-learning study by Santos [2013], there was no need for IT support while taking part in quizzes using the students' own mobile devices. The technical difficulties that were encountered were related to network access. This is something where the institution should create clear policies before starting any e-learning program.

2.3.4. Equity

The digital divide and equity is a major concern especially with BYOD programs. Even though the amount of mobile phones and tablet devices is increasing even at elementary level, requiring the students to have their own device can create inequality, since there are families that cannot afford a device, or the devices owned might be older and less powerful than others. Mobile devices can also be seen as a symbol of social status and having an older device can be seen as something shameful amongst the students. [Panagos, 2013]

Ihaka [2013] gives examples on schools that have made tablet computers mandatory for some of their students, and it is up to the parents to provide them. One of the schools had provided devices for six of its 320 year 9 students on a loan scheme, but not all institutions offer this possibility. Even though the prices for mobile devices is getting lower, it can still put a lot of financial pressure on families with a lower income and/or multiple children. Song [2014] presents a BYOD program study, where the school would lend iPads to the students that did not own a tablet device needed for the study.

Although this approach can be useful in a single study, in a greater context it might create even more equity issues and put the students in unequal position.

It is up to the institution to make sure that the lack of available technology does not affect learning results. This is something that must be taken into account when designing and developing the learning activities. Material and exercises must be accessible on multiple devices with different capabilities, and the students should not be expected the students to use their own data plan while outside the institution's wireless network.

2.3.5. Disruption

Using mobile devices in education is quite a big change since bringing mobile devices to the classroom or using them while in class has been even forbidden or at least frowned upon. While using mobile devices in classrooms has many opportunities to enhance learning, one of the concerns discussed by Santos [2013] is regarding the possible negative effects mobile devices can bring to classes. The possible disruptions mentioned are distraction, cheating, inappropriate use of the technology and the problems with ringing mobiles, texting and multitasking. Strategies to handle these disruptions are needed. Santos [2013] suggests implementing policies for mobile use and emphasizing classroom etiquette when it comes to mobile devices. A key challenge for the educators is how to efficiently integrate the new tools into teaching, so they are not used for disruptive behavior.

2.4. Integrating mobile learning with existing Learning Management Systems

Even though it is clear that mobile devices provide new opportunities for learning, the level of utilizing these devices in e-learning is still low [Bogdanović et al., 2014]. As mentioned in Section 2.1, e-learning and the use of Learning Management Systems (LMS) has already been widely adopted. An LMS generally provides functionalities for instructors to create learning materials that the students can access using the system, and also facilitate interaction between students and teachers [Ako-Nai and Tan, 2013]. What these e-learning systems are lacking, is the content adaptation possibilities based on the learner's level, preferences, learning style or location [Ako-Nai and Tan, 2013].

For m-learning to be effective and to gain the best results, it should be integrated to an existing e-learning platform that enables centralized administration of all learning related services, regardless of the end device or platform [Bogdanović et al., 2014; Fayed et al., 2013]. Studies have shown that mobile devices can be successfully used for educational tasks, and it has been suggested that they can even replace the need to buy expensive textbooks for every student [Houser and Thornton, 2005; Fayed et al., 2013].

It has been shown that multiple choice questions are effective for self-assessment and can be used as a method to investigate students' prior knowledge or misconceptions on a subject [Bogdanović et al., 2014]. Pop quizzes have been used in traditional in classroom learning for ages to support this function. Bogdanović et al. [2014] consider quizzes to be an appropriate learning activity for mobile devices as well, because the presentation of a quiz can be easily controlled, and the students are already accustomed to these type of exercises.

In previous research it has been noted that learning material for mobile devices cannot be presented the same way as the content for traditional books or e-learning systems used on computers mainly because of the small screen size [Houser and Thornton, 2005; Shih et al., 2011; Bogdanović et al., 2014]. Breaking content into smaller pieces that are easily readable on small-screen devices has turned out to be also pedagogically beneficial, but not supported by the existing systems [Houser and Thornton, 2005]. When adapting content for a small screen, it might be required to eliminate nonessential parts and large images and tables from the material altogether [Houser and Thornton, 2005]. For the LMS to provide a seamless learning experience across devices, there would need to be a way for the teacher to define what to show on desktop computers, and what to show on mobile devices. The LMS could also automatically adapt the content based on the technical context it is being used in. During their research Houser and Thornton [2005] discovered that most educational web services can be modified to work on small-screen devices, and that mobile phones are a promising platform for many educational tasks.

In the example by Houser and Thornton [2005], a new course-management system (CMS) called Poodle was developed as a step towards adopting the use of mobile phones in education. The motivation behind this project was the fact that students in Japan have a better access to mobile phones than PCs, and that they are much more comfortable using their mobile devices for learning related activities. The other major point was that the students were already using their mobiles while commuting and waiting before classes, but also spontaneously during class to perform various educational tasks, even though the use of mobile phones was prohibited.

The Poodle system is a lightweight version of the popular LMS Moodle, providing quizzes, a polling system, a wiki server and a flash-card server to enable m-learning. Even though the system is used separately from Moodle, it has the potential to be integrated in the future, since it already uses the same quiz format. The polling system, wiki and flash card server are not part of the Moodle platform, but could be used as plugins that provide extra functionality.

The Poodle polling system is designed to be used in-class, where the teacher can ask questions during a lecture and have the students use their mobile devices or a PC to answer, like the classroom response systems presented already in the 1980s as discussed

in Section 2.1. The results are saved to the Poodle system and the teacher can show the results immediately in the form of a bar graph.

The Poodle wiki works like any other wiki service supporting collaboration between students, with the difference that the content is designed to work well on mobile devices as well. A wiki consists of pages created by the users themselves and anyone can edit content created by others. The Poodle wiki also had a separate forum for users to post explicitly-signed articles and discuss them in a more structured way. The students liked using the wiki without time and place constraints, like in the train or before going to sleep and while lying in bed.

According to Houser and Thornton [2005], many Japanese students use collectable flash cards inserted to a metal ring to learn the vocabulary of a foreign language. The idea of the flash card server is to support this type of learning and make it more efficient. The Poodle flash card server can contain a lot more words than a physical ring with cards, and it provides a more sophisticated algorithm to determine what cards to show in order to support more efficient learning.

Bogdanović et al. [2014] extended the Moodle platform with a mobile quiz application to study how students respond to m-learning in real context. Question types already supported by Moodle were used in the quizzes: multiple choice, true-false, short answer, and matching. The presented application works as a plug-and-play component that recognizes the used device and adapts the content accordingly by using different CSS themes. Using web-based technologies seems to be a suitable way for providing educational content, because it removes a lot of the cross-platform development issues and adapting content just by using CSS is fairly simple.

Overall students had a positive opinion on m-learning, and they considered this way of taking tests interesting and motivating, with the possibility to improve their learning process significantly. What was a bit concerning about the results is the fact that the type of mobile phone had a significant influence on the achieved results, with students using smartphones with larger screens performing the best. This indicates that if the students are using their own devices for m-learning, on top of the concerns discussed in Section 2.3, this could also bring inequality to the learning result, which is something that needs to be studied further. Understandably students who frequently use the internet with a mobile phone also performed better than students that were not that familiar with using mobile devices, because they are more accustomed to the interface of mobile applications. When comparing overall results to students who took the same quiz using a desktop computer, no significant difference was recorded other than the time it took to answer the questions, which was much longer when using a mobile device to answer the questions.

This study also shows some of the disadvantages that mobile phones have. The reported problems were about battery life, the cost and speed of mobile internet, slow

input, and visibility and time consumption with some of the question types. As a result from these findings the questions should be able to fit nicely even on a small screen, and the required answers should be kept short, because of the input difficulties. This applies to all types of mobile learning content.

As stated by Bogdanović et al. [2014] assessment has proved to be a suitable way to introduce mobile technologies in learning. Even though quizzes are already widely used in all existing e-learning environments and they can be easily implemented to be used with mobile devices as well [Bogdanović et al., 2014], they do not really offer anything new to the field of education, especially in the day of responsive web-design where all the web-pages should adapt to be viewed on any device. These solutions do not yet support the mentioned affordances that mobile devices have to offer, like providing individual learning content and taking advantage of the contextual information mobile devices can provide. It would be important to study how we could integrate more of these affordances to existing learning management systems to support a variety of different kind of assignments and the context and location based information that can be utilized by mobile devices.

2.5. Supportive pedagogies for mobile learning

In the history of information technology in schools, many innovations have come and gone because of the lack of theoretical foundation and understanding, and the poor communication of the linked theories of learning by the designers and developers of these innovations [Falloon, 2013]. Even though m-learning is a relatively new field, there has been quite a lot of research on the subject. The mobile learning applications research have evolved from using mobile devices as very simple information resources to more sophisticated learning applications that support the learning process in a more complex way.

As a result of the rapid increase of mobile devices and the mobile application revolution, a lot of learning applications have been developed without any pedagogical research behind them. This is probably one of the reasons why m-learning is sometimes considered to be just hype, like other technical innovations that have come and gone in the past [Falloon 2013]. Falloon gathered some of these available applications to research if and how they affected the students' learning. The research showed that freely available applications usually have advertisements and links to other web-pages, which are actually considered to be an impediment to learning. Applications that provided pedagogical scaffolds (systematic and organized steps for learning), corrective and formative feedback, effective communication of learning purpose and instruction, and a more traditional teaching model with a mentor figure teaching particular knowledge or skills, seemed to provide indication of real learning compared to more game like or drill based applications.

According to Falloon [2013], using text-to-speech functionality to provide instructions and guidance for younger students was considered especially effective, whether it was automatically activated or given as an option. This approach has also been used in the Seek’N’Share platform presented in Chapter 4, where the text-to-speech converted descriptions of the learning objects are automatically played back to the user when they get close to the location of the object with the options to pause and replay the description whenever needed.

In research, Chen et al. [2003] have also used the scaffolding technique as a base for developing a mobile learning system for bird-watching (BWL). The basic element for scaffolding is a learning goal that can be divided into hierarchical component skills with decreasing support levels. Learning is done by repetitive authentic practice and ongoing assessment on how the student is progressing and their ability to proceed to the next level of the hierarchical component skills. The goal of this strategy is to eliminate the need for additional support as the learner increases their learning ability. The BWL platform consists of two different interfaces, one for the teacher (m-instructor), and another for the students (m-learner). During a bird watching learning activity, the teacher can broadcast video and images about a certain bird to all the students’ devices through the m-instructor interface. The students then use the m-learner interface to identify the bird by following a step-by-step search operation. During this task different levels of support are provided based on the abilities of the learner. According to Chen et al. [2003] this approach was considered to be appropriate for the outdoor activity of bird watching, where it can be hard to give guidance that meets the needs for each of the learners. Experimental results also showed that using the BWL system improved the learning results of the students.

To implement a successful m-learning strategy that takes advantage of the affordances of mobile devices, appropriate pedagogies and supportive authoring tools must be further developed. Huizenga et al. [2009] summarize that what ICT needs to promote meaningful learning is tools supporting constructive, contextual, reflective and social learning. Since mobile learning is in many cases intended to be independently used by the students in outdoor learning activities, it is very important to apply appropriate pedagogy for this learning context that differs greatly from the more traditional approach to in-class learning. As stated by Song et al. [2011] the main issue in applying these new mobile technologies is not technical, but social because of the different learning context, and the lack of appropriate pedagogies for it. While system development is important, the most essential components for implementing successful mobile enhanced learning are appropriate instructional design and learning evaluation [Shih et al., 2011]. In the next subsections the concept of context-aware learning and some of the suggested learning models to support m-learning are further discussed.

2.5.1. Context-Aware Learning

As mentioned before, context sensitivity is a key feature in both mobile and ubiquitous learning. The concept of context has many dimensions and definitions, but the basic idea behind context-aware learning is to adapt and personalize learning based on the learner's context. By continuous monitoring, context-aware learning can support individual learning styles by providing personal assistance and enable seamless learning by adapting to different devices and learning scenarios [Shih et al., 2011]. According to Sampson et al. [2013], one common but vague definition of context – often used in computer sciences – is: “any information that can be used to characterize the situation of an entity”.

Crompton [2013] defines context-aware m-learning so that it encompasses: (a) learning that can occur despite of location, using a mobile device as part of a formal lesson inside or outside the classroom; (b) learning that can be either directed by others, or be self-directed, where the user determines their own approach to achieve learning goal; or (c) spontaneous learning that happens when a mobile device is used to look up information about something interesting on the spot. According to Crompton [2013], environment can be a planned part of the learning experience (location-based learning), or it can have a neutral role (learning taking place whenever, e.g. reading learning material on the bus home from school).

The key issues defined by Sampson et al. [2013] on designing context-aware adaptive and personalized learning systems are the detection of the learners' contextual information, and based on the context, the type of adaptations that can be performed to provide the most suitable learning activities. At the moment context information is described and represented in various different ways. To be able to develop commonly used context-aware learning environments, a unified context model must be developed [Sampson et al., 2013].

Sampson et al. [2013] divide context information further into learning context and mobile context. The learning context includes the used learning design and the learner profile. The learning design refers to chosen pedagogies, learning objectives, activities and roles, also including the selected tools and learning resources to be used. The learner profile contains information about the user's level of competence, role, and personal characteristics like preferred learning style, needs, interests and disabilities. This information is used in context-aware learning to provide personalized content matching the learners' profile, but still complying with the frames set by the learning design. Song et al. [2011] extend the learning context further with bodily information about the learner, e.g. pulse rate, blood pressure, temperature and voice. In order to present the user content that is relevant to their learning context, the learning system needs to be able to automatically capture information about the user and learn by it [Hodgins, 2002].

The mobile context by Sampson et al. [2013] includes temporal information about the learner's current mood, preferences, needs and interest, and other people possibly influencing the activity. In addition to the technical properties of the mobile device, the mobile context also holds geospatial and other location-based information like present zones, cultural background, and the whole learning setting. Current time constrictions and physical conditions of the learning environment, like noise, illumination and weather conditions, are also included in the mobile context defined by Sampson et al. [2013].

Sampson et al. [2013] suggest that based on previous research context adaptation can be divided into two categories: educational resources and learning activities. There are three types of adaptation related to educational resources identified by Sampson et al. [2013]. These are: (1) selection of resources based on the learner's contextual information, including the learner's profile and mobile context; (2) presenting appropriate material based on the mobile context (type of device, environmental information) and learner's profile, by deciding what format to use (e.g. audio or video over textual presentation); and (3) adapting the navigation and sequencing of content especially based on the learner's previous knowledge, location, needs, preferences and availability to create personalized learning paths. Learning activities related adaptation includes: (1) general adaptation, which means the automatic generation of individual learning activities based on the previously mentioned contextual elements; (2) personalized scaffolding and feedback; (3) suggesting suitable navigation to locations in real-world situations; and (4) adaptation to support communication and interaction during the learning activity, by e.g. detecting peers based on their location and providing suitable tools for communication.

Huang et al. [2010] present a context aware m-learning tool called the Mobile Plant Learning System (MPLS). They discuss the concept of context in outdoor learning by dividing it into three main categories: social context, knowledge context, and technical context. In outdoor learning the social context means that students have the opportunity to interact with their peers as well as the environment. Because outdoor learning requires students to move around, it is important to provide opportunities for communication while in the field. According to Huang et al. [2010] being connected to a social network, cooperating and exchanging information in a social context reinforces academic fundamentals. PDAs were chosen for the study, because they provide connectivity that can enhance the social context by connecting students to each other.

Huang et al. [2010] look at the knowledge context from the viewpoint of social construction of knowledge, where each student contributes to the discussion and knowledge construction collaboratively. By helping each other and sharing knowledge and resources, students can develop higher-quality comprehension while gaining important social interaction skills. When sharing content, the students need to think

about what information is important and worth sharing, which is part of the information-processing activity that helps clarifying and comparing relationships between new and previously gained information. By sharing knowledge, instant feedback can also be given by the other students or the teacher, to clarify or rectify misunderstandings. To support the knowledge context, a knowledge-sharing function was developed for the MPLS.

The technical context by Huang et al. [2010] refers to all the different technical factors that can influence the learning activity. Using appropriate technologies is important to help eliminating technical barriers, like differences in skills using technologies and applications. Technology should support teachers in designing learning activities and the students in knowledge gathering and sharing, by making it as quick and easy as possible. The MPLS by Huang et al. [2010] provides different ways to record their thoughts, so every user can find the most appropriate way for them. The system can also work as a stand-alone application if no network connection is not available. This is an important feature, because an application that does not work because of e.g. the lack of internet access can diminish the learning experience. The same approach was also used in the Seek'N'Share mobile application presented in Section 4.1. The small size and light weight of PDA makes it a good solution for outdoor activities, but the small screen size also has its drawbacks, because content must be carefully planned to fit on the screen.

These three areas of context presented by Huang et al. [2010] have a complementary connection to learning. The social and knowledge context support each other in a way that if a good social context is provided, it makes sharing knowledge and engaging in information processing easier. The right technical context on the other hand can enhance the knowledge context by providing the right tools for the students and teachers.

In the study by Huang et al. [2010] the MPLS was used on an elementary-level science course about plants. The experimental group used the application to gather, search and share information about plants they were observing during a course organized in the Southern Taiwan University campus. The MPLS provides GPS-enabled navigation based on the data about surrounding plants. This data can be predefined by the teacher, or to be collected and shared by the students themselves. While exploring and studying the nearby plants, students can take photographs and add text to describe the plant and their learning experiences. The coordinates of the plant are automatically saved, so it can be associated with the right location and added to the map. This presents a good way to enable in situ content creation that also the teachers can use to design location-based learning activities. In situ content creation will be discussed more in Section 3.2.

As stated in the research by Huang et al. [2010], text entry as input was considered to be difficult with the PDA, and it reduced the students' motivation to record their learning experiences. Using audio or video would be more suitable in this technical context, where there is no full keyboard available. To support the context-aware seamless learning experience better, it should be possible to edit the notes later using a PC, and while working in the field, other input methods should be utilized, like recording audio, video and taking images, as in the Seek'N'Share mobile application presented in Section 4.1. During the experiment, other technical difficulties were also experienced, which was considered to reduce motivation. Without the technical issues, most of the students would be interested using the MPLS in the future.

Even though the MPLS does not have built in cooperation support, it was stated that using the PDAs worked as an "ice-breaker" and triggered interaction between the students, although the teacher included in the experiment considered the outdoor learning activity by itself improving teamwork amongst the students. Overall compared to the control group that did not use the PDAs in a similar learning activity, the students in the experimental group seemed to be more engaged and motivated during the learning activities. There was also a significant difference between the two groups learning performance, with the use of the MPLS providing better post-test scores.

The study by Huang et al. [2010] again shows that the use of mobile devices can improve student engagement and naturally stimulate cooperation and discussion between learners. Even though the theoretical foundations of this study are in providing seamless context-aware learning, the proposed application does not really support anything other than location detection of the user and the surrounding plants. What would make this system more context-aware, would be the addition of cooperation between students based on their locations and learning objectives, providing different input methods based on the learning context, and by adapting the plant navigation based on also the user's learning profile, e.g. guiding the user to plants that they have not visited yet. Context-aware mobile learning applications with location detection will be discussed more in Chapter 3.

2.5.2. Inquiry Based Learning

Song [2014] proposes a seamless inquiry-based learning model to support the use of mobile devices in creating a seamless learning environment. She characterises inquiry based learning as "*a process of posing questions, gathering and analysing data, and constructing evidence-based explanations and arguments by collaboratively engaging in investigations to advance knowledge and develop higher-order thinking skills*". In this learning model the teachers have a supportive role in these tasks, like in the problem-based learning pedagogy discussed in Section 2.1.3.

The study by Song [2014] was conducted as a one year BYOD program with 28 primary school students in Hong Kong. The assignment for the students was to gain knowledge in the subject of the anatomy of fish by using their mobile devices to collect information for themselves by taking pictures and video and recording audio. The knowledge inquiry was conducted both collaboratively and individually. Three mobile applications were used to support the inquiry-based learning: (1) Edmodo – a social network platform for the students to communicate, share information, and coordinate learning activities; (2) Evernote – application suite for note taking and archiving; and (3) Skitch – a mobile app to help annotating images. The Seek’N’Share platform presented in Chapter 4 also supports this inquiry based learning method by supporting the students to collect information using multimedia inputs, with the added feature of instruction for the data gathering in outdoor learning scenarios.

The seamless inquiry-based learning model consists of six activities: engage, explore, observe, explain, reflect, and share [Song, 2014]. In this study by Song [2014] the first activity consisted of the teacher first introducing some online information about fish in class, and then the students continued to search information on their own and resumed this task at home, where they used Edmodo to share their results on a preferred device. As the second activity the student went to a wet market to look at actual fish and to capture multimedia content to gain general understanding of fish. Activities three and four were in-class activities, where the teacher provided real fish for the students to observe by finding and labelling the body parts of the fish. Again the student used their personal mobile devices to capture and record the knowledge gained in the activity. As activities five and six, all the students posted the results of the previous assignment to Evernote, and added their own reflections on the subject of the anatomy of fish for sharing.

The results of the study by Song [2014] shows that a guided inquiry-based pedagogical design and implementation in a seamless learning environment was successful in helping students advance their knowledge and improve their inquiry-based skills. It was reported that because students could use their own devices, they had more of a sense of ownership and control over their learning, than compared with studies where the students were using loan devices. It was considered that it was the combination of using mobile technologies and the teacher guided inquiry-based learning model that made the study a success. Since improving inquiry skills is something that is very important throughout life, this approach seems to support lifelong learning very well, which was also one of the main goals for the first attempts to implement mobile learning in the 1990s, as discussed in Section 2.1.3 [Crompton, 2013].

2.5.3. Cooperative Learning

Cooperative learning has become a broadly applied pedagogy in many educational contexts. Cooperative learning methods include group discussions, peer support and guidance. It also emphasizes personal responsibility and interdependence among group members. These attributes are considered to increase interactivity, help in gaining academic knowledge, helping problem solving, and increase motivation and positive attitudes towards learning. [Huang et al., 2014]

Huang et al. [2014] introduces a jigsaw-based cooperative learning application as a solution to increase interaction among peers during an e-learning activity, and to achieve optimal learning effects by enhancing learning achievements and motivation. This method should also help students develop important social skills like respect for others, and communicate their knowledge. In the jigsaw-based approach to cooperative learning, the students have different learning responsibilities and learning objectives are achieved through this division of labor. The students work as teachers in the group by sharing their gained knowledge through social interaction.

Huang et al. [2014] mention two crucial elements of successful cooperative learning suggested by previous research: (1) active learning through social interactions and discussion must be promoted, and (2) teachers must carefully design and arrange the course to support cooperative learning, and they need to be able to provide additional knowledge and guidance to the students during cooperative learning activities. The jigsaw-based method gets everyone involved in the learning activity, and because of the shared responsibility, no-one can rely on someone else doing the work for them. This can sometimes be a problem with group work, where the more active students take the main role, and the less active students get away with doing less. The jigsaw-based method also supports the development of critical thinking, problem solving abilities and clear expression of independent thoughts and ideas through team work.

Cooperative learning relies in the communication between the group members themselves and with the teacher giving guidance, therefore it is necessary to have tools for real-time support independent of time and place. In the study by Huang et al. [2014] Google+ social networking platform was used to support real-time communication in outdoor situations where students are scattered around and face-to-face communication could not always be achieved. This way students can learn and construct their knowledge in real context, while teachers can observe the activity and address any problems that might arise.

In the experiment conducted by Huang et al. [2014], tablet devices were used to help a group of Taiwanese university level students to collect and share information about various water regions in Taiwan during a cooperative learning activity in the National Museum of Marine Biology and Aquarium in southern Taiwan. A control group participating in conventional individual learning was used to validate the results

of the experiment. Students in both groups were divided into low-, medium-, and high-achievers based on previous academic performance.

Before the learning activity the teacher explained the concept of jigsaw-based cooperative learning and the groups spent ten minutes practicing it. During the cooperative learning activity the students were divided into groups of three, with one student from the different levels of achievement. Each of the group members had a different question they needed to find an answer to. Students with the same question used the Google+ platform to form expert groups for discussing possible answers. Instant messaging and videoconferencing provided by the Google+ platform could be used to engage in real-time discussions while exploring different areas of interest. Especially the videoconferencing feature supports face-to-face type of interaction very well and as a bonus it does not require typing, which could slow down the learning activity.

After the knowledge gathering, the original groups gathered together for the individual students to share their results. As a final task, the groups were given one more question for the groups to answer together. The control group was also using the Google+ platform to gather information, but they did not engage in any group activities or knowledge sharing.

The results from the experiment by Huang et al. [2014] show a significant difference between the results from the experimental and the control group, leading to the conclusion that a jigsaw-based cooperative learning strategy is better than individual independent learning. It was considered that the positive peer pressure was making students work harder in order to help their partners. The low-level students had the best results, probably because the added support provided by other group members. The high-level students on the other hand did not gain much of an advantage compared to the results from the control group. This might be because they generally had the leadership role in the groups, and they used a lot of time helping others. Not being able to work at their own pace could lead to the students feeling frustrated, because they could have been advancing more quickly by themselves. It was reported that the high-level students preferred individual learning compared to working in groups, although some of them felt bored because they could not share their ideas with others like the students in the cooperative learning group. This shows the importance of incorporating a way to communicate and share ideas and comments using the m-learning application.

It should be noted that besides improving learning results, cooperative learning enhances other abilities that are highly appreciated, like social interaction and leadership skills, which individual learning does not offer. Overall, the results show that students enjoyed using the jigsaw-based cooperation method and the learning environment was able to enhance learning outcomes.

2.5.4. Formative Assessment Strategy

The formative assessment strategy has previously been successfully used in web-based learning, and it has also been studied in the m-learning context [Chu, 2014; Hwang and Chang, 2011]. Formative assessment includes providing feedback, guidance and support during the learning activity, so that learning can be adjusted to achieve set learning goals [Hwang and Chang, 2011]. This has been recognized to be beneficial to student learning, whether the feedback comes from the teacher in a traditional learning environment, or using a web-based learning environment [Chu, 2014; Hwang and Chang, 2011]. The strategy of repeated answering combined with immediate feedback and making the student find out the right answer on their own has proven to have a positive impact on students' learning achievements, because it supports the "practicing, reflecting and revising" process [Hwang and Chang, 2011].

Hwang and Chang [2011] developed a mobile learning system that uses the Formative Assessment-based Mobile Learning (FAML) guiding mechanism. The system is web-based and it includes several management functions for teachers. These include user profile management, subject materials management, item bank management, and learning portfolio management, but unfortunately these were not discussed more in the research paper. The students connect to the system via a wireless network, and receive support and guidance to a PDA while exploring in a real-world learning environment. The system provides hints and learning materials while asking questions about a subject. A test item is randomly selected from a pool of items for a unit, and the user has to answer three questions in a row correctly before moving to the next learning unit. If the student answers incorrectly, the counter for the right answers is reset, and the student is guided to find the right answer on their own. All the students needed to pass six units created for a local culture course. The study was conducted in Chin-An temple in southern Taiwan with two classes of fifth grade students. One of the classes worked as the experimental group, and the other as the control group for comparing the learning results, interest, attitude, and cognitive load of the different learning methods.

As mentioned in Section 2.2, there has been some indication that in-field learning can have negative effects, if the cognitive load is too heavy. The experimental results by Hwang and Chang [2011] show that formative assessment can be used to promote learning achievements and attitudes with appropriate cognitive load when combining real-world and digital-world resources. It was reported that the FAML approach improved the students' interest and attitudes towards learning the local culture course content, which is important to achieve meaningful learning. The students in the control group were also using a tour-based m-learning system to answer the same questions that the experimental group. The difference was that if they answered a question incorrectly, they were told that the answer was wrong while showing the correct answer. It was

noted that the control group spent most of their time reading learning materials from their devices, instead of actually exploring the environment and trying to find the answers themselves. Hwang and Chang [2011] explain that the poorer learning attitude and motivation could be partially due to the students being discouraged by the feedback concerning false answers. The study shows the importance of having an appropriate learning strategy to gain the best results from m-learning. It also suggests that many existing e-learning tools and strategies could be also used for m-learning in a real-world environment.

Chu [2014] conducted a similar experiment with the main focus being on the cognitive load caused by students needing to observe and interact with real-world learning targets while paying attention to the instructions and supplementary material from a mobile device. Because the human working memory can only handle two or three novel interaction elements at a time, poor content design and instructional strategies in mobile learning can overload the working memory and increase the cognitive load of students [Chu, 2014]. Chu [2014] divides the concept of cognitive load into three different types: (1) intrinsic cognitive load, which is concerned with the structure and complexity of the instructional materials; (2) extraneous cognitive load, which refers to the instructional design effecting how difficult the task is; and (3) germane cognitive load, which facilitates the learning process by separating the relevant from the irrelevant cognitive processing and thus reduces the extraneous cognitive load of the learner. These types can be further summed up as mental effort, which is a combination of extraneous load and germane load, and mental load as intrinsic load.

The experiment setting in the study by Chu [2014] was almost the same as in the previous example by Hwang and Chang [2011], with the exception that the control group did not use mobile devices, but participated in a traditional learning activity with human guidance. A notable difference was found in the results of the measured learning achievements between the two groups, indicating that the formative-assessment learning strategy for mobile learning actually had a negative effect on learning. There was no remarkable difference on the mental effort (extraneous load and germane load) between the two groups, but when looking at the results concerning the mental load (intrinsic load), it was discovered that it was significantly higher with the experimental group. It was then noticed that the students in the experimental group had too many questions to answer, considering the amount of time it takes to look up relevant information in a mobile context combining real-world and digital resources. This makes the students answer in a hurry, which causes more wrong answers and could be the reason for the high cognitive load. Since the system gives instant feedback which requires the student to make more observations, this can cause anxiety especially if they can see their peers already moving on to the next assignment. Because of the stress to complete all the assignments, students did not take the time to make deep reflections and thorough

observations of the task at hand, which could be the explanation for the bad learning achievements and the contrary results compared to the study by Hwang and Chang [2011].

The study by Chu [2014] highlights the importance of adjusting the amount of learning content in m-learning scenarios to decrease the cognitive load for the students. Either more time is needed to complete the assignment, or there needs to be less content to go through. If all the students proceed in the same order, this could cause negative competition that makes the students hurry too much, which reflects in their learning results. The experiment also shows that m-learning is not always successful and it could lead to disappointing results even when well-known strategies are used. Chu [2014] ends with a note that if a proper learning design that takes into account the more complex learning environment is applied, mobile learning still has the potential to be more effective than the traditional approach.

2.6. Learning Objects

To support the new pedagogies and technologies connected to technology enhanced learning, a new conceptual model for content creation and distribution has been developed, with Learning Objects (LOs) as a fundamental element to it [Hodgins, 2002]. There is no single format for a LO, or clear definition on what it can and should contain. Barak and Ziv [2013] describe learning objects as *“independent instructional experience that contains an objective, a learning activity and an assessment”*. Other definitions presented in the paper by Barak and Ziv [2013] include seeing learning objects as reusable digital resources that support learning by enhancing, amplifying, and guiding the cognitive processes of learners. They also identify the three key functional requirements that are connected to the concept of learning objects: accessibility, reusability and inter-operability. Firstly a LO needs to contain appropriate metadata about the content, so it can be referenced, stored and accessed using a general database. Secondly, the LO should be reusable in different instructional contexts. And thirdly, the LO should not be connected to a certain delivery media or learning/knowledge management system, which could restrict the reuse of the object.

Hodgins [2002] talks about how information technology and learning objects can be used to capture knowledge that can be analyzed, reused, shared and used to create new knowledge. He also discusses the possibilities of using LO's to offer the right type of information at the right time for every type of user, which is the idea behind context aware learning and in the 5R adaptation framework presented in Section 3.2. In order to be able to fully take advantage of learning objects, widely adopted and open standards must be created for metadata, learning objects and learning architecture [Hodgins, 2002]. This work has been going on for quite some time, and there is an IEEE Learning Objects Metadata (LOM) Standard already developed [Barak and Ziv, 2013], but using

this standard has not been present in the examples found during the research for this thesis.

Sotsenko et al. [2013] discuss the use of LOs in mobile learning settings by adding the contextual information to them as metadata. This way providing the learner with the right content at the right time can be achieved. Contextualized LOs can also address the problems with mobile devices, such as small screen size and the lack of proper keyboard [Sotsenko et al., 2013]. The idea is to get contextual information from the learner, using the sensing mechanisms in the mobile device and contextual information provided by the learning platform, and provide the best-fit content that matches the learner's personal context (e.g. interests, language, learning courses, available time to study), environmental context (location, noise level, etc.), and the device's properties and network connection.

Hodgins [2002] takes the metadata concept further, by suggesting that metadata should be in the future added to describe every piece of data, event and person in the world. He divides the metadata into two categories: objective metadata that can be automatically generated, and subjective metadata. Subjective metadata is considered by Hodgins [2002] to be more valuable information, determined by the creator of metadata, and it can contain tacit knowledge, other contextual information, different perspectives and opinions on the object of metadata. This metadata added to the LO's enables the selection of meaningful data by filtering and searching based on the user's contextual information.

According to Hodgins [2002], information on how the learning objects should be used and sequenced is also very important, but this information should be kept separate from the metadata. He also reminds that for learning objects to be widely adopted, there must be tools that make the process of conceptualizing, designing, constructing and selection quick and easy, but the prospective users must also see the high value of good reusable LO's. In the Seek'N'Share location-based learning application presented in Chapters 4 and 5 the learning assignments and the content for the assignments work as reusable LO's that teachers can utilize when creating new learning activities.

3. Location-based mobile learning applications and content creation

Outdoor learning has been studied and conducted in the form of field trips long before the emergence of m-learning. This type of learning has usually been referred to as informal learning, because there has not been much instruction or alignment with the curriculum included in the learning activities conducted in the field. Mobile learning has the opportunity to extend the formal in-classroom learning into other environments, like museums or zoos, and provide instruction and support in a seamless learning environment. [Santos et al., 2014]

Like in any electronic learning environment, the device only provides means for novel ways of learning, but to create meaningful learning experiences, suitable learning material must be created by the educators themselves, with the appropriate domain knowledge incorporated. Even though there has been quite a lot of interest in the area of development and research for location-based learning applications in various fields of education, there has been only little focus on the content creation for these applications. As stated in previous research, a big problem for implementing m-learning in practice is the lack of available learning management systems and tools for designing content for location-based mobile learning [Houser and Thornton, 2005; Ako-Nai and Tan, 2013; Pérez-Sanagustín et al., 2012; Shih et al., 2011].

While other mobile authoring tools have reached the commercial market (e.g. GoMo Learning: <http://www.gomolearning.com>), there are only few that incorporate the location awareness aspect [Giemza and Hoppe, 2013]. The problem with a lot of the research done in the area is that the applications have been created to support mobile learning in only one subject, and in one specific location. Usually there is no reference on how the learning material for these applications has been created, which probably means that the content has been hard coded or added to a database/content repository by the developers of the application, not the educators themselves.

One of the key affordances of mobile devices is the ability to provide context aware learning material and support in out-of-school situations. These type of new learning experiences require new ways to organize the learning, and they are not suitable for all levels of students. For example supervision can be problematic when it comes to smaller pupils that cannot leave the school environment alone, and without the parents' permission. One possibility could be to use location-based learning assignments only as homework, during planned field trips, or possibly implement the use of mobile devices in other type of contexts inside the classroom. One example of how mobile technology could be used to help the teachers to monitor the outdoor learning activities is to provide support for the teacher to follow the movement of the students and their progress during the learning activity like in the example by Santos et al. [2014]. It should also be noted when designing m-learning experiences that e.g. in the study by

Huizenga et al. [2009] the outdoor learning activity took the whole day, while going through the same content in a regular project-based lesson series took only two class hours.

As mentioned by Shih et al. [2010], managing a class when taking students outdoors is often not easy, but when the students are focused on their mobile devices, the teacher can have more time to spend on monitoring the class and assisting individual students that might need help during the learning activity. After conducting an outdoor learning experiment using a mobile game-based learning application, Huizenga et al. [2009] reported a teacher mentioning that during a day of playing the m-learning game, he could see pupils that usually had difficulties engaging in learning activities stay focused for six whole hours, and that they were too busy to act up during the m-learning experience. The teacher also mentioned that m-learning helped some of the more quiet people to take charge of the learning activity, and that students were able to work with their peers in a more diverse way, not just with their best friends in the class.

In traditional classroom learning the teacher is usually always present for the students to ask questions and get clarification on things that were perhaps misunderstood. In the informal learning activities, where the students are scattered around or working on their free time, this type of face-to-face guidance is not possible. According to Song et al. [2011] one of the most requested functions for location-based learning applications is to provide some sort of service for answering questions from the students during the learning activity. Asynchronous communication can be easily provided using readily available solutions like e-mail, SMS, and any other instant messaging applications, or a default communication channel can be added to the learning platform, as in the example by Ako-Nai and Tan [2013] discussed further in Section 3.2. Handling questions from many learners at the same time can be slow or even impossible in this type of communication. As a solution to this problem Song et al. [2011] suggest using a context-aware dialogue-based feedback system that students can use to ask questions and receive answers immediately despite of time and place. Implementing such a system requires careful mapping of the domain knowledge and analysis of the questions presented by students.

Previous research on location-based learning applications has shown that using these applications can improve learning and create positive learning experiences, but geocaching of resources on its own is not enough to support learning in a meaningful way [Santos et al., 2014]. Generating educational content requires both domain knowledge and pedagogical knowledge, which according to Giemza and Hoppe [2013] is already a complex task. Adding the dimension of location to this equation makes content creation even more challenging [Giemza and Hoppe, 2013].

Santos et al. [2014] divided mobile learning activities roughly into two categories: activities that take advantage of the everywhere/anytime possibilities of mobile devices,

and situated learning activities that rely on a specific location and possibly time. In this chapter the focus is on learning applications that provide support for situated learning activities. There is a discussion about the used technologies in the development of location-based applications, content creation for location-based learning applications and look at some example applications where an authoring system is included in the application design.

3.1. Technologies used in the development of location-based applications

In previous research, location-based m-learning is usually separated between indoors and outdoors learning activities, based on the architectural constraints and the technologies that are needed to support the learning activities [Santos et al., 2014]. There are many different opportunities that mobile devices offer to detect the user's location, and how location-based information can be provided in the context of learning activities and authoring location-based learning. Here we will shortly discuss the most commonly used technologies.

The main technology to detect the user's location in outdoor setting is GPS (global positioning system). Most mobile devices have built in GPS support, and now even the HTML5 version supports the geolocation API, which can be used to detect the user's position in web-applications [Pilgrim, 2013]. As mentioned by Pilgrim [2013], using the device's IP address, used wireless network connection, or information about which cell tower a mobile phone is connected to, are other options to get positioning information of the user.

Even though detecting the user's location has improved a lot over the years, GPS detection is still only suitable to be used outdoors. This excludes a lot of destinations, like indoor museums. Another problem with GPS detection is the accuracy. Performance can especially degrade in high-rise urban areas [Santos et al., 2014]. If there are a lot of LO's located in a small area, it might be hard to handle presenting them correctly, and the user might end up seeing more content than was intended.

Because GPS does not work in enclosed spaces, other technologies like RFID (radio frequency identifier), QR codes and Bluetooth have been utilized in indoor learning settings [Santos et al., 2014]. These solutions usually require that the teachers have access and control over the space where the learning activity is going to occur beforehand. Using the tag-based solutions like RFID or QR codes to present location-based information to the user, has the advantage that you can easily pinpoint the exact location of the learning object, especially in indoor situations.

What makes using QR codes more laborious to the content creator is the fact that the codes are physical objects (e.g. printed on paper) and the content creator must position the tags in a specific place, making sure that the right code is in the right place. This means that somebody has to take the QR codes to the destination beforehand,

which could be problematic if the destination is far away, or if access to it is limited. Another problem is the use of physical objects placed in public spaces, where the QR codes might be exposed to vandalism, or it might be hard to get permission to set up (e.g. in museums). On the other hand, QR codes are easy to print and cheap to produce, which makes reproduction not such a big problem [Giemza and Hoppe, 2013].

Web map services are a key part in authoring location-based learning activities, and in displaying the user their location or the location of learning objects on a map in outdoor settings. One of the most commonly used commercial web map services is the one provided by Google (<https://developers.google.com/maps/>). The Google Maps API enables the use of Google Maps on websites and mobile applications. Probably the biggest difference to other web map services, and a major advantage of using the Google web map service, is the street view option that enables more precise positioning of the learning objects. OpenStreetMap (OSM, <https://www.openstreetmap.org>) is another popular way to include geographical data to an application. OSM is based on collective gathering of open-source geographical data, and it can be freely used together with different frameworks and tile providers. The word tile is used for the small images that web maps consists of. Depending on the provider, tiles can have various styles that are suited for different purposes, e.g. a satellite map for a realistic view of the area or a transit map that highlights metro lines in a certain city. In the constructive part of this thesis, OSM was used together with the Leaflet library to provide web map services for content creation in the Seek'N'Share platform.

3.2. The 5R adaptation framework

Information retrieval, personalized knowledge management, and context-aware mobile services management are some of the challenges regarding the development of adaptive context-aware mobile learning systems [Tan et al., 2011]. To help with this task, Tan et al. [2011] present the 5R adaptation framework for developing location-based mobile learning systems. The framework uses available contextual information about the learner, location, time, and the device, to generate and adapt learning content to be consumed using a mobile device or a PC.

The framework by Tan et al. [2011] is based on an ontology model of personalized learning objectives, learning context information and the proposed 5R constraint information, where the learning content is pre-developed and stored in a learning contents repository. According to Tan et al. [2011], the goal of the 5R framework was to create a standard structure that can be used as a meta-architecture when designing mobile learning systems with the support for adaptation of learning contents.

Tan et al. [2011] present the adaptation concept of 5R as: at the **right** time, in the **right** location, through the **right** device, and providing the **right** contents to the **right** learner. The right time includes two factors, the date-time when the learning context is

available (e.g. depending on opening hours of a museum), and the context of the learner's learning process. The right location indicates the learner's geographic location, e.g. GPS coordinates for outdoor learning activities, and QR code information for indoor learning activities. This means that the mobile learning system must be able to track the user's location. The right device means adapting the content so it will work on the target device based on the operating system and available hardware and other features. The right contents include learning objects, learning activities, and learning instruction included in the learning contents repository, which needs to be properly described and tagged for it to be filtered based on the learner's context. The right learner aspect includes static and dynamic information about the learner, including learning objectives, progress, behaviors, and assessment results, which can be automatically gathered by the learning environment, or manually entered into the system. Using this information to adapt the learning content, optimized and personalized learning assistance can be provided, which usually is not possible in traditional classroom learning. For the content adaptation Tan et al. [2011] provide a mathematical model where the inputs are the available learning contents, location constraints, time constraints, learner constraints, and mobile device constraints, and the result is the learning resources matching this contextual information. Since presenting content that is out of context, or cannot be viewed on the user's device, can cause significant distraction and reduce motivation, proper adaptation is essential for the learner to be able to focus on the learning task effectively and pleasantly [Tan et al. 2011].

As discussed in Section 2.6, there is still the problem of how to describe and tag the location-based learning contents and their relationships in a unified and reusable way. Tan et al. [2011] use a components ontology to describe the five adaptation inputs (time, location, device, content, and learner) and to identify data structures and their relationships. In a full 5R system architecture, a content creation platform based on the 5R input ontology is used by the educators to develop location-based learning contents. An example architecture of a full 5R adaptation mobile learning system by Tan et al. [2011] is presented in Figure 1.

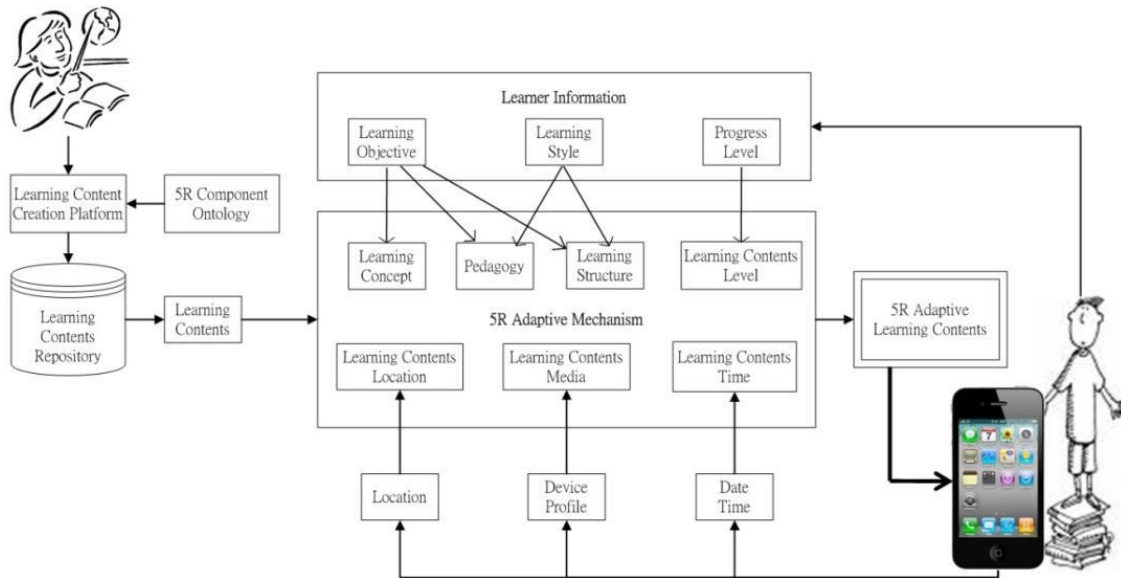


Figure 1. The 5R adaptation mobile learning system architecture by Tan et al. [2011]

Ako-Nai and Tan [2013] used the presented 5R framework as a base for creating a location-based learning management system for adaptive mobile learning (LMS). The LMS consists of eight main components: (1) location sensing engine, which is used to match the location-based content and group users for collaborative learning activities based on the learner's location; (2) content generation engine for creating the learning contents; (3) grouping engine that can be used to group learners by their location, learning style, preferences and interests; (4) learning engine, which handles presenting the learning contents, and keeping track of the completed assignment; (5) messaging engine, which provides student-to-student and student-to-instruction interaction; (6) administration module for managing administrative function; (7) instructor module for managing learning contents, LO's and activities; and (8) learner module, which is used to access learner's information, retrieving learning contents and collaborating with other learners.

The five main concepts of the 5R framework was used as a guideline for the content creation in the LMS, in order to be able to use the learner's context to adapt the learning contents to meet the requirements of the learner and the used mobile device. The content was created according to the 5R input schema presented in Figure 2. The main inputs of the framework – learner, location/learning environment, learning object/content, presentation types/devices, and time – create reusable building blocks that are used to create learning content for a course by the educators. A course consists of a name and a collection of location-based learning objects, which include the material and/or learning activities connected to them, the order of the learning materials are meant to be presented, and the type of device the learning material can be accessed.

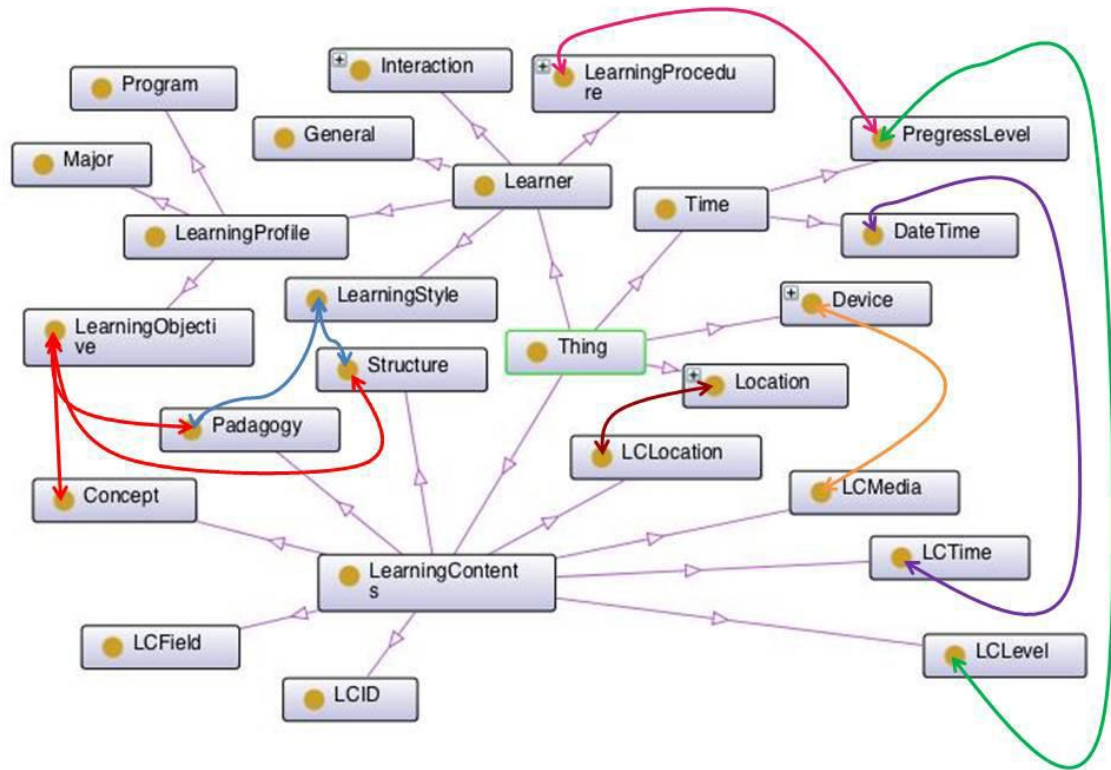


Figure 2. The 5R input schema [Ako-Nai and Tan, 2013]

Courses created using the LMS presented by Ako-Nai and Tan [2013] can have as many learning objects and different locations connected to it as needed. This means that a learning object with a certain learning goal can be connected to similar locations in e.g. different cities and therefore it can be easily reused. The location-based learning objects do not have to be connected to certain coordinates, instead an “open” object can be used, where the user needs to find e.g. the closest river, where the connected learning assignments can be conducted. For LO’s with a set location, a radius must be specified in order to define when the users will be able to access the content. Learning activities and materials can be added in multiple formats, including video, audio, flash or text, in order to support the adaptation functionality for different devices.

When a learner signs in to the learner module and selects a course, the gathered context information is sent to the learning engine, which then returns the adapted content based on the user’s location and other contextual information. During the learning activities, the grouping engine can be used for collaboration between peers. In the example assignment by Ako-Nai and Tan [2013], students are required to discuss their findings and create a presentation for the next unit of the course. This is the same method that is used in the Seek’N’Share platform discussed in Chapter 4, with the exception that the collaboration and creating a joint presentation is conducted as group work using a joint mobile device.

Even though the approach by Ako-Nai and Tan [2013] gives a more useful approach to the 5R framework, it does not at this point give a full presentation of how the content information is entered to the system in practice. More practical solutions for generating location-based learning content will be discussed in the next subsection of this chapter.

3.3. Content creation for location-based learning applications

Content creation for location-based learning applications can differ based on the learning context and the chosen technology and pedagogy for the application. The learning activities can be divided into two main categories based on whether the learning activity is intended for indoor or outdoor context. Depending on the type of chosen location, content creation can have different requirements.

Santos et al. [2014] did a study on what must be considered when designing learning activities for GPS supported mobile outdoor learning. Content creation for GPS based systems differs a lot from tag-based systems, because it enables content creation without the teacher actually going to the learning area beforehand. After studying previous work done in the area, Santos et al. [2014] found out that this was not actually true in all cases. Based on this finding, they decided to divide the design and content creation process into two different categories based on the outdoor setting: virtual and in situ design.

Virtual design of an outdoor learning activity can be conducted without the need to interact with the real physical area. Learning objects can be connected to a specific place using its latitude and longitude coordinates. To help the teachers with this process a web map service can be used to place the LO's in the right location. This approach was also used in the Seek'N'Share assignment editor presented in Chapter 5.

Design in situ is required when a digital map is not enough to define the characteristics of the area, or if the learning activity is to be conducted indoors. The teacher is required to interact with the environment in order to connect the right coordinates or tag to a LO in situ. This type of design must be applied when the environment is constantly changing, like in natural parks, gardens or exhibits (both outdoor and indoor). An example of this type of application is the Mobile Plant Learning System (MPLS) presented by Huang et al. [2010], which was already presented in Section 2.5.1. With the MPLS the student and teachers can add content to a shared database by connecting their current location with images and notes about the surrounding plants. Even though the Seek'N'Share platform presented in Chapter 4 already supports capturing content using the mobile application, this information cannot be further utilized in the assignments at the moment. To support in situ content authoring, content created using the mobile application should be automatically assigned with GPS coordinates and made available in the assignment editor tool.

In the next subsections of this chapter, some example mobile learning platforms with included support for creating location-based learning content will be presented. The QuesTinSitu and Treasure-HIT discussed in Sections 3.3.1 and 3.3.2 respectively, are applications for GPS-based outdoor learning activities; Wandering and Mobilogue, presented in Sections 3.3.3 and 3.3.4, support both outdoor and indoor learning; and etiquetAR and an RFID-based learning management system presented in Sections 3.3.5 and 3.3.6 are examples of tag-based solutions for location-aware mobile applications.

3.3.1. QuesTinSitu

In the experiment conducted by Santos et al. [2014], an m-learning system called QuesTinSitu was used for two different learning activities with different locational requirements for content authoring: (1) exploring the history and art of Girona, using virtual design to author content, and (2) assessment at the botanic garden of Barcelona, with in situ design. A participatory design approach was used to understand and define the type of information the teachers needed to design their learning activities. The system was also tested with students taking part in the outdoor learning activities based on the formative assessment learning strategy.

The QuesTinSitu mobile application provides different routes with geolocated questions to the students. After selecting a route, a map is shown with all the questions for that route, where a different marker is used to distinguish between answered and unanswered questions. When the students get close to a marker, the question related to that location is automatically displayed. The idea is that in order to answer the question, the students need to interact with the environment e.g. by observing, touching, or talking to other people. Answers to the questions are automatically scored by the m-learning system.

Google Maps was the chosen web map service to provide geographical information for authoring content virtually, displaying the user's location on the mobile device and to provide a monitoring interface for teachers. In the virtual design of learning assignments, the teachers can use a map to assign questions to a location by clicking on the desired destination. In the research case by Santos et al. [2014], the learning resources were associated with visible landmarks and sub-areas of the space.

A unique feature in QuesTinSitu is the monitoring feature, which enables the teachers to constantly monitor the location and progress of students during the learning activity. This way the teacher can e.g. contact a group that is moving out of the perimeter of the defined learning area or correct any misunderstanding that can be detected based on the students answers. The system itself does not offer support for communication or cooperation between teachers and students, but because of the other communication possibilities offered by mobile devices, this was not considered to be a problem. Students in the experiment used Twitter, Whatsapp and email for

communication. The teacher used email to communicate with the students, while Whatsapp was mainly used by the student to share personal comment about the learning activity, and Twitter was used to share the results with other students and teachers of the school, by using a certain hashtag to identify the content created during the learning activity. For a more complete m-learning system, incorporated communication and cooperation tools should be developed, like in the example framework by Ako-Nai and Tan [2013] presented in Section 3.2.

In the design phase for the first experiment (exploring the history and art of Girona) some key requirements were identified by analyzing design documentation provided by the teachers prior to the design activity, and during the actual participatory design activities were conducted to create the learning content. It was discovered that teachers need to be able to divide the learning activities into smaller subareas and define the learning resources based on them. This notion supports the idea to provide the teachers the possibility to define learning areas that can have an unlimited amount of areas inside them, as in the Seek’N’Share assignment editor presented in Chapter 5. The second requirement discovered by Santos et al. [2014] was the ability to edit the grading mechanisms connected to questions. Thirdly, the teachers considered the time factor very important when planning the activity, mainly on the day of the activity, and the start and finish time for the activity.

Because the QuesTinSitu system does not have an application for in situ content creation yet, this part of the research focused on evaluating which functionalities should be offered to support this type of design. The researchers chose an existing Android application called WayPoint to collect the data in the in situ design phase. For the actual design activity, the teachers and researchers needed to visit the botanic garden of Barcelona to see which plants were in a condition to ask questions about them, and then come up with the appropriate questions to support the learning activity. This experiment showed that the teachers should be able to make a sketch about the planned route in situ, but then have the opportunity to finish the design using a web authoring tool with a map of the added data. It was also discovered that teachers liked to divide the tasks of content creation between the group of teachers taking part in the designing activity, and that collaborative editing of the questions should be supported by the m-learning system. This was considered to be one of the key requirements also in the Seek’N’Share assignment editor presented in Chapter 4.

Because the accuracy of GPS positioning is not so good, Santos et al. [2014] suggest that there should be around 30 meters distance between the different geolocated points, but there should be the possibility to add multiple learning tasks to a single point. The appearance of multiple learning objects in the same area could make their location unclear and decrease the feeling of contextual learning [Santos et al. 2014].

The Seek'N'Share platform discussed in Chapters 4 and 5 supports adding multiple tasks to a learning object, but also enables adding tasks with different learning contexts.

Santos et al. [2014] mentioned in their study that students interactions with the learning system should be well recorded, and statistics reports provided to the teachers about the assessment progress after the in situ learning activity. For the learning activity from the students' point of view, it was discovered that they liked to work in groups cooperatively, and that hints and descriptions before the actual question about a certain topic helped to promote the exploration of their surroundings. It was also an interesting discovery that the students preferred to use a paper map to get a grasp of the whole area because of the size of the map, and use the mobile device to check their own location and to see where the learning tasks were situated. This combination of a paper map and mobile device seems to be beneficial for the learning activity, and was recommended by Santos et al. [2014].

3.3.2. Treasure-HIT

Another example of a system using virtual content creation is a mobile treasure hunt game called Treasure-HIT presented by Kohen-Vacs et al. [2012]. The system includes a web based authoring environment for the teachers, and a mobile application used by the students. Like in QuesTinSitu, the Google Maps web map service was used to author the learning activities. Teachers can search the map by address or location, and place markers that represent stations on the map by clicking on it. It is also possible to control the radius of required distance (Tolerance) for the station to be activated, like in the LMS presented by Ako-Nai and Tan [2013] in Section 3.2. Because of the limitations of GPS, the minimum distance is set to be 20 meters. It is also possible to use Google Street View to position the stations more accurately as seen in Figure 3.



Figure 3. Google Street View can be used to refine a stations position in the Treasure-HIT mobile learning game. [Kohen-Vacs et al., 2012]

Each station in Treasure-HIT must be assigned with at least one clue that helps to guide the players to the station. The clues can be textual, images, or links to other web-content. Using Google Street View also offers the content creator the possibility to use screen captures of the map as instruction or clues on the location of the learning object. Different tasks can be connected to the stations for the player to perform in order to advance in the game. These tasks could be quizzes or requirements for collecting information.

The author of the learning assignment can define a route that the players have to follow, or one can be created automatically by the system with certain preconditions, like calculating the route based on the shortest path. Based on the authors' definition, the route can also be different for each player. The teacher can as well define a starting point for the game, or let the system auto assign one for each player. If the players have different routes, the teacher should define a generic feedback for the students when they have reached the end goal. If the final station is same for all the players, the feedback can be related to that station.

The Treasure-HIT system provides an API that supports possible connectivity to other learning platforms and the use of learning objects from external environments. The goal of the Treasure-HIT project is to have teachers creating learning materials that can be used to improve the design of the system further, and which can be used by other teachers as examples. It was also mentioned in the paper by Kohen-Vacs et al. [2012] that in the future the system will also support communication possibilities between students and teachers, and control facilities for the teacher to follow the players' activity during the learning activity, as in the QuesTinSitu example presented in 3.3.1.

The Treasure-HIT mobile application is designed for cross platform mobile operating systems, and it can be downloaded to various GPS enabled mobile devices. A

unique identifier is connected with each game created by the authoring system. After installing the application, the user can start a specific game by entering an identifier provided by the teacher. This same approach was used in the Seek’N’Share platform discussed in Chapter 4, but instead of using a hard to remember identifier, the students can choose the appropriate activity from a list of available assignments.

When starting a new game, first some initial instructions and guidance to the starting point are given to the player. The game advances by the application giving more clues after the user has reached a station and performed the task connected to it. The user’s location is not automatically detected, but the user can use the mobile application to check their location at any time. If they are close enough to a determined station, a confirmation on the location is given and the connected tasks are introduced. The game can be played as a competition between individuals or as teams. Even though research has shown that a game like approach to mobile learning and positive competition can be effective, it should be considered that if the students rush from one station to another in order to win the game, it might have a negative effect on the learning results as were seen in the research by Chu [2014].

The Treasure-HIT authoring environment is available at <http://treasure-hit.telem-hit.net/en-US>, and the mobile application can be downloaded e.g. to Android devices from the Google Play app store.

3.3.3. Wandering

Wandering by Barak and Ziv [2013] is another web-based platform that facilitates authentic and interactive in situ mobile learning in both indoor and outdoor activities, and includes support for virtually designing these learning activities. According to the authors [Barak and Ziv, 2013], Wandering also supports the development of important 21st century skills like engagement with others, personalization, control release, and the ability to adapt to changes, as well as accessibility, reusability and inter-operability, which are principles adapted from object-oriented programming, and the main functional requirements for learning objects.

The learning experiences provided by Wandering are based on location-based interactive learning objects (LILOs) which are called stations in the application. According to Barak and Ziv [2013], besides presenting interesting content in the form of LILOs, the most important part of Wandering is the support for constructivist learning, where the students create the LILOs themselves by first engaging in searching for information, creating a LILO based on the discovered information, sharing the LILO with their peers, and organizing the created LILOs in a meaningful way.

Anyone can start using the application by signing in with an existing Windows Live ID, Yahoo account, OpenID, Foursquare account, or a separate account can be created just for Wandering [Wandering, 2015]. A guest account is also available for viewing the

stations. According to the paper by Barak and Ziv [2013] Google account and Facebook account can also be used, but these options have since been removed. The application is available at <http://thewandering.net/>.

The Wandering platform offers two main functionalities: creating stations and exploring the created stations. To find LILOs that are relevant to the user, the application provides means to filter the content. LILOs can be searched by name of the location (e.g. street name, city, museum), by keyword, type, or possible costs related to the station (e.g. museums with entry fees), and by showing stations near the user's current location. The LILOs are divided into two types: Knowledge LILOs that contain systematic information and Experience LILOs that should inspire emotions.

According to Barak and Ziv [2013], because anyone can add new stations to the platform, content reliability was a big concern when developing Wandering. To verify the reliability of a LILO, a grading mechanism is used among the users. Stations can also be given a certificate by an expert user, and this can also be used as a parameter to filter the stations. In order to improve the reliability of the content, stations cannot be created anonymously and anyone can see who created the stations. This makes the creator responsible about the accuracy of the provided information. Inappropriate content and misuse of the platform can also be reported to administrators using an online form.

The user can choose if they want to explore individual LILOs or find a route to follow. LILOs can be viewed as a list or as markers on a map. When an interesting station is selected, the user has four different options to interact with the LILO: Go, Do, Info, and Share. By selecting Go, the user is presented directions to get to the station (map and verbal directions); Do contains the learning activity connected to that station; Info provides more information about the subject and who created the station; and Share enables sharing the LILO via different social media platforms, adding comments and grading the quality of the LILO from 1 (horrible) to 3 (excellent).

The process of creating a station includes five different steps: Info, Arrival, Action, Tagging, and Characterizing. These steps are divided into separate tabs in the application (named as Part 1 – Go, Part 2 – Go, Part 3 – Do, Part 4 – Tagging, and Part 5 – Info) as seen in Figure 4. The first step is to add some preliminary information about the station, like a name, a textual description and the geographical information about the LILO. The user can search for locations to place the LILO in the right position on a map provided by the Google Maps API. To help with creating a good description, the following instructions are given: “Think of a place. What do you find interesting about it?”

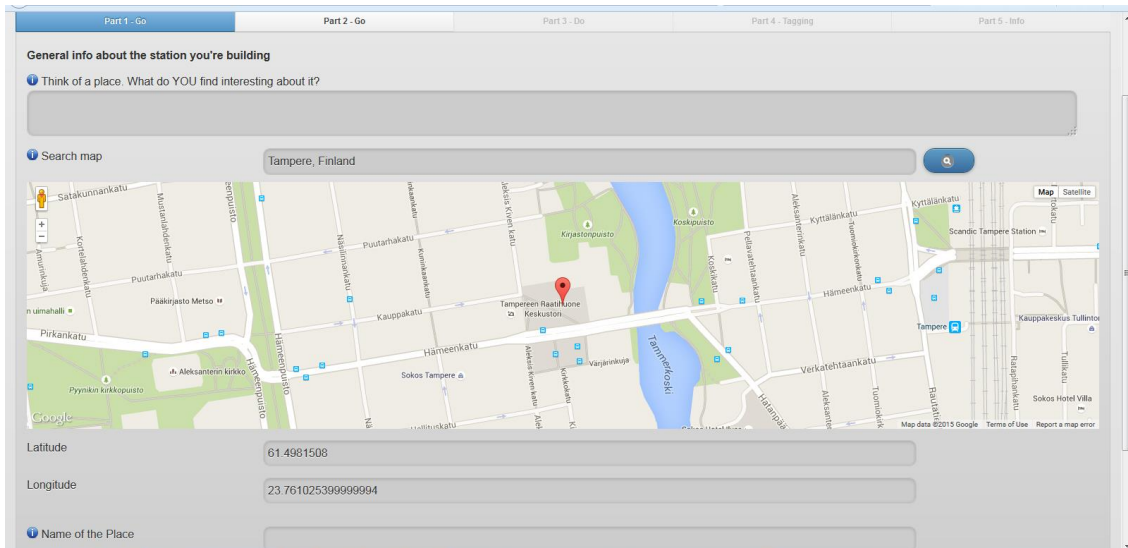


Figure 4. The first step of creating a station in the Wandering platform [Wandering, 2015].

The next step (Arrival) contains information about how to get to the station. This could be a question the user has to find the answer to, an activity they have to perform, or the geographical location of the station (e.g. address). The user can also choose to add an image, audio file or a video to be shown to help locating the station. It is possible to use a file previously uploaded to the service, upload a new file, or use a predefined URL to display content from a different service. Only one type of arrival info and one type of file can be selected (if the user has chosen arrival with a picture/sound/video). To be able to support the concept of context-awareness, it should be possible to add different ways to enter arrival information and to be able to add multiple content files to the information.

The action part is considered to be the main content in the LILO [Barak and Ziv, 2013]. Here the user needs to describe the action related to the station. This could be something that the user can perform by themselves, or it could involve other people as well. The creator can also define a question that needs to be answered using text, or by uploading an image, video or an audio file. The question can be in the form of a test, which requires the author to write possible right answers, and feedback if the question is answered correctly. Surprisingly this step does not give any options to include additional content other than a textual description and a question connected to the station. For example smaller children could benefit from being able to receive the instructions using audio or video.

In order for the users to find relevant LILOs, the station creator has to add keywords describing the content of the station (knowledge, place, time, etc.). Tagging is the fourth step of the creation process (see Figure 5). Besides adding the normal keywords, the user needs to add additional information about the station, including an emoticon, verbs, availability of the LILO (e.g. opening hours for a museum), and adjectives in the form of icons that best describe the LILO. Even though offering rich ways to tag the content

is very important, the user should not be forced to add all the different types of tags available.

Figure 5. Tagging information required for describing a LILO [Barak and Ziv, 2013]

The last part is to characterize the station, and define a type for the LILO (Knowledge or Experience), and add information about the costs and other info that needs to be prepared before visiting the station. The user also needs to add a description why they wanted to create this station, and an additional image for the LILO. After all the information is finally filled in, the submit button appears and the station can be submitted to the system. When a LILO is saved, it is assigned with information about the creator of the station, and a URL address that is used to retrieve the information about the station. As a general instruction for content creating, the users are encouraged to keep the information short and concise.

The user is guided through the station creating process by making them fill out all the information on a page before being allowed to move to the next step. This helps making sure the user has filled in all the necessary information, but also limits the user's possibilities to work at their own pace, especially since the LILO can only be saved after going through all the steps. The other problem is that if the content creator does not work fast enough, they might lose all their work, which actually happened during testing of the application, because of session timeout and the lack of saving option during the creation of a new LILO. This can make the user fill out the content in a hurry, which can diminish the quality of LILOs. The wizard-type approach could be used when the user uses the authoring tool for the first time, but to make authoring stations more fluent in the future, the user should not be forced to proceed in a set order and to add all the information in one sitting. This approach is quite the opposite that has been used in the assignment editor for the Seek'N'Share platform further discussed in Chapter 5, where the user gets to work on a whole assignment on just one page, and the only required

information is the coordinates of the learning object that are automatically saved when the element is added to the map.

Because the user has to fill out all the inputs on a page before moving forward, it is poor usability to add additional inputs after the user has filled in one field, if there is no selection involved that could require the user to add additional information. This happens e.g. in the first page when the user has filled in a name for the station, and an additional field for a description is displayed. After filling in the description, a set of options are displayed where the user needs to select the appropriate option that describes the station the best. This type of adding new inputs on the fly is used throughout the content creation process, which made it a bit annoying.

To help with the content creation, a set of tips and concrete examples are given to the user about what type of information they should enter. The hints are displayed when hovering over or clicking at the info icons connected to the inputs as seen in figure 4. This is good, because concrete examples help the user to better understand what kind of information is expected, rather than using just a label. This diminishes the need for additional instructions or reading a manual before being able to create good LILOs. Although at the time of writing this thesis, not all of the hints were translated to English.

Besides discovering and creating stations, the Wandering platform enables the user to edit their profile information, previously created stations, and the media files uploaded to the service. LILOs can be organized in meaningful ways into different activities like routes or games (e.g. matching game, bingo, crossword puzzle, monopoly, or Tic-Tac-Toe). Using game-based learning has the potential to address the way young people learn today and to engage them more successfully as was suggested by Huizenga et al. [2009] in Section 2.2. Barak and Ziv [2013] highly recommend organizing LILOs into different learning activities in order to create more structured learning experiences.

When creating a new activity, the user can choose to use existing LILOs created by anyone, or add new LILOs to their own collection during the creation process. The Wandering platform also provides an opportunity to organize LILOs under a specific code, which can be used to create content that is only visible to specific groups or subjects [Barak and Ziv, 2013]. To support indoor learning, each LILO can be connected to a QR code as well. Each of these activities requires different kind of operations, and going through them here is out of the scope of this thesis. It is good to offer plenty of different ways to organize the learning objects, but because creating just one LILO is so laborious, this option might be overlooked. It also seems that besides the game-like approach, there is no pedagogical strategy behind these different options.

The Wandering platform was evaluated by conducting an experimental study with 102 grade nine students by Barak and Ziv [2013]. The goal of the study was to examine the learning outcomes and experiences of the students while using the platform to create

new LILOs and exploring content created by others. Barak and Ziv [2013] were also interested on what kind of new skills might be needed for teaching and learning when using the Wandering platform.

The students started the activity by exploring previously created exemplary LILOs that were placed around the schoolyard. After conducting an activity provided by a LILO, the students were introduced to the Wandering platform by the teacher, and asked to create a LILO while the teacher guided them through the process. Then the students were given an assignment to create at least two LILOs individually or in pairs without supervision from their teacher. As a part of the assignment, the students were asked to encourage peers to visit the LILOs they had created, and to comment and rate LILOs created by others. Later the LILOs were graded based on the relevancy of the content and the comments added by peers.

The result of the study confirmed that students like working in groups and that cooperation is important in this type of learning. Working in groups also resulted in better results when looking at the grades given to LILOs. It was also observed that students or groups who created more than one LILO had also higher scores connected to them. Even though the task was to create at least two LILOs, it was reported that 4% of the students created only one, but the paper by Barak and Ziv [2013] does not elaborate reasons behind this. It would be important to know why others did not manage to produce even the required amount of LILOs.

Barak and Ziv [2013] report that the students were motivated to create the LILOs, but their use of the tagging and comment tools were not very efficient. This indicates that they did not understand the importance of tagging the LILOs correctly in order to be able to filter the relevant content later on, and the application of using the comments to improve the content of the LILOs in a cooperative way. Overall Barak and Ziv [2013] consider the Wandering platform to be successful in enhancing the students' learning experiences and skills required in the 21st century.

When visiting the Wandering site, it is clear that it is designed for mobile devices with small screen size. Unfortunately using one layout for every device does not work very well especially with larger displays. Buttons that stretch across the whole page just look awkward and make perceiving the page more difficult. Since especially creating the stations is most likely to be done using a PC, it would be important to adapt the layout at least for that. Since Wandering is a web application, creating different layouts for various screen sizes can be simply done by plain CSS.

Even though the Wandering site is up and running and anybody can use it, based on the brief testing done by the author of this thesis, it does not seem stable enough to be used in production. There were many technical bugs when creating and editing a station, and e.g. the need to fill out every bit of information in the Tagging step of content creation (even if the label indicates that it is optional) might have been a technical bug.

Even though the content creator is only supposed to see the files uploaded by themselves, during the testing of the application there were also other files visible that were not uploaded by the author. This indicates big problems with information security and access control, which are crucial in the context of learning.

Because of all the technical difficulties encountered, the Wandering platform cannot be recommended, but by fixing the mentioned issues it has potential to be used as a base for providing location-based learning activities. This example shows the complexity of creating content for location-based learning applications, and the importance of making the content creation process as smooth as possible. If content authoring is too difficult, the application will not be used beyond the research phase. Compared to the other application the Wandering platform lacks the need to actually perform the learning activities in situ, because all the stations are available at any point, and no location detection is used to present the information, except in the case when QR codes are used to facilitate learning.

3.3.4. Mobilogue

Mobilogue (“MOBile LOcation GUIDance”), presented by Giemza and Hoppe [2013], is another example of a domain independent content authoring and content deployment platform that combines the use of GPS and QR codes to create tour like learning activities. They have identified that a lot of these types of applications are already available for museums etc., but they are usually too general to be effectively used for educational purposes. The Mobilogue platform uses QR codes to form a tour of the learning environment, and to provide in situ learning content and additional stimuli in the form of quizzes, which according to Giemza and Hoppe [2013] brings the gaming aspect to Mobilogue. A quiz should be about a subject that requires the user to engage and interact with the environment in order to answer correctly. The quizzes connected to the QR codes are simple questions with four answering options, from which only one is correct.

Each QR code contains a unique identifier that connects the location to the content created with the authoring tool. The Mobilogue platform also includes a repository where this content is stored. Each code can also be connected with GPS coordinates, so the users can be guided to the learning content using the mobile application. Using GPS is optional, which means that Mobilogue can be used in both indoor and outdoor settings. Besides the quiz functionality and GPS coordinates, the location can have an additional image connected to it. This image could be used to help guide the students indoors, if the location can be recognized through the picture.

The Mobilogue authoring environment differs from the other reviewed authoring systems by not being a web based tool. The authoring application has been built as a plug-in for a graph-based modelling environment called FreeStyler. The application can

be downloaded from <http://mobilogue.collide.info/>, and it is available for Windows, MacOS, and Linux operating systems, the only requirement for the application is Java 7 [Mobilogue, 2013].

According to Giemza and Hoppe [2013], the idea behind the Mobilogue authoring tool is to have both students and teachers creating the learning content, as with the Wandering platform discussed in Section 3.3.3. The application uses the direct manipulation paradigm for creating and organizing the learning objects, and it should be easy enough to be used by everyone, without regards to their technological background. This approach was also used in the design for the Seek'N'Share assignment editor presented in Chapter 5.

The planning of a route starts by adding a new location node with a title and a description. Added location nodes can be dragged around in the main view seen in Figure 6. To create a route, the location nodes must be connected to each other by first clicking on the arrow button of a selected location, and then clicking on the next location in the main view. The created route can have multiple incoming and outgoing edges.

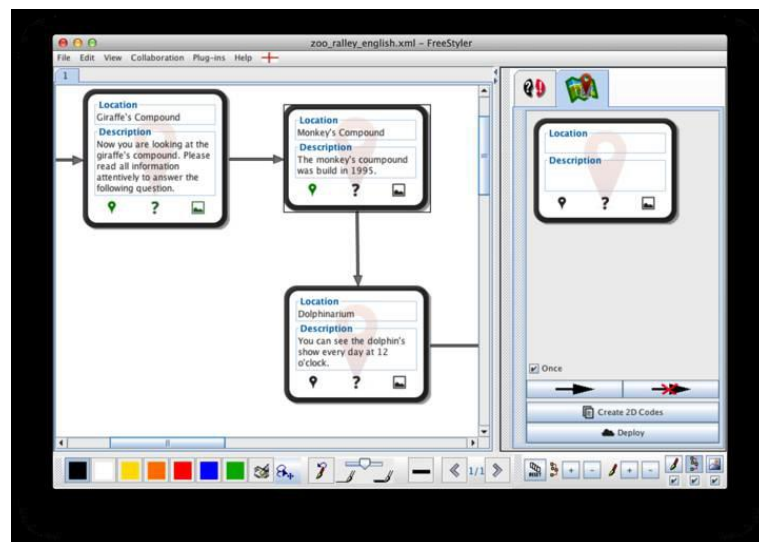


Figure 6. The Mobilogue content authoring systems main view [Giemza and Hoppe, 2013]

To add GPS coordinates to a location, the user can click the marker-button in the lower left corner inside the location node to open the GPS Positioning Editor, as seen in Figure 7. The editor enables the user to search locations, or use their own location if it is available (used as default position) [Mobilogue, 2013]. The map shows only the location of the selected node at a time. It would be useful if the user could see the other added nodes as well, so they could easily see which one they are modifying, and what the relation to the other nodes is.



Figure 7. The Mobilogue GPS Position Editor [Giemza and Hoppe, 2013]

A quiz can be added to a location by clicking on the button with the question mark icon. This opens up the Quiz Editor seen in Figure 8. Here you can add a new question with four possible answers, and an explanation that is shown to the user after answering the question. Only one quiz can be added to a location. A better solution would be to enable adding multiple resources to a single location, as suggested in the study by Santos et al. [2014].

Question and Answers	
Question	How many cervicals does a giraffe have?
Correct Answer	7
Wrong Answer	10
Wrong Answer	12
Wrong Answer	14
Explanation	As a giraffe is a mammal, it has only seven cervicals, despite of having such a long neck.

Figure 8. The quiz editor for Mobilogue [Giemza and Hoppe, 2013]

After a route has been successfully created, the final steps are saving the route to a repository, printing the QR codes, and placing the codes in the matching locations. The Mobilogue repository stores all the information connected to a route, and provides lookup facilities through a RESTful Webservice interface using the JSON protocol, as does the Seek'N'Share platform presented in Chapter 4. According to Giemza and Hoppe [2013] this open architecture enables creating new implementations of Mobilogue and adding support for other devices.

When printing the QR codes using the authoring tool, the user can define the size of the printed code, and add an optional subtitle to it [Mobilogue, 2013]. If GPS coordinates have been used, special attention must be paid when placing the QR codes to make sure there are no conflicts.

The Mobilogue Android application can be freely downloaded from the Google Play store. Before the user or group can start using the mobile application, they have to create an account to the Mobilogue service, so actions of different users can be distinguished even if the same mobile device is used by multiple users (e.g. when the school provides shared devices for students that do not own a mobile device). A logged in user can see a list of the already performed activities on the start page of the application. The start page also includes the next activity or a list of possible activities the user needs to perform, and a QR code button to activate the code scanner provided by the Mobilogue application. The paper by Giemza and Hoppe [2013] does not give any clarification on how the user can select the route or is it provided automatically based on the user's location.

When the user locates a QR code and uses the mobile applications' code scanner to read the tag, the description, image and the quiz (if not already answered) connected to that tag are shown. If the learning activity is outdoors, and the location nodes have GPS coordinates connected to them, a map with the user's current location can be shown with a list of available locations. The locations with GPS coordinates are marked with a separate map icon in the list of available targets. The application does not enforce the order of the locations, and the user can scan the codes in any sequence.

Answers to the quizzes are stored on the mobile device, not to the Mobilogue repository. To enable the teachers to evaluate the learning activity, the system should support downloading usage reports and answers on the learning activities as suggested by Santos et al. [2014] in Section 3.3.1. The users can control the saved information by deleting the whole activity log whenever, and possibly go through the same learning activity again.

Giemza and Hoppe [2013] conducted a feasibility study on the authoring tool to see if it fulfilled the goal of simplicity, and if real learning scenarios could be created using the platform. The study was conducted with 20 10th grade students creating content based on an introductory given by the teacher, with the idea to stimulate interest towards the topic and foster learning by teaching. No major technical difficulties were observed during content creation, but creating rich content by the students was considered challenging. For example many of the locations did not have any description or instruction connected to them at all. Even though constructive learning is considered to be beneficial and even required of effective m-learning solutions [Huizenga et al., 2009], creating content from scratch might not be the best approach. In this context, the wizard type approach and using real examples as hints of the required data as in the

Wandering platform discussed in Section 3.3.3, could have improved the quality of the learning content.

It was reported that when the students got to try the content created by themselves, this seemed to increase enthusiasm and encourage the students to improve the content. This proves the importance of being able to test the created content before applying it in a real in situ learning activity, as in the results from the pilot group testing the Seek'N'Share platform further discussed in Section 5.3. The response to the Mobilogue authoring tool itself was very positive, and that using it was easy because there was no need to care about the technical details related to creating location-based content for a mobile application.

A usability study on the Mobilogue mobile application in a museum context was also conducted by Giemza and Hoppe [2013]. Results were overall very positive, although some technical problems were reported. One of the problems was issues reading the QR codes in dimly lit locations. This is something that needs to be taken into account when designing the learning activity and when placing the codes in the learning environment. Because the workflow using the mobile device is very structured, this left the students feeling like they did not really have control over the learning activity, even though the users could freely choose to deviate from the planned route. Because the learning activity was conducted indoors, there was no evaluation of using GPS for location detection. Based on the experiment, 88% of the students would recommend using the Mobilogue learning application in a museum context.

What could make Mobilogue a more successful m-learning platform, is to add more content options like video, images, audio, links etc. When GPS is used to guide the students, the need to scan the QR codes should be removed and instead take advantage of the location awareness of mobile devices and display the content automatically when the user is near a target. At the moment the format for quizzes is very simple and strict. As stated by Santos et al. [2014], it would also be important that the grading mechanism could be edited by the teachers. To get better learning results, a suitable learning pedagogy like formative assessment should be applied to the learning platform.

3.3.5. etiquetAR

Tag-based solutions are used to attach digital information to physical objects in order to extend and transform real spaces into digitally augmented spaces [Pérez-Sanagustín et al., 2012]. As stated by Pérez-Sanagustín et al. [2012], there are many tools for creating content for these tag-based solutions, but they have not been designed with the learning context in mind, which can make creating novel learning experiences difficult for teachers and students. Pérez-Sanagustín et al. [2012] present a tool called etiquetAR for this purpose. It is a web based authoring tool that enables creating content for QR codes (available at <http://etiquetar.com.es/>). The codes created with the etiquetAR can be read

with any QR reader, unlike the Near Field Communication (NFC) tags that were used in a previous version of the application.

The etiquetAR authoring tool can be used by both students and teachers to create, update, delete and add resources, and print their QR codes. The codes are added to collections, which represents a learning activity. A screen capture from the current version of the etiquetAR, including a collection with two added QR codes, is presented in Figure 9.

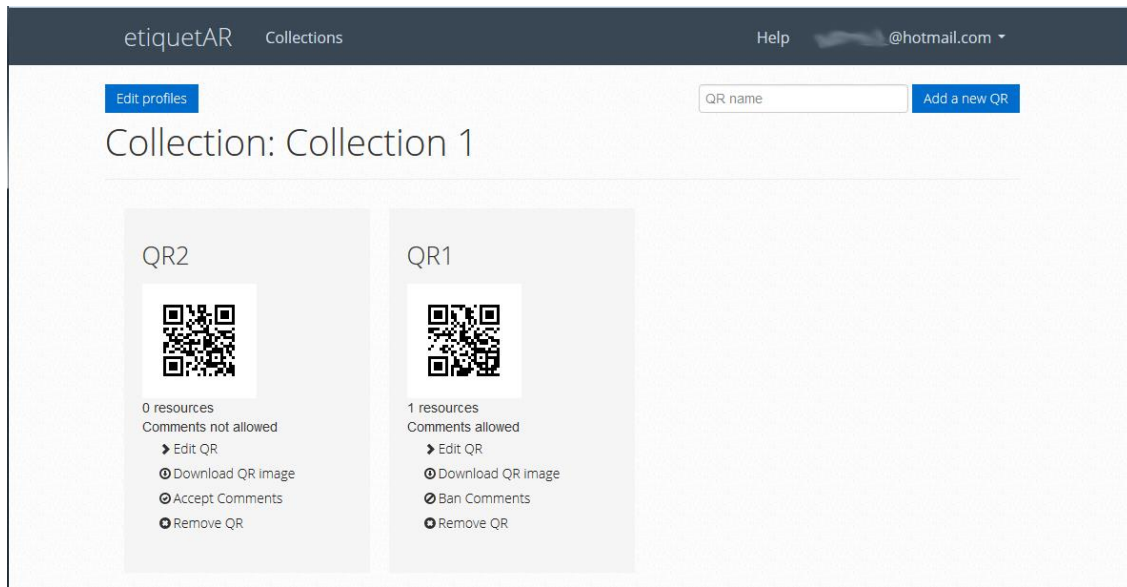


Figure 9. etiquetAR authoring tool with an example collection created [etiquetAR, 2015]

Each QR code can contain multiple resources as seen in Figure 10. The available resource types are text, images, videos, URLs, and a file upload option, which enables the user to upload any file to the etiquetAR service and have it downloaded by the mobile users onto their devices. The image and video resources are also linked to the system by an existing URL, and for videos only YouTube is supported. Even though any type of files can be uploaded to the service, it is not good usability to make the user download e.g. images just to see them. Adding comments to the QR codes is a new feature that has been added after the release of the paper by Pérez-Sanagustín et al. [2012]. This option enables the students to add comments and additional knowledge regarding the visited locations and the content provided by the QR code during the learning activity [etiquetAR, 2015].

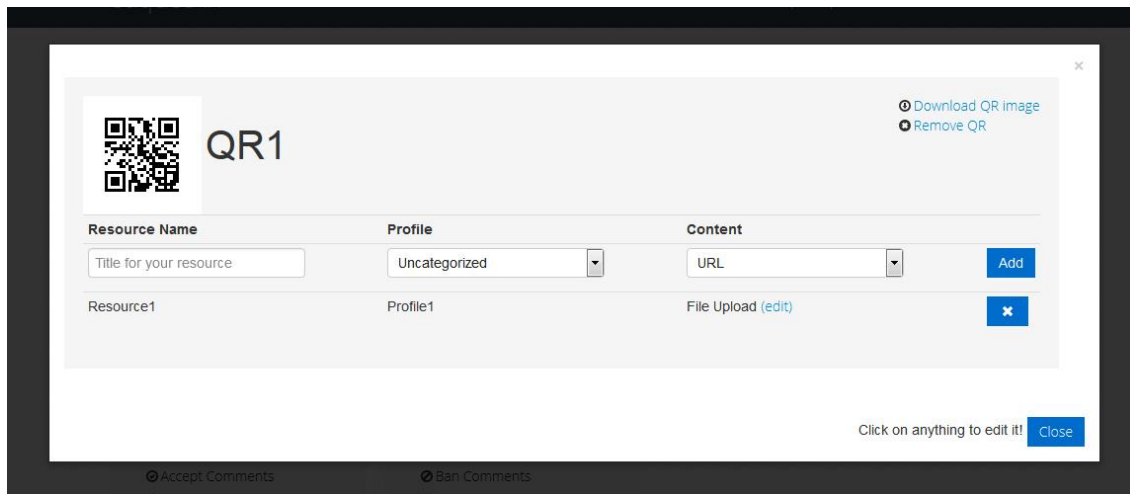


Figure 10. Editing a QR code in etiquetAR

What makes etiquetAR unique from other QR code authoring tools and the previously used NFS tags, is the opportunity to have different user profiles connected to the content and the tags. This way the same QR code can be utilized to offer distinct learning experiences for e.g. students from various degrees. Using QR codes to virtually augment the learning space has also the advantage that the content related to the tags can be updated virtually by the teacher anytime using the authoring tool, without the need to replace the physical tag. This is not possible with the previously used NFS tags that require the user to be physically touching the tag to update its content [Pérez-Sanagustín et al., 2012].

Sanagustín et al. [2012] present two experimental learning scenarios for the etiquetAR learning platform: a tour type outdoor learning activity called “Discovering the campus 2012”, and an indoor learning activity placed in a museum called “Discovering the kidnapped scientist”. In the first scenario new students used their personal mobile devices to get to know the campus area and the different services provided by a university, by interacting with QR codes placed around the campus. The second scenario is an example of how the system could be utilized in the future. In this scenario the students are the ones creating learning material for the museum visit using the profile option for the content. In the experiment students are divided into groups, and they are provided with an additional application that guides them through a museum where they need to interact with the tags placed previously by the teacher. Each group uses a different profile than in the creation phase. Users need to record their learning activity by taking pictures and adding comments to the visited tags using their mobile devices. The same constructive approach was also used with the Wandering and Mobilogue platforms discussed in Sections 3.3.3 and 3.3.4 respectively.

Based on the experiments conducted by Sanagustín et al. [2012], etiquetAR was considered to be a good application for creating tag-based learning activities, because (1) it is easy to use both by the teachers and the students, (2) it enables personalizing the

user experience through the application of user profiles, and (3) it does not require any special mobile application. The last point is very important in a sense that many m-learning applications have been developed that are not reusable because they are that OS dependent and/or intended for only certain types of learning activities. A lot of effort has been put into coding applications that might not be suitable in actual educational context, because of the diversity of devices and operating systems. Of course the tag-based solutions have their own problems and limitations, but with inspired and pedagogically relevant design they have the possibility to offer rich and meaningful in situ learning experiences. The biggest problem with tag-only solutions is that they do not offer guidance to the tags placed in the environment, and usually this means that a separate mobile application or a paper map must still be provided for the students to be able to locate the tags.

3.3.6. RFID-based Learning System

Shih et al. [2011] present a very different approach from the previous examples to content creation. In their experiment radio-frequency identification (RFID) was used to incorporate additional digital content to different plants for a natural science course. The learning activity was called Campus Plants Learning Activity (CPLA), and it was tested by 34 fifth-grade students. Each student had a PDA to guide them through the learning activity and to read the RFID tags. The goal was to get the students to make detailed observations about the plants by answering a series of questions and taking notes.

A web based solution was used to present the learning material and questions. Because of the small screen size on PDAs, some considerations were taken into account in the design of the learning material: favor single screen views without scrolling, avoid complicated input methods and use simple clicks and touches instead, use short words to lighten the cognitive load and to provide the most information in the limited space available.

Generating appropriate feedback at the right time based on the learning conditions of the user was considered to be one of key features to provide a seamless learning experience. The system also acts as a web server that provides the learning materials, records the user's learning processes and learning condition, provides authoring of the learning materials and the repertory grid, and provides the teachers a log analysis interface for observing the results of a learning activity.

The study by Shih et al. [2011] uses a repertory grid method to design the learning content in a way that guides and assists students in the learning activity in a structured way. It means that a class of objects are represented in a matrix with element labels as columns (concept to be learned, classification of an object etc.), and construct labels as rows (e.g. tall/short, oval-shaped leaf/heart-shaped leaf) as seen in Figure 11. Each element is graded from 1 to 5 based on the degree the element matches the given

constructs. After the matrix has been filled, the similarity between the elements is calculated using a similarity-analysis formula. If there are elements which have a too high similarity value between them as seen in Figure 11, an additional construct should be added to distinguish these elements. This guides the teacher to add enough information about each plant. For the experiment with school children, nine constructs were defined for six different plants for the students to observe.

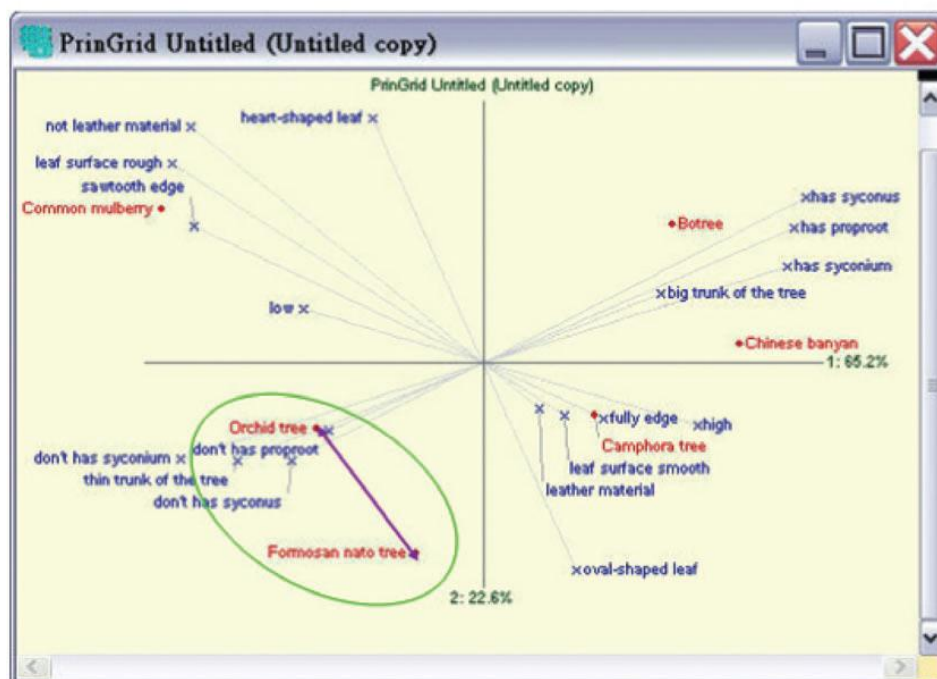
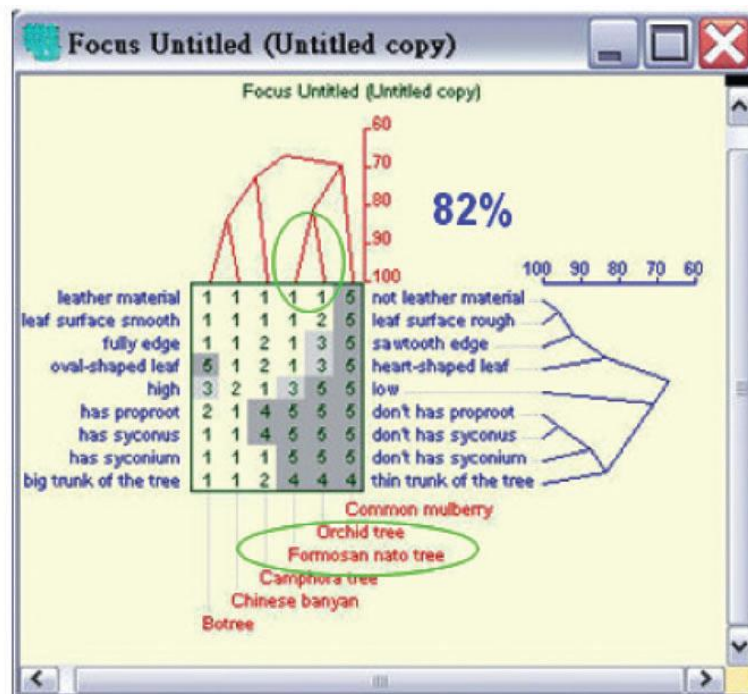


Figure 11. A repertory grid matrix with two elements that are too similar to distinguish [Shih et al., 2011].

The results from the study by Shih et al. [2011] showed that students liked using the PDAs to learn more about plants, and they thought that this type of learning could enhance their learning attitude by being more interesting, liberating and pleasant than traditional learning. Using PDAs was considered to be convenient and easy, one of the reasons being the automatic sensing mechanism of the RFID tags, which did not require any user input to read. Observing and interacting with real environment rather than just looking at images was beneficial, because images can be sometimes misleading and one sided. Even though every student had their individual PDAs, it was observed that they were also communicating a lot with their peers, and cooperative learning and positive competition could improve the learning activity further. On the other hand, the one-to-one PDA guidance was liked because it enabled the students to control their learning speed and to take a more active role in the learning process. According to Shih et al. [2011] this way no students are neglected or isolated from the group because of the limited resources of the teacher. It was also mentioned by the teachers that having the students working with personal PDAs made class management easier, and they could concentrate on giving personal advice to students that needed guidance, instead of making one presentation to the whole group.

Even though the goal of the m-learning system was to provide more structured real environment learning experiences, it was noted by one of the students that a teacher's explanation is more structured and complete than the instruction provided by the mobile application. It was also considered by the teachers and the students that the richness of the content needs to be increased in order to support learning better. Suggested methods were adding more interactive mechanisms and instant feedback.

The paper by Shih et al. [2011] only discusses the design of the domain specific information using the repertory grid method. There was no mention on how the location context or additional learning material was entered in the system, as was the case with the previously presented examples. As mentioned by Shih et al. [2011], special attention must be paid to both system and instructional design to adapt this solution to other learning situations. The next step would be merging these different solutions to provide a more full m-learning management system.

4. The Seek'N'Share platform

Seek'N'Share is a platform that supports the creation and fulfillment of location-based collaborative mobile learning activities in outdoor scenarios. The application was originally targeted for secondary school pupils, but because of the generic nature of the platform, it can be used in all levels of education.

The Seek'N'Share platform supports the inquiry-based learning and cooperative learning pedagogies discussed in Section 2.5 by encouraging a group of students to gather knowledge together in real situations, and then to create a joint presentation using the collected material. The application can also be used individually. Creating a presentation based on the observations and material collected in the field, and later sharing the work with the teacher and classmates, supports the six activities for inquiry-based learning defined by Song [2014] as presented in Section 2.5.2: engage, explore, observe, explain, reflect, and share.

Previous work has shown that utilizing group work is a successful way to implement location-based m-learning, and this way of learning is often preferred by the students (e.g. Santos et al., 2014; Shih et al., 2011). Even though Seek'N'Share does not have built in features that support cooperation, using a shared device to explore and capture the learning experience can work as “an ice-breaker” and naturally foster collaboration between peers, as was reported in the study by Huang et al. [2010] discussed in Section 2.5.1.

The Seek'N'Share platform consist of two parts as seen in Figure 12: (a) a web-based assignment editor that is used by the teachers to virtually create location-based learning assignments, and (b) a mobile application for exploring and documenting learning outcomes in the field (c). The Seek'N'Share assignment editor is discussed further in Chapter 5 and the mobile application is presented in more detail in the next section of this chapter. The platform can be used to create outdoor learning activities in a generic and flexible way, despite of the subject to be learned.

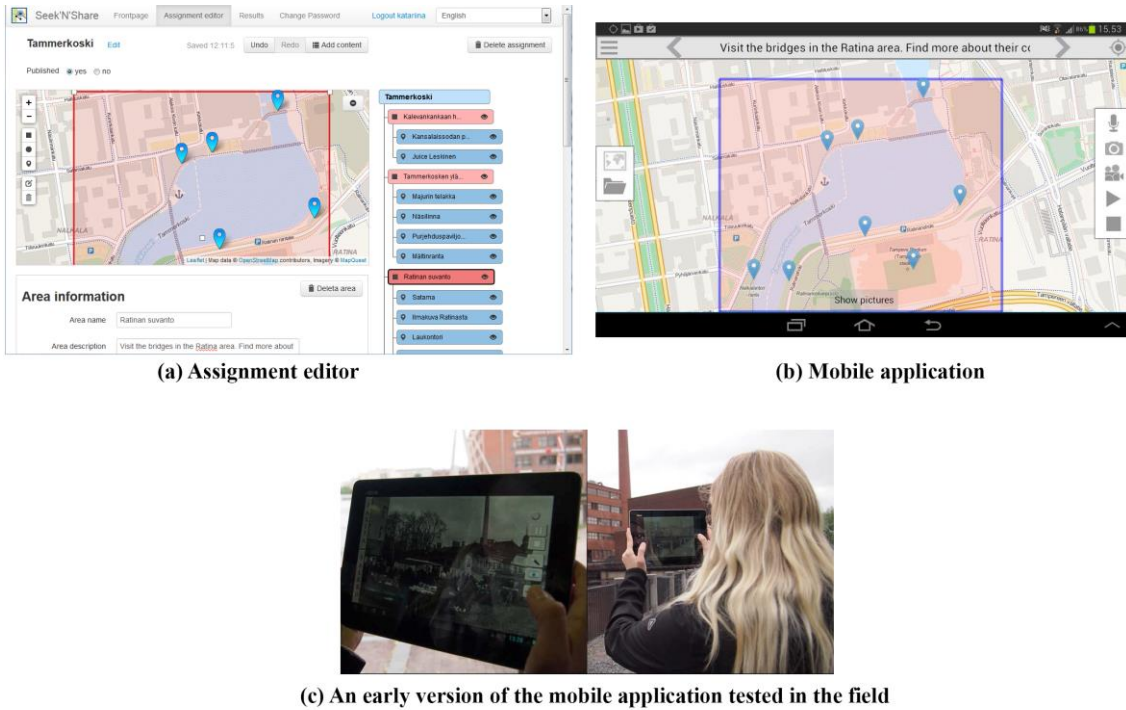


Figure 12. An overview of the Seek'N'Share platform consisting of (a) an assignment editor, (b) mobile application [Heimonen et al., 2013], and (c) using the mobile application in the field [Heimonen et al., 2013]

The learning assignments in Seek'N'Share are based on a set of defined areas and points of interest (POIs) that can be placed anywhere on a map. Both areas and POIs can have a description defining the learning object and possibly include some instructions to the users. The learning objects can also have different audio cues connected to them. Selected audio is used to notify the user when s/he has entered or is leaving an area or a POI. Audio is also used with the descriptions of the learning objects. When the user of the mobile application enters an area or a POI, the description of that element is automatically played back using text-to-speech conversion performed during content creation. As mentioned in Section 2.5, using text-to-speech to provide instructions, especially for young students, is a good way to support guidance in mobile learning [Falloon, 2013].

Since GPS-based learning objects cannot be placed too close to each other in order to the system being able to distinguish what object to show, it was suggested by Santos et al. [2014] (see Section 3.3.1), that there should be a possibility to add multiple tasks and/or activities to a single learning object. From an authoring perspective, a key feature in Seek'N'Share is that both areas and POIs can have multiple different tasks connected to them, but the tasks can also be connected to different topics. This enables the possibility to use one assignment from different viewpoints and increase collaboration between different subjects and teachers. One example of how this feature could be utilized is a park containing tasks related to its history in the context of urban planning,

and its present flora and fauna from a biology perspective [Heimonen et al., 2013]. The different topics could also be used to support a jigsaw-based cooperative learning strategy as discussed in Section 2.5.3, where students are divided into groups, and each member is assigned a different task – or in this case a topic – that they need to research, create a presentation, and lastly share their knowledge with the other group members.

The POIs in Seek'N'Share can include an unlimited amount of supportive multimedia content, like images, audio and video, that the students can also use in recording their learning outcomes. Providing different content options supports context-aware learning in a sense that the students have the opportunity to choose which type is most suitable for their learning style. In order to include support for indoor learning activities, each learning object could also be connected to a QR code, like in the tag-based examples presented in Chapter 3.

An assignment created using the Seek'N'Share assignment editor can be copied in order to reuse the same base for another assignment. All areas and POIs in an assignment are also reusable learning objects (LOs) that could possibly be shared in a universal database for location-based learning. At the moment, all assignments and the LOs included in them are only visible to the person who created them, so in order to support collaboration, only one username was used per organization during the testing of the application.

In this chapter we will shortly present the Seek'N'Share mobile application and the used platform architecture. The implementation and design of the assignment editor is discussed in more detail in the next chapter of this thesis.

4.1. Mobile application design

The Seek'N'Share mobile client is a native Android application targeted for versions 4.2.2 and up. It can be used with a tablet or a smartphone, but the user interface is designed with tablet use in mind, because of their larger screen size. Controls are placed on both sides of the screen, so they can be easily manipulated while holding the mobile device in horizontal direction with both hands. The application is meant to be used by a group of students, and as the first task when starting the application the pupils need to choose a name for their group and the assignment they want to complete (see Figure 13). Compared to the solution of using a specific identifier to select a learning assignment in the Treasure-HIT application presented in Section 3.2.2, providing a dropdown menu with the list of available assignments makes the selection easier, because the user does not have to enter the code by hand. The list of available assignments can be controlled by the teacher from the assignment editor side. Only published assignments are listed on the start screen of the mobile application.



Figure 13. Start screen of the Seek'N'Share mobile application.

After selecting an assignment, the pre-defined content and media files are downloaded to the device. Because one assignment can contain multiple media files, it would be best to preload the assignment at school, or another place where a proper network connection can be used. This way no network connection is necessarily needed while using the application in the field. By disabling the internet connection it can be prevented that the students use the tablets for anything other than completing the assignments. This is an important feature, because misuse can be a problem with students who are not engaged by the learning activity, as reported by Huizenga et al. [2009] in their study about engagement and learning effects in mobile learning. By preloading the assignments there is no need to equip the devices with costly networking services and if the students are using their own tablet computer, they do not have to pay for data transfers themselves, and it can also help to save the battery of the mobile device during the learning activity.

Since the same learning assignment can be utilized by multiple teachers with different subjects, the pupils must choose what tasks will be shown to them by selecting the appropriate topic from the list that has been created for the assignment. When an assignment is opened, a map view is shown with areas and POIs that are in the viewpoint. User's location is displayed with an animated arrow when GPS connection is available and the user is inside the defined assignment area. Only the map of the assignment area is loaded, so users can not span outside the pre-defined area. The map view with an active task is presented in Figure 14. Tasks get activated by entering the area or POI connected to them. When the pupils enter an area or POI a sound effect is given and the description of the LO is automatically played. The description can be stopped, paused or played again using the audio controls on the right side of the screen. Audio, video or images can be recorded at any time using the reserved controls. Pupils

can preview images connected to POIs by tapping a button on the bottom of the screen. This way they can easily find POIs that have interesting content in them.



Figure 14. Assignment opened in the map view.

Users can document their learning outcomes by collecting material presented in POIs, taking pictures, and recording audio and video. Multimedia is preferred over text entry, because writing on mobile devices is still considered to be quite laborious [Heimonen et al., 2013]. All the created material is added to the presentation editor 'folder', where it can be later accessed to create a presentation inside the tablet application.

Tapping a POI on the screen opens the POI view. In the example seen in Figure 15, the selected POI contains two images that can be browsed by using the tab controls on top of the screen, or with a swipe gesture on top of the content. The images can contain a title and some additional context information, as seen in the bottom right corner in Figure 15. This is meant to contain information like copyrights or who took the image.

POI content can be added to the presentation editor by clicking the folder icon located in the controls on the right. The folder icon has a plus sign on top of it indicating when the selected item can be added, and a minus sign when the item has already been added to the folder. Clicking the folder icon with the minus sign removes the item from the presentation editor. This way, if an item is accidentally added to the presentation 'folder', the user can easily delete it without leaving the POI view. If the item is accidentally removed, it can always be added back to the folder by returning to the POI view, even after leaving the area of the POI.



Figure 15. POI view with two content images.

The presentation editor presented in Figure 16 has two timelines where the user can drag images and audio on top of each other. The images can be stretched along the timeline to make it display as long as wanted. When video is added it covers both of the timelines. The presentation can be previewed before sending the final result to the server. In the future it should be possible for the pupils to edit the presentations using a more complex web-based editor and share the results in social media where they can get comments from their peers. Creating a presentation about the learning experience supports the constructive need for learning applications mentioned by Huizenga et al. [2009].

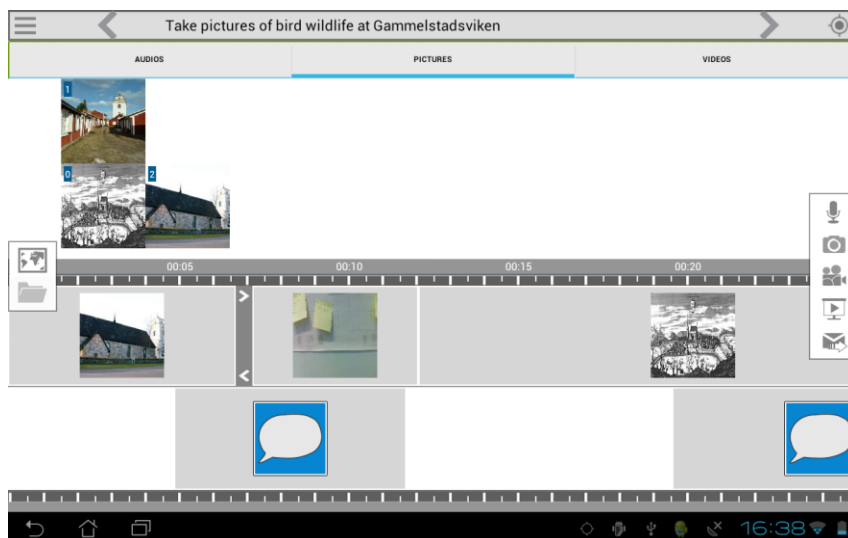


Figure 16. The folder view with the presentation editor.

To support better collaboration during the in-field learning activity, a default communication pathway that enables student-to-student and student-to-teacher

communication should be included to the platform, like in the example learning management system discussed in Section 3.2. This way the teacher could provide assistance during the learning activity when face-to-face interaction is not possible.

In order to provide a more structured learning experience, adding feedback to the system would be important, since now the students can get comments from the teacher only after the presentation has been sent to the Seek'N'Share server, and the in situ learning experience is over. Incorporating a formative assessment strategy – as discussed in Section 2.5.4 – could be an effective way to increase structure and improve the learning results of the students by helping them make better presentations with more relevant content.

4.2. Seek'N'Share platform architecture

The Seek'N'Share platform is based on a client-server architecture, where the client applications (web and mobile) connect to the server using an application programming interface (API). The server provides services for the applications through a RESTful API and stores the assignments and presentations in XML-format with the multimedia files connected to them. A TTS web service provided by Nuance (<http://www.nuance.com>) is used for the text-to-speech conversion of area and POI descriptions. The overall platform architecture is presented in Figure 17.

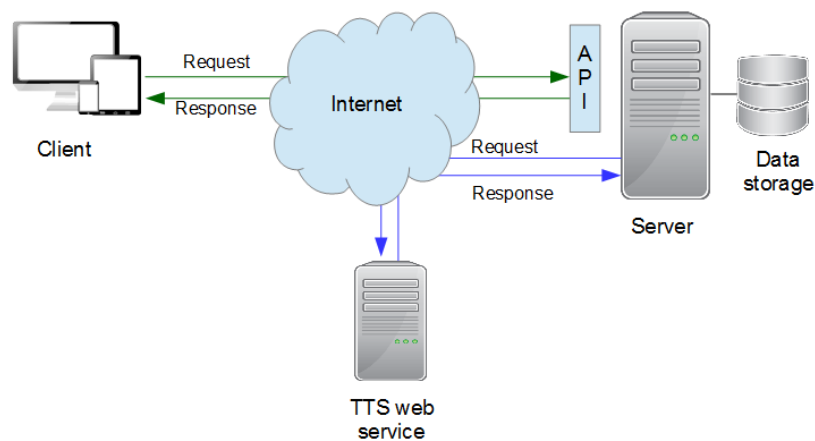


Figure 17. Overview of the Seek'N'Share platform architecture.

4.3. Server side architecture

The Seek'N'Share server backend is implemented as an ASP.NET web service that is used by both client applications through a RESTful interface. Because all the communication with the backend goes through the RESTful API, it would be easy to move the system to another platform without needing to change anything on the client

applications. As mentioned in Section 3.3.4 by Giemza and Hoppe [2013], this type of open architecture enables creating new implementations of the mobile application and adding further support for other devices, which was also a request coming from the pilot group testing the platform. The results of the piloting activity will be discussed more in Section 5.3.

The server side architecture of the Seek'N'Share platform can be divided into five main layers: presentation layer, service layer, application logic layer, Data Access Layer (DAL), and data storage. The server side architecture is presented in Figure 18.

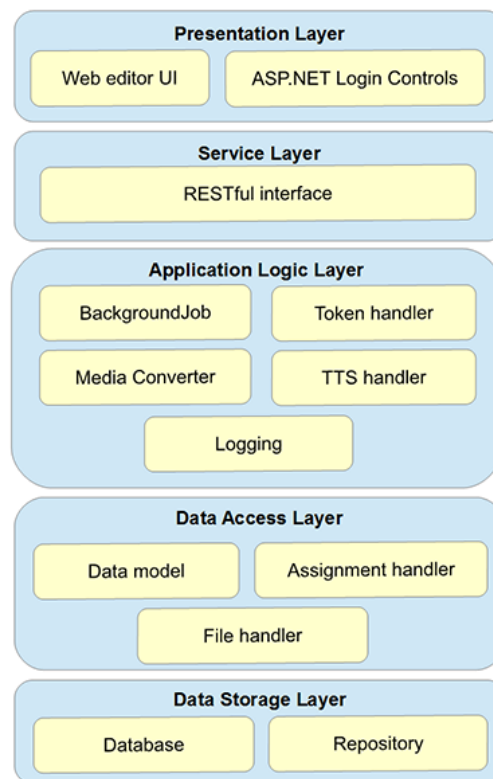


Figure 18. Server side architecture.

4.3.1. Presentation layer

The presentation layer consist of the web editor, which is mainly composed of HTML, JavaScript and CSS, and the ASP.NET Login Controls implemented in C#. The web editor is developed using open-source web technologies like OpenStreetMap (OSM, www.openstreetmap.org), Leaflet (leafletjs.com), and the Twitter Bootstrap framework (getbootstrap.com/2.3.2/).

OSM provides the map data that is used by Leaflet, a JavaScript library for interactive maps, which can be used to add map-functionality into web-applications. Leaflet draw (<https://github.com/Leaflet/Leaflet.draw>) is a plugin that provides the draw functionality that is used to add and edit the areas and POIs on the map in the

assignment editor (see Chapter 5). Map tiles for the editor are provided by Mapquest (<http://www.mapquest.com/>).

Bootstrap is a front-end framework for the development of responsive web-applications. It provides reusable UI-components and a 12-column responsive grid for creating different layouts, which makes the development process faster. Bootstrap has a nice clean base style, which saves a lot of time, because you do not have to create styles for every element from scratch. The framework also includes a set of icons by Glyphicons (<http://glyphicons.com/>) that can be used for example to add descriptive icons to buttons.

ASP.NET provides the authentication functionality for the web editor in the form of Login Controls that do not necessarily require any programming. Visual Studio project templates for Web applications and for Web sites include pre-built templates that can be used for registering new users, logging in and changing password. One of the drawbacks of using ASP.NET controls is that localization of server side strings has to be done by using separate resource-files, where plain HTML content is localized using plain JavaScript. A better solution would be to add these functions to the REST-interface and to build the forms using HTML and JavaScript.

The assignment editor is built using dynamically changing HTML-pages. Dynamic HTML-pages can be created using different client side scripting languages, in which JavaScript has become the “de facto standard” [Casteleyn et al., 2009]. Modifications can be made by leveraging the Document Object Model (DOM) representing the HTML/XML document [Casteleyn et al., 2009]. This means that changes to a web page can be made without refreshing the page or redirecting the user to a new page.

There are plenty of different frameworks for JavaScript development. In this project jQuery was selected as the main framework for client side scripting. It is one of the most commonly used fast and concise JavaScript libraries, which simplifies creating dynamic HTML, helps in handling events and creating transformations and animations without making any post backs [Dhand, 2012]. JQuery also has diverse built in AJAX support that was used to connect to the Seek’N’Share RESTful API, discussed more in the next subsection of this chapter.

4.3.2. Service layer

The service layer consist of the RESTful application programming interface (API). REepresentational State Transfer (REST) is a software architectural style consisting of constraints for designing a hypermedia system with good scalability, mashup-ability, usability, and accessibility. REST is also used in the development of Web services (RESTful Web services) and is especially suitable to be used in AJAX Web applications with simple interactions like updating and retrieving information. [Wilde and Pautasso, 2011; Casteleyn et al., 2009]

There are four main principles in the REST architecture. By Casteleyn et al. [2009] these principles are:

1. Operations are based on standard HTTP methods, generally used to perform specific tasks like: GET for retrieving data, POST for creating new resources, PUT for updating, and DELETE for deleting a resource.
2. Services are stateless, meaning no state information about the application is saved on the server side.
3. State information is encoded in URIs that are used to interact with the service.
4. HTTP is used for data transference by adding the payload of the message in the body of the HTTP operation. The data type can be e.g. XML or JSON (JavaScript Object Notation), and MIME types are used to identify the type of content handled in the operation.

The RESTful API provides all the functions the tablet and web applications need to communicate with the server backend. All the calls made to the API must have a valid token included, created for every user by the token handler service. This prevents unauthorized API calls. Users can only get and edit assignments created by themselves. The Seek'N'Share API provides functions for retrieving and saving data as both JSON and XML. The services are divided into functions used by the tablet and the web UI. Complete list of provided services is given in Appendix 1.

In the assignment editor, AJAX (Asynchronous JavaScript and XML) is used to call functions provided by the REST interface. These include: getting a list of available assignments; creating, updating and deleting assignments, uploading files; copying files from one assignment to another; and loading information about submitted presentations. The term AJAX comes from the notion of using JavaScript, XMLHttpRequest, XML, and DOM manipulation to create dynamic HTML pages using the XMLHttpRequest API to perform HTTP requests to a Web server [Casteleyn et al., 2009]. These calls can be performed transparently in the background, independently of user actions and without the need for page reloads leading to more responsive and ergonomic applications [Casteleyn et al., 2009]. According to Casteleyn et al. [2009] AJAX can be almost seen as a synonym for client-server distributed Web applications. As stated by Dhand [2012] the biggest advantage for the end user of using AJAX to build web services is that while the web service gets invoked and page is partially refreshed, they can still work on other parts on the page.

The jQuery library offers extensive support for AJAX capabilities. Here is an example of a typical jQuery enhanced AJAX request, where the variable `serviceUrl` is one of the URLs used to communicate with the Seek'N'Share RESTful API:

```
$.ajax({
    type: 'POST',
    url: serviceUrl,
    contentType: "application/json; charset=utf-8",
    dataType: "json",
    data: input,
    success: function (data) {
        // Request was successful
    },
    error: function (xhr, ajaxOptions, thrownError) {
        // Something went wrong with the request
    }
});
```

4.3.3. Application logic layer

The application logic layer consists of the server side specific services. The five main services provided by this layer are: (1) the Token handler responsible for creating and handling of user specific tokens used to verify the user when making calls to the Seek’N’Share API; (2) Media Converter, which converts media files to different formats so that they can be used on Android tablets; (3) TTS handler, which handles the calls to the remote TTS Service, and processes and saves the result on the server; (4) Logging component that handles saving the server side log information and other log events that could be received from the client; and (5) BackgroundJob responsible for garbage collection, which means removing unused files from the server every hour. As with AJAX applications in general, most of the application logic is located on the presentation layer and included in the client side applications, which in this case are the assignment editor and the Android application for Seek’N’Share.

4.3.4. DAL – Data Access Layer

The Data Access Layer is concerned with the data model and accessing data and files on the server. It also handles the data serialization from JSON (JavaScript Object Notation) to XML (Extensible Markup Language) and vice versa. The layer is responsible for saving and retrieving the assignments and connected files from data storage.

XML and JSON are used to present the assignments shared by the tablet application and the web-editor, because both languages are well supported. It was important that the data model was very flexible, so it would not restrict the use in other applications and it could be easily updated during the development process. The web editor uses JSON to

construct and modify the assignments, but the data is then serialized by the Data Access Layer and saved as an XML-file to the server. The latest version of the data model in JSON and XML formats can be found in Appendix 2.

4.3.5. Data storage layer

Seek'N'Share data is divided into a database and a repository, which contains all the assignment data and files. The database contains the user and token information, while the assignments are saved as XML-files in a directory named by the owner. All assignment related files are located in subdirectories under the user's main directory. When assignments or learning objects are copied, all the connected files are also copied in the corresponding directory by the Data Access Layer. A learning assignment can be copied to another user or to a whole other implementation just by copying the one directory and changing the id-number of the assignment if necessary to avoid conflicts with existing assignments on the target system.

5. Design and implementation of the web-editor

The assignment editor for Seek’N’Share was developed with the goal to produce a generic tool for enhancing outdoor learning activities, with the aim of making the system as flexible as possible [Heimonen et al., 2013]. This way the assignment editor could be used in various different scenarios, even outside the learning context. Because of this generic approach, the context-awareness support provided by the application is at the time limited to the location of the user.

When designing any application, good user experience and usability should be considered from the beginning. When it comes to Web applications, user experience could be considered to be even more important, because a Web page is generally delivered as a “self-service” with no instruction manual or previous training [Garrett, 2002]. This was one of the design principles that was considered when designing the Seek’N’Share assignment editor. Even though the users should have some idea of what the application is for, creating assignments and working with the editor should be easy, fast and self-explanatory. The application supports a direct manipulation metaphor by enabling the user to create new learning areas and points of interest to the assignments by dropping them straight on a map, without the need to know the exact coordinates for the elements.

An iterative design process was used in the development, with feedback from the development team, dedicated testers, and a group of teachers that were testing the application in the later part of the development. In this chapter we will discuss the requirements defined for the editor and look at the design principles and decisions used to support these requirements by presenting the final version of the editor user interface. The results and comments provided by the teachers testing the Seek’N’Share platform will be discussed in Section 5.3.

5.1. Primary users and requirements for the Web-editor

Before the development of the assignment editor for Seek’N’Share, the first version of the mobile application had already been created and piloted with schoolchildren. Requirements for the editor were mainly created on the base of the mobile application and the identified use cases and users of the editor.

Knowing and understanding your users is a key point in designing applications with good usability and user experience. Since the Seek’N’Share platform is targeted to be used in an educational context, the main user group is quite well known but diverse. The main users of the web-editor are teachers in all levels of education, with various backgrounds in using computers and developing e-learning activities. The amount of time a teacher is willing to use to learn a new system can also vary a lot. People who are

interested in using different technologies might be willing to use more time to learn the system and carefully create new learning assignments, but then there are also the people who think that using new technologies is a necessary evil, and do not want to use any extra time learning the system. The users are experts in their own domain, and the editor is only a platform where they can use their knowledge to create meaningful learning assignments without any previous experience with location based learning application or e-learning in general.

For the editor to support teachers in their task of creating learning assignments, a few key requirements were identified:

1. The system must be easy enough to be used without any additional training.
2. The system must be fast to use, because teachers generally do not have too much time to fiddle around with computers, and a too “simple” system with defined steps for assignment creation can be frustrating for the expert users.
3. No special computer skills should be needed to be able to use the system, it should be easy even for the novice users.
4. Content sharing to support reuse of assignments and collaboration between teachers must be provided.
5. The user interface should be intuitive and any complex navigation should be avoided (one page editor).
6. The editor should inspire the teachers to create assignments.

The main functionality that the application editor should provide was first described by use cases, which are presented in Appendix 3. The main four scenarios for the use cases were: (1) adding new users to the system, (2) creating a new assignment and content to the assignment, (3) editing an existing assignment and publishing it, and (4) viewing of presentations created by the students. After identifying the main requirements for the application, a complete feature list with all the functional requirements for the editor was created to support the development. The list was updated as needed during the implementation phase, and some features were still left out from the first version of the editor because of time constraints. The final feature list can be found in Appendix 4.

From the more technical side, some key requirements were also discovered based on the main users of the application. Cross browser compatibility was an obvious requirement, but one main concern was the fact that the application must provide support for slightly older browsers that might be used in schools, while still maintaining the look and feel of a modern web application. It was considered not to be uncommon that older versions of Internet Explorer (IE 9 and below) that do not support HTML5 and the XMLHttpRequest2 standard (<http://www.w3.org/TR/XMLHttpRequest2/>) that is needed for AJAX type file uploads, could still be used in some organizations.

Because users might not have the option to update or download another browser, providing support for these older browsers was considered to be important.

One of the requirements from the development side was to create reusable components and learning assignments, so the system could be later easily extended. Extendibility and maintainability should be supported by providing good documentation for the application. The system also needed localization to support wider use in the future, and because of the multicultural development team and Finnish speaking end users, this was considered an important feature from the start. This has the advantage that by building in localization at the beginning of the development is usually easier than adding it later in the development process. Adding localization to the application means that it can be easily translated and deployed in other countries as well. To support different reading directions (e.g. right to left), additional CSS-styles would also be needed. In addition one of the goals was to use open-source solutions for the development whenever possible.

5.2. User interface design

In this subsection we will look at the final version of the user interface for the assignment editor included in the Seek'N'Share platform. The application consists of a few user controls and only three main views: 1. Frontpage, 2. Assignment editor, and 3. Results-page. This makes navigation inside the application extremely easy and reduces the feel of complexity.

5.2.1. User controls

The Seek'N'Share assignment editor has a simple login page as seen in Figure 19, where the user can enter their username and password to login. On the top of the screen there is a navigation bar that is visible throughout the pages. When not logged in the navigation bar only contains the Seek'N'Share logo and a dropdown menu where the preferred language can be selected. At the moment the system supports English and Finnish. While not on the loginpage or frontpage the logo on the top left corner works as a link to the frontpage, which is a generally known convention.

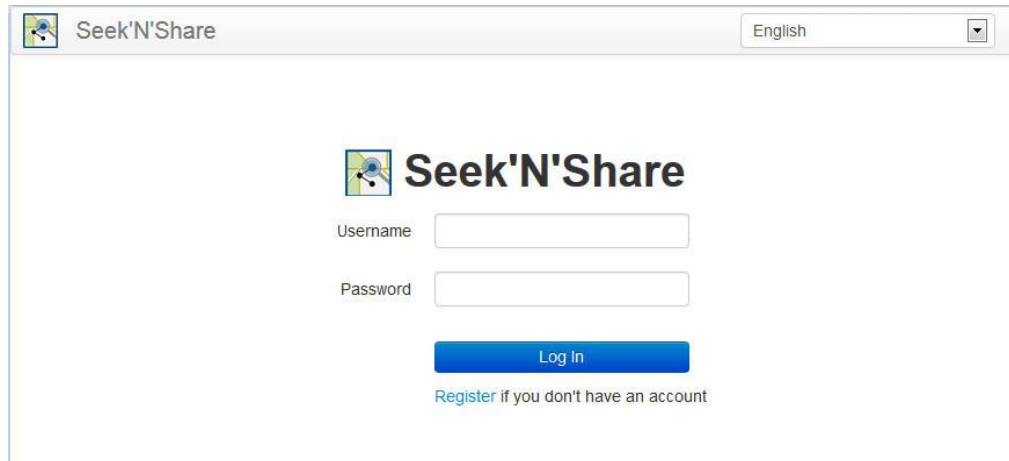
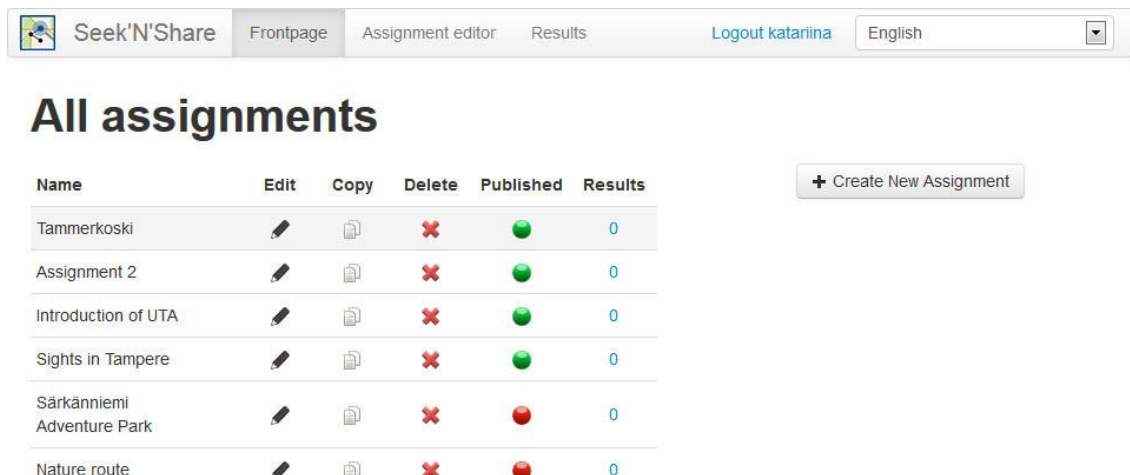


Figure 19. Log in screen of the Seek'N'Share assignment editor.

New users can register to use the service through the *Register* link under the *Log In* button. Required information is a unique username, email and password, which must be a minimum of six characters. After the user has registered and logged in, they can change their password using a simple form. At the moment there are no controls in the system for changing the username or email address, but for further use, more user controls should be added.

5.2.2. Frontpage

When a user has logged in to the assignment editor, a log out link with the user's name and navigation links are displayed on the top navigation bar (see Figure 20). The current page is highlighted with a darker background and the link is disabled. The frontpage contains a list of all the assignments created by the user. New assignments can be added by clicking the *Assignment editor* link in the top navigation bar, or the *Create new assignment* button. Previously created assignments can be edited by clicking the pencil icon next to the assignment's name.



Name	Edit	Copy	Delete	Published	Results
Tammerkoski					0
Assignment 2					0
Introduction of UTA					0
Sights in Tampere					0
Särkänniemi Adventure Park					0
Nature route					0

Figure 20. Frontpage-view with a list of assignments created by the user.

Assignments can be deleted, copied, and the published state updated straight from the frontpage. When an assignment is set as published it can be downloaded using the mobile application. Unpublished assignments are not visible for the students in the list of available assignments. The state of the assignment is presented using a green icon for published assignments and red for unpublished assignments. When an assignment is copied, a new assignment is added dynamically to the bottom of the list, and it is highlighted to make sure the user notices the added assignment (see Figure 21). By default the assignment has (copy) added to the name and its state is set to unpublished.



Figure 21. Copied assignment added to the bottom of the assignment list.

Because when deleting an assignment all the data and connected media files are permanently deleted from the server, a default alert is used to prompt the user if they really want to delete the whole assignment and all the content connected to it. To make sure the user knows which assignment is about to be deleted, the selected assignment is also highlighted, as seen in Figure 22. If the user decides to delete the assignment, all the files connected to the assignment are also deleted from the server. In the original design an undo option was chosen before an alert to create a better user experience, but because the focus in the development was in the content creation, the undo option for deleting assignments was dropped from the first version of the editor.

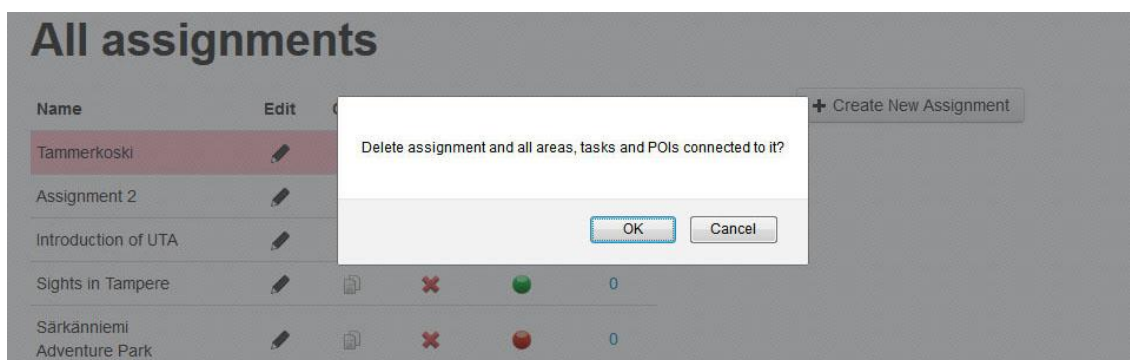


Figure 22. User is prompted to make sure they really want to delete an assignment.

A teacher can track the number of updated presentations from the Results-column. The number of results works as a link that directs the user to the Results-page with a more detailed view of the received presentations.

5.2.3. Assignment editor

The assignment editor view is divided into five different blocks as seen in Figure 23: the navigation bar (1), assignment settings (2), map and draw controls (3), navigation tree (4) and content/target information (5). Assignments are created by adding areas and POIs onto the map by using the draw controls, and then editing information connected to them in the content information block. The assignment editor is designed to work more like a desktop-application. While editing an assignment the user stays on the same page and no page reloads are needed. All the content is dynamically updated when changes are made. This makes it easier for the teacher to concentrate on the task at hand and keep their focus on the element that is being edited, because there is no added navigation between multiple pages. It also saves time because you only have to wait for the page to load once.

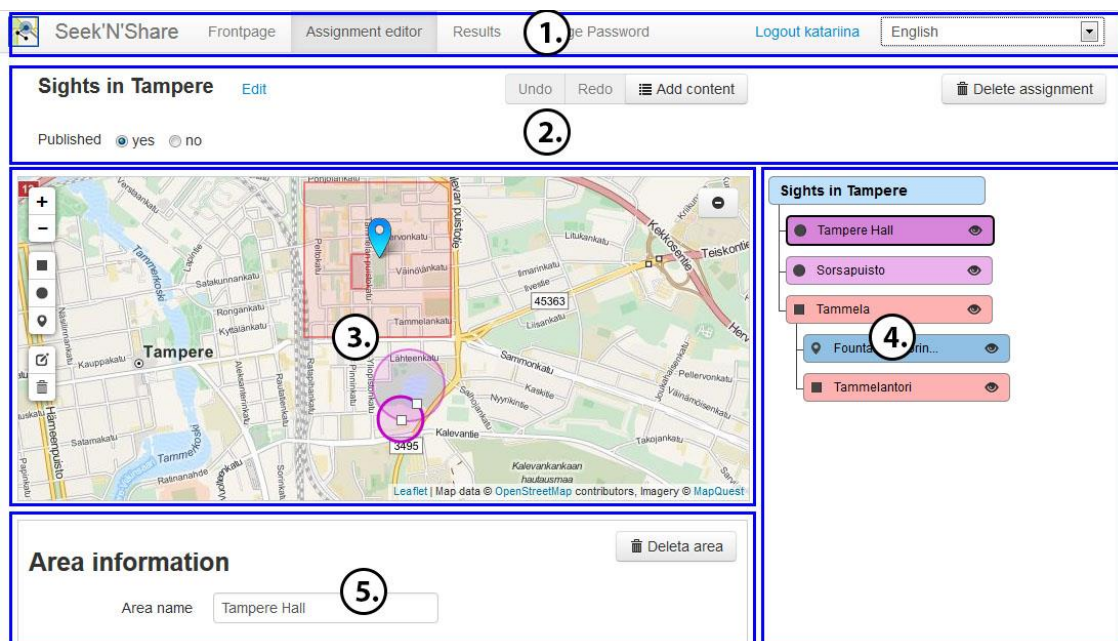


Figure 23. Assignment view divided into the main five blocks.

Assignment settings

The assignment settings block contains high level functions connected to the assignment. These include changing the name and state of the assignment, saving and deleting the assignment, and the undo/redo controls. Also the *Add content* button is located in the assignment settings block. It provides a list of all the assignments and included content which can be added to the current assignment. When a new assignment is created, it is given a default name, but the edit name field is automatically activated as a hint that the user should provide a more descriptive name. A unique name makes identifying assignments on the frontpage easier.

After every change made with the editor, the assignment is automatically saved. This gives the user one less thing to remember, and there are no time-out problems that

might cause the user to lose work, which was a big problem e.g. with the Wandering platform presented in Section 3.2.3. Using automatic saving instead of a traditional save option also presents some challenges both in the interface design and from a more technical point of view. The two main the issues were how to make sure the user understands that the assignment is saved after every change, and how to make sure all changes are saved before a user leaves the page. In the UI, as an effort to make the user understand this feature, and to make them feel secure that the changes are saved, the time of the last save is presented next to the *Undo* and *Redo* buttons in the assignment settings. If no changes have been made the buttons are disabled as seen in Figure 23. This design decision should be validated through user testing.

Sharing content between assignments

Sharing content between assignments was a feature requested by the teachers testing the assignment editor. Being able to use material from other teachers was believed to help with the assignment creating process. Content can be added to the current assignment by clicking the *Add content* button in the assignment settings block. This opens up a modal dialog as seen in Figure 24, where the user can view all the content from other assignments. This modal dialog is one example of using a ready-made component provided by the Bootstrap framework [Bootstrap, 2015]. By clicking on the *Info* button next to the header in the modal window, the user is given some instructions about this feature. This information is by default hidden, because it is assumed that the user does not require additional instructions in order to figure out how content can be added, at least not after reading the instructions once.

The modal dialog presents a simple list of the available assignments. When the user clicks on an assignment name, the first level areas and POIs connected to that assignment are presented. Clicking on an element inside an assignment expands the content further. Single tasks and content elements like images are added by default to the current selected element in the editor. If the current element is an area, no POI content is available for selection without selecting the parent element as well.

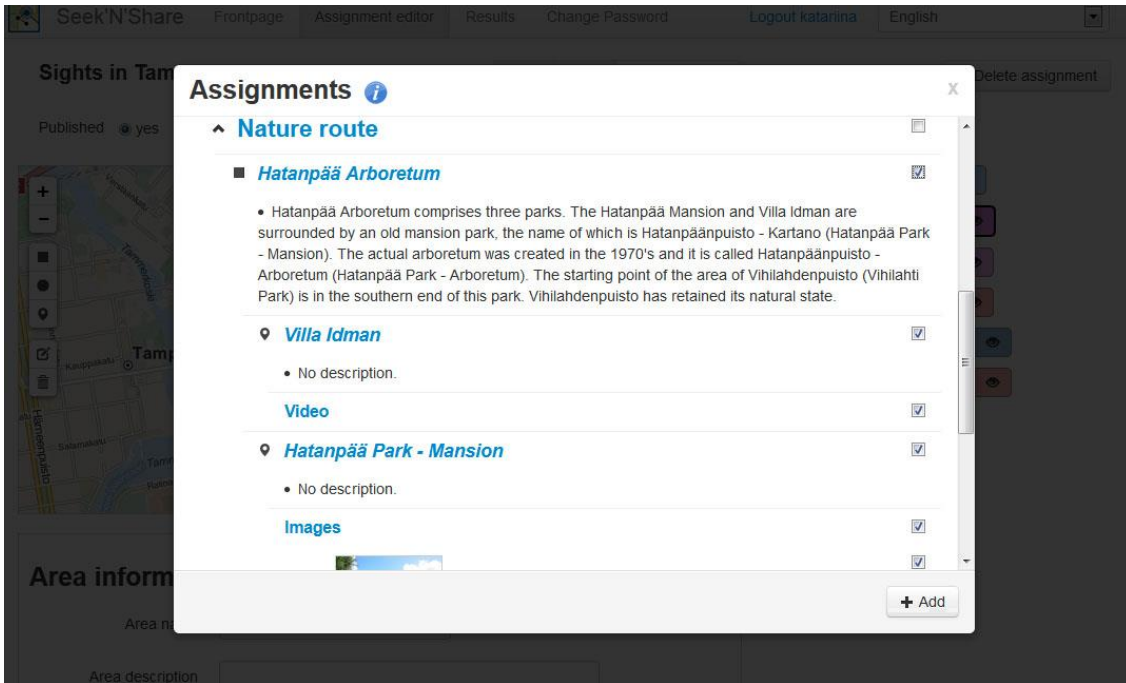


Figure 24. Assignment expanded and elements selected to be added to the current assignment.

Because all the areas and POIs are location-based learning elements, it would be necessary to add this information to the assignment listing. Also adding a search function and better filtering options with the possibility to listen and preview audio and video would be essential for the users to find relevant content added by other users for their assignments. Although some filtering can be automatically done based on the description and content added to an element, it would be important that in the future the users could also add additional metadata to the learning objects using the Seek'N'Share editor, as discussed in Section 2.6.

Map and draw controls

The map is one of the key elements in the Seek'N'Share editor, and because of that it occupies most of the space on the editor page (50% of the screen height). A default location is given in the application's configuration to set the initial view on the map, but the user can move anywhere in the world by dragging the map in the wanted direction. Since dragging for long distances can be slow and frustrating, a search option for the map should also be added in the future. Using the direct manipulation metaphor and a map where the elements can be edited was an obvious choice for creating content for the application. This way the user does not have to know anything about coordinates and elements can be easily repositioned and resized by dragging.

In the top-left corner of the map (see Figure 25) there are controls where the user can zoom in and out on the map for more precise control when positioning the elements on the map, and a wider view while navigating between larger areas. Adding a search function and an option to detect the user's current position would make navigation on

the map easier. Because the map consumes such a large portion of the screen, it is possible for the user to minimize the whole map using a button in the top-right corner of the map, and concentrate on editing the content information connected to the elements themselves.

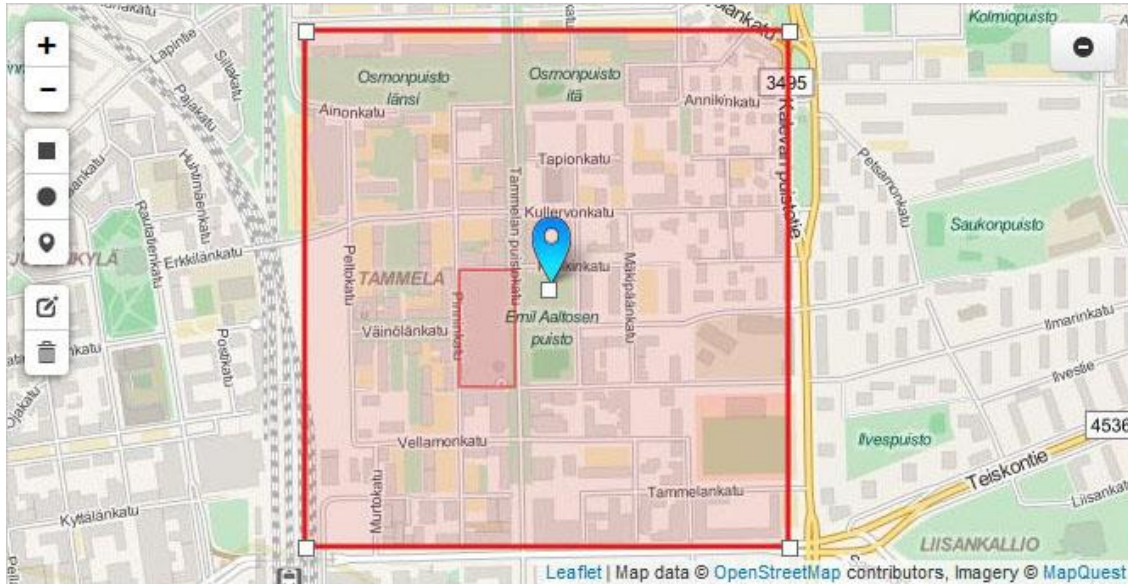


Figure 25. Map and draw controls.

Adding new elements to the assignment

New areas and POIs can be added to an assignment using the draw controls on the map. Currently only rectangular and circular areas are supported. When the user clicks on one of the draw controls some instructions are given on how to use that specific control (see Figure 26). Areas are drawn by dragging and POIs can be dropped on the map by clicking on the preferred location.

When a new element is added onto the map, the system automatically checks for collision with other objects. If the element is placed inside another element, the new element is added under that element. This is also reflected in the navigation tree presented in Figure 29. The application does not give any restrictions on where the elements can be placed, or how many elements can be placed inside another element. This gives the author complete freedom for the content creation.

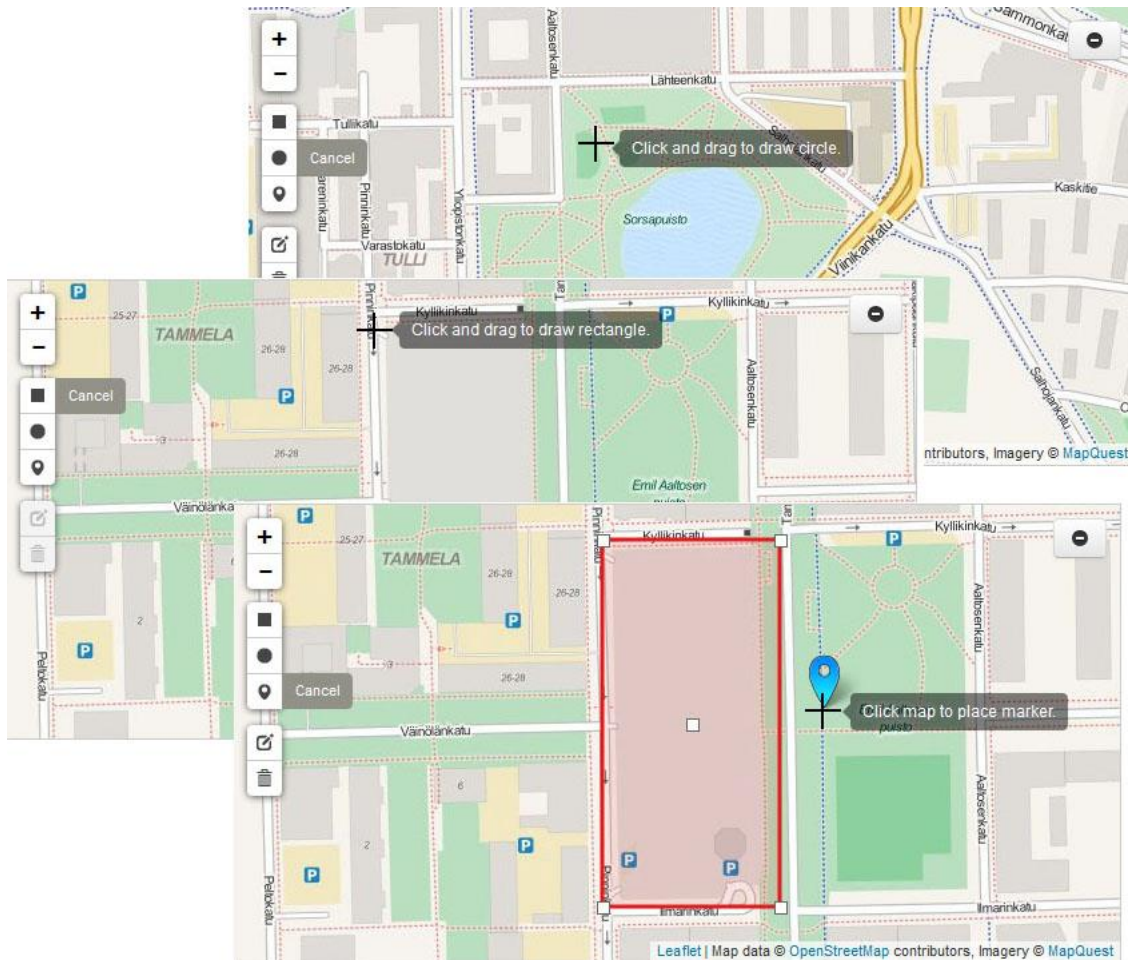


Figure 26. Instructions are displayed after selecting a draw control.

Editing and deleting elements on the map

Leaflet provides default controls for editing and deleting multiple elements at once on the map. In addition to the default editing options, some custom features were also added for a better user experience. The POIs on the map are by default draggable at any time, and the selected area is always editable as was seen in Figure 25.

When the user clicks the edit icon in the map draw controls, all the areas on the map turn pink with rectangle handles in the corners for resizing the elements (see Figure 27). Because POIs are by default draggable, this action does not have any special effect on them. Again the user is given some helpful tips on how this feature works. When this edit mode is on, the assignment is not saved after every single edit, but the user has to click the *Save* button next to the *Edit* button. All the changes made while in edit-mode can be cancelled using the map draw controls while editing. After saving the changes and leaving the edit-mode, the default *Undo* button can also be used to revert back to the state before using the edit-function.

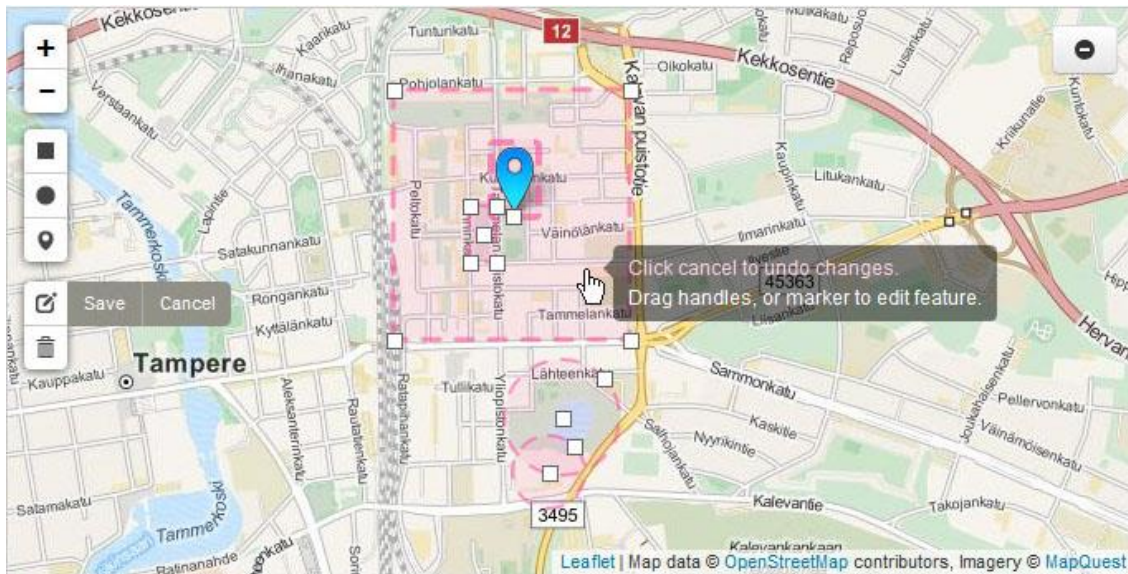


Figure 27. Editing elements using map controls.

Multiple elements can be deleted at once by using Leaflets delete-option. Elements are selected by clicking on them, which removes the element on the map immediately. Again the changes are saved only after the user clicks 'Save' on the map controls as shown in Figure 28.

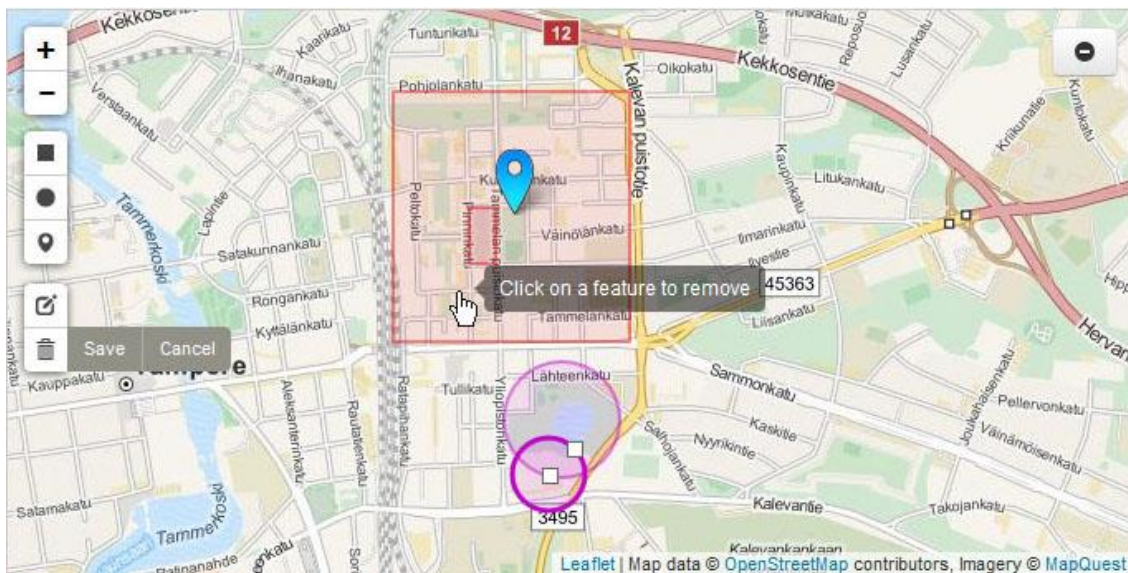


Figure 28. Deleting elements from the map

Tree navigation

The tree navigation gives a nested list of all the areas and POIs added to an assignment. Elements are colour coded for easy detection (round areas = purple, rectangular areas = red, POIs = blue) as seen in Figure 29. Each element also has an icon that represents the type of the element in front of the name. The current selected element is highlighted in the navigation tree, and when the user hovers over the elements, the corresponding

element is also highlighted on the map. By double clicking an element in the navigation tree the map is focused on the element in the centre. This helps locating elements that are outside of the map view.

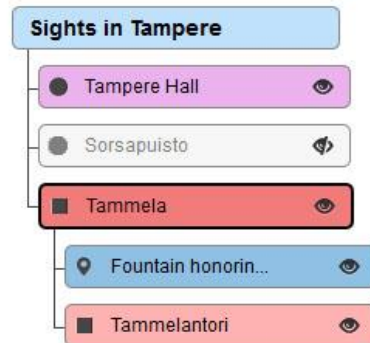


Figure 29. Tree navigation with colour coordination and different icons for each element type.

There is also an eye icon in all the elements in the navigation tree. By clicking this icon the user can hide elements on the map. Invisible items are greyed out and can be made visible again by clicking the closed-eye icon. The hiding feature is only for making editing and detecting of elements on the map easier, it does not affect the state of the assignment. This means that hidden elements are not hidden on the tablet application, or when the user returns to edit the assignment.

Content information

When a new element is added to the assignment, some defaults are provided to make the creation process easier and faster for the user. For example, each element must have a unique name, and this is automatically generated. Since using audio is a key feature in the tablet application, areas and POIs are also given default enter and leave sounds, but the user has the option to upload custom audio files, or disable the audio cues using the editor. Because these are settings that are not expected to be changed often, sound options are by default hidden and can be opened by clicking the *More options* link as seen in Figure 31. Figure 30 displays an example of content information connected to an area with audio options visible. Hiding less important features that the user does not need to change often lets the user focus on creating the actual content for the element. As stated by Garret [2002]: “a well-designed interface recognizes the course of action users are most likely to take and makes those interface elements easiest to access and use”.

Figure 30. Area information

Because areas can have other areas and POIs inside them, if the user decides to delete an area with other elements, a confirmation dialog is used to ask the user if they also want to remove all the other elements as well, or should they be preserved. If a POI or an area without other elements is deleted using the *Delete* button, no warning is given, but the user always has the option to undo the action by using the undo-feature.

Multimedia content

POIs can also have related images, video and audio added to them (see Figure 31). Images can be associated with a caption and other additional text, for example copyright information. Uploading files using the editor is made quick and easy for the user by starting the upload automatically after the user has selected a file. Because all files can be previewed in the editor, if the user selects a wrong file accidentally, they can just delete it. If the user tries to upload a file that is not supported by the application, or the wrong kind of file, an error message is provided with the supported file types listed. Supported file types are: wav and .mp3 for audio files; .jpg, .jpeg, .gif, .bmp and .png for images; and .wmv, .mp4 and .avi for video.

Because Android has a limited support for audio and video, some files are also converted during the upload process, which might take some time. During the conversion/upload the user can still edit the current element, but if s/he tries to select another element or close the editor, a prompt is given that explains that uploading files is still in progress and information might be lost if the user decides to leave.

POI information

 Delete POI

POI name	Fountain honoring Emil Aaltonen
----------	---------------------------------

POI description	Fountain honoring the industrialist and philanthropist Emil Aaltonen.
-----------------	---

+ More options

- Content

Images (1)

Video (0)

Audio (0)

Image 1



Add image Browse... Emil_Aaltonen.jpg

Caption	Emil Aaltonen
---------	---------------

Infotext | lomain], via Wikimedia Commons

+ Add image

+ Tasks

Figure 31. POI content information with images, video, and audio.

All uploaded content can be preview in the editor, and by clicking the thumbnail image, an image carousel is opened with the possibility to navigate between added content (see Figure 32). The image carousel is another example of the JavaScript components provided by the Bootstrap framework [Bootstrap, 2015].

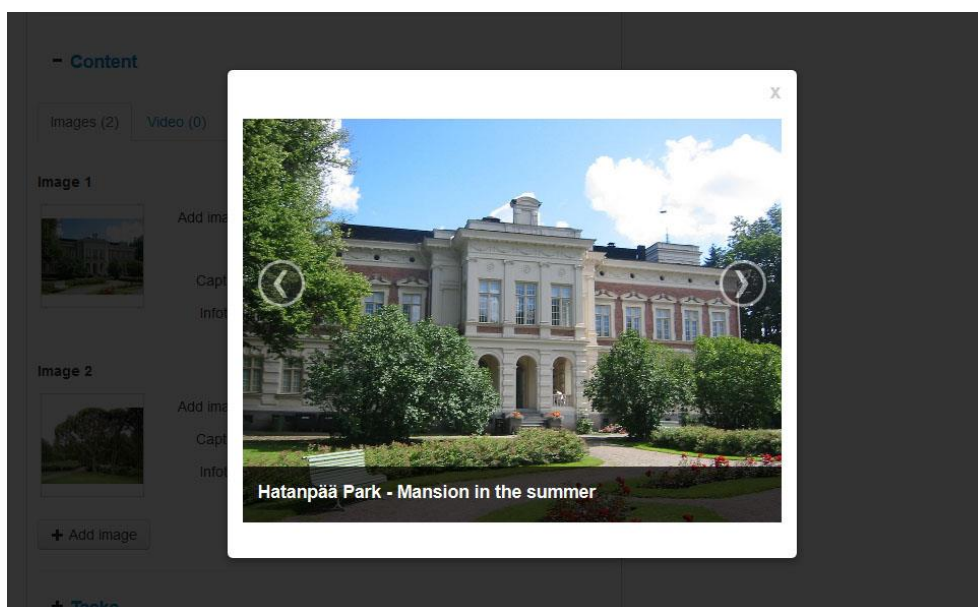


Figure 32. An image carousel is displayed when clicking the uploaded image.

Videos can be previewed using a video player embedded on the page. Uploaded audio files can be listened by clicking the same speaker icon that is used in all audio files through the editor (seen in Figures 30 and 31). Playing stops automatically if the user selects another element, or presses the stop button that replaces the speaker icon during playback.

While using HTML techniques to create the editor makes it naturally cross-platform accessible, there are certain difficulties when it comes to different browsers and browser versions. In a more complex web application like the content editor, where there are multimedia and file uploading possibilities, it can be hard to be able to offer the same user experience for users with a modern browser vs. users that have to use older versions for example due to organization policies. Since we knew that schools might have older versions of the Windows operating system with older versions of the Internet Explorer browser, this was something that was closely considered during the development. Fortunately there are ready solutions for the two main problems encountered during development: handling of AJAX-style file uploads and streaming audio and video. In this project a jQuery file upload plugin (<https://github.com/blueimp/jQuery-File-Upload>) was used to enable AJAX-style file uploads, which are not normally possible with older browsers that do not have built in XHR2 support. Another library called Mediaelement.js (<http://mediaelementjs.com/>) was used for enabling cross-browser video and audio support.

Task information

Textual tasks can be added to both areas and POIs. Tasks are divided by subject and displayed in separate tabs. If the same assignment is used by other teachers, or in other subjects, it is possible to connect tasks to a certain subject. If no subject is specified, the task is visible to all.

When the *Add task* button is clicked, new input fields for a task are dynamically added to the list of tasks. The system makes sure that the task description is not left empty, and a new task can only be added after the previously added field is filled. Before that, the *Add task* button is disabled as seen in Figure 33. The subject where the task belongs can be changed using a dropdown menu.

The screenshot shows a 'Tasks' section with tabs for 'All (2)', 'History (0)', and '+ New subject'. Below the tabs, 'Task 3' is displayed. It includes a 'Subject' dropdown menu currently set to 'History' and a 'Task description *' text area. A '+ Add task' button is located at the bottom left of the form.

Figure 33. Adding a new task to a subject.

Subjects can be added and edited from the *New subject* tab, as seen in Figure 34. If the user tries to delete a subject with tasks, a confirmation dialog is shown with the options to cancel the event, to save the tasks or delete the subject and the connected tasks as well. If the user chooses to save the tasks, the topic for them is changed to 'All'. As discussed in Chapter 4, the topics can be used to create various learning experiences for different users, like implementing the jigsaw-based cooperative learning strategy presented in Section 2.5.3.

The screenshot shows the 'New subject' tab selected. Below the tabs, there is a confirmation dialog with an input field and an 'OK' button. To the right, a table titled 'Topics' lists 'All' and 'History' with 'Edit' and 'Delete' actions.

Topics	Edit	Delete
All		
History		

Figure 34. Subjects can be added and edited from the 'New subject' -tab.

5.2.4. Error handling

Dealing with user error and error recovery is one of the most important parts of interaction design [Garrett, 2002]. People will always make mistakes and how the system deals with them can have a huge impact on user experience. Garrett [2002] divides error handling to three categories: prevention, correction and recovery. The first and the best option is to design the system so that making errors is impossible or at least very difficult. Since errors do still tend to happen, the system should help the user to figure out what caused the error, and how they can fix it. The system can even try to correct the mistakes on the fly, although automatically correcting and giving warnings on actions that were not actually mistakes can be very annoying to the user. In Seek'N'Share, this approach is used if the user tries to enter an invalid input, e.g. an empty name for an area. A notice is given next to the input field, and the previous value

is inserted back to the field to make sure the error does not happen again (see Figure 35).



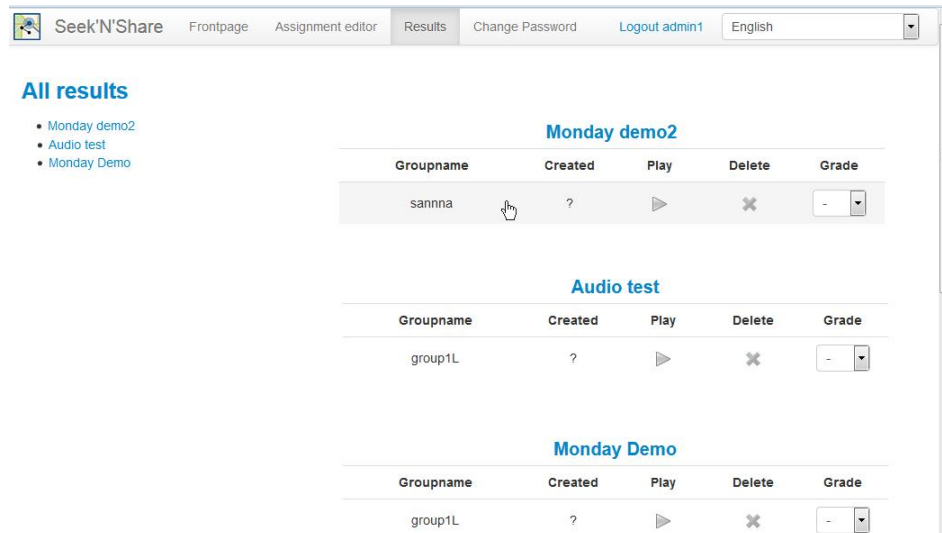
Figure 35. User is given a warning if the name field is left empty while restoring the previous value.

After a user makes an error, it is very important that the system provides a way to recover from the situation. The “undo” function is one of the best known solutions for this. Of course if an action cannot be recovered from, a sufficient warning must be given to the user before performing the action. Confirmation dialog boxes usually end up only annoying the user, and can be dismissed without even reading the content. This was also one of the design principles in the Seek'N'Share editor: undo function should be used rather than pop up dialogs whenever possible. [Garrett, 2002]

The undo and redo functions are generally familiar features from desktop applications. When a user performs a function that changes the state of the assignment, the previous state is saved in the undo stack. If the performed action was a mistake, or the user changes their mind, the previous state can be retrieved and the previous state is moved to the redo stack. The redo stack is cleared when a new state is pushed into the undo stack. In Seek'N'Share the stacks are limited to ten most recent changes. This type of linear undo and redo possibility supports exploration and makes users feel “safe” with the application [Berlage, 1994]. In addition to the *Undo* and *Redo* buttons, the common Ctrl+Z (undo) and Ctrl+Y (redo) keyboard shortcuts used in Windows applications also apply.

5.2.5. Listing of results

After students have created their presentations and uploaded them to the server, the teacher can see which groups have submitted a presentation from the Results-page seen in Figure 36. By clicking on the assignment name in the left-hand menu, only the results for that assignment are displayed on the right. If the teacher wants to go look at the assignment for the presentations, they can move to the editor view by clicking on the assignment’s name.



Seek'N'Share Frontpage Assignment editor **Results** Change Password Logout admin1 English

All results

- Monday demo2
- Audio test
- Monday Demo

Groupname	Created	Play	Delete	Grade
sannna	?			-

Groupname	Created	Play	Delete	Grade
group1L	?			-

Groupname	Created	Play	Delete	Grade
group1L	?			-

Figure 36. Listing of presentations in the Results-view.

At the moment the system only lists the presentations, but the idea is that in the future the teacher should be able to view and grade the presentations straight from the Results-page. As mentioned in the research by Santos et al. [2014], teachers should be able to see more conclusive reports about the learning activity, e.g. where were the students moving around and where was the content for the presentation created.

If the assignment editor would be connected to an existing e-learning platform or other communication channels, like social media sites (e.g. Facebook), the teacher could also send the grade, and possibly some comments on the presentation, straight to the students. One option could be using Seek'N'Share as a plugin for Moodle, like in the example by Bogdanović et al. [2014] discussed in Section 2.4. Even though there seems to be a trend towards incorporating social media in education, there are some concerns related to that. Already in 2008, Graf et al. [2008] anticipated that most of the students were using social media outside the institutional context, but not all would be willing to share their private life in this context. Using social media should be optional, not a requirement. According to Graf et al. [2008], opening up content and educational information in social media has the increased risks for spamming, malware, and outsiders invading the trusted space of educational institutions. Cyber bullying is also a whole other subject that is closely related to the overall use of social media. During the development of the Seek'N'Share platform, it was planned to add the possibility to share the presentations created using the mobile application, e.g. straight to Facebook, by the teacher or the students themselves, but since it was not considered to be a key feature, and because all these connected issues on using social media in education, it was decided not to be implemented at this stage.

5.3. Testing and evaluation of the web editor

In the development of the Seek’N’Share platform, an iterative agile software development model was used. The project team involved in the development of the platform had weekly meetings, where incremental goals were set for the next week. When a new feature was added to the assignment editor, the development team was asked to test it, and give comments right away, or at least in the next weekly meeting.

The assignment editor was taken into active use by the development team in a quite early phase of the development process, because test cases were needed for developing the tablet application. This helped to find any bugs or usability issues in a very early stage. Before starting the pilot test with actual users, an identical testing server was set up, so any new features added during the piloting activities could be safely tested before pushing the changes to the production server. This way it was possible to react quickly to new feature request, and to fix any bugs that might have been discovered during testing.

Early versions of the assignment editor were piloted with a group of teachers during the fall and winter of 2013, to test the initial concept while the development was still in progress and comments from the teachers could still be taken into account. Seven teachers from the Tampere region participated in the piloting activity [Yrjänäinen, 2013]. The teachers used the editor to create assignments with the support of one of the researchers involved in the project. After testing the editor together with the mobile application, two group interviews were arranged to collect feedback from the teachers.

The results from the pilots showed that overall the editor was easy to use, and the teachers managed to create learning assignments with it. One of the teachers commented that while the user interface for the editor is intuitive, some guidance and an example model for an assignment is needed for the teachers to be able to start creating assignments on their own [Yrjänäinen, 2013]. It would be useful to create a quick guide or take a wizard-type approach, as in the Wandering platform presented in Section 3.2.3, to help the teachers to create their first assignment.

The concept of using areas inside other areas was something that was considered an experimental feature, but the pilots confirmed that it was actually used by the teachers. For some of the pilot users, the concept of areas and POIs seemed to be unclear, and one of the teachers considered the material to be too static, not even intended for school work [Yrjänäinen, 2013]. Unfortunately the material provided by Yrjänäinen [2013] does not elaborate what the user meant by static and which part of the Seek’N’Share platform they thought was unsuitable for this type of work. This again calls out for a good example assignments that the teachers could use as a base for their own work.

As discussed in Section 5.2.3, it was chosen to use automatic saving of the assignment after every change to make sure that everything gets saved without the user needing to remember to do it by themselves. Even though this feature seemed to be

understood by the pilot users, it was mentioned in one of the group interviews that there should also be the opportunity to save the work by the user, just to make sure everything has been successfully changed [Yrjänäinen, 2013]. Adding a *Save* button next to the information about the previously saved change could help the users feel more in control of their work.

The teachers also had some other comments and requests concerning the assignment editor. In the beginning, the map was considered to be too small, which led to the decision to increase the map size and add the option to minimize the map if needed. The teachers would have wanted to use also polygons alongside the rectangles and circles to define areas. Adding this to the assignment editor would have been very easy, since the Leaflet Draw library has default support for polygons. The reason why this option was not included was the difficulties in using polygons in the mobile application.

Some of the teachers had difficulties in telling what POI was selected on the map. Making the selected POI darker than others or adding some animation to the selected POI was suggested to make it more distinguishable. This denotes that the teachers did not recognize the hiding feature indicated by the eye-icon in the navigation three, or did not know how to double click an element in the navigation tree to make it the centre point of the map. To help with the identification of a selected POI, a pop-up with the name of the element was added to be automatically shown on selection (see Figure 37). There was also a custom version of a darker POI icon added, but because changing the marker on the fly seemed to cause some problems with the map, it was left out of this version, but should definitely be added later on.

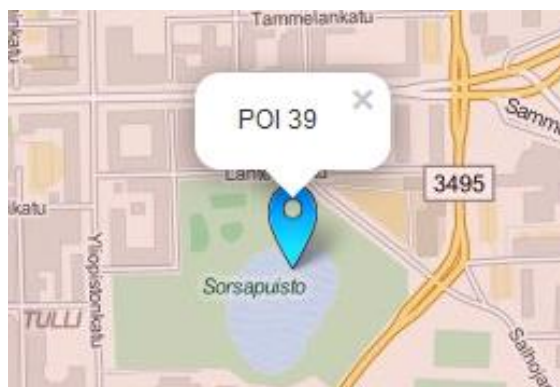


Figure 37. A pop-up with the name of the element was added to make identifying a selected element easier.

As mentioned Section 5.2.4, being able to reuse already created materials was also one of the requests made by the teachers in the pilot group, although there were some concerns expressed in the interviews about copyrights of the created material [Yrjänäinen, 2013]. The teachers also suggested the possibility to add content from other resources e.g. an image database or using a URL to fetch material from a different

source. One of the teachers presented the idea that it would be good to be able to use the material collected by the student as content for the assignments, and that it would be nice to have the students creating their own routes for their peers. This same constructive approach was also used and considered effective in the studies by Barak and Ziv [2013], Giemza and Hoppe [2013], and Sanagustín et al. [2012] discussed in Section 3.2. Even though these were all considered excellent ideas, because of time constraints it was not possible to include them in this version of the Seek’N’Share platform.

The lack of a testing possibility was mentioned as a problem during both of the interviews [Yrjänäinen, 2013]. The teachers commented that the only way to test the created assignments was to go out with a tablet and try the assignments in situ, which they do not always have the time for. This is something that must be addressed in the future by adding a testing functionality to the editor, which can be used to view the assignments just as they would appear on the tablet device.

Even though it was mentioned in the notes by Yrjänäinen [2013] that at this point the Seek’N’Share does not provide that much new in the area of location-based learning, the pilots show that this type of one-page approach for content creation is a good start. The comments by the teachers support the notion that in order to create meaningful learning experiences that differ from the already available solutions, support for an appropriate learning pedagogy should be implemented to the learning platform.

For Seek’N’Share to work as a full e-learning platform, the assignment editor should also be included in the package and available under the same service, and the mobile application should not be platform dependent [Yrjänäinen, 2013]. A further suggestion from one of the teachers was to add augmented reality to the application, where the user could point to a target and automatically see information about that location.

6. Conclusion and future work

Mobile learning is still a fairly new concept, even though the idea relates back to the 1970s. Pedagogies and even the definition for m-learning are still developing. Mobile devices provide many affordances that can be utilized in learning. Key benefits of m-learning systems are summarized by Sampson et al. [2013] as: personalized learning experiences in real world situations, adaptive feedback and support by detecting learners' behavior.

There are also many considerations that must be addressed before adopting mobile-learning into the curriculum. Is the school going to provide the devices or is a BYOD program a better solution? Can the school network handle the additional Wi-Fi-traffic? Other concerns are network security, the possible increase in the amount of needed IT-support, equity issues between students, and possible disruption that allowing mobile devices in the classroom can cause.

Since e-learning has already been widely adopted and platforms like Moodle are already familiar to the teachers, it could be beneficial to incorporate location-based learning to an existing e-learning platform. As presented in Section 2.4, there have already been implementations to support providing material designed especially for mobile devices. Providing learning content in web-form could alleviate some of the issues related to the amount of different mobile devices and operating systems.

Successful implementation of m-learning requires understanding and developing supportive pedagogies that are needed to provide meaningful learning experiences. In Section 2.5 we discussed the concept of context-aware learning and three different pedagogical suggestions for implementing mobile learning were presented: inquiry-based learning, cooperative learning, and the formative assessment strategy. Learning objects (LO's) is another concept closely related to e-learning and m-learning. A learning object is an independent learning resource that can be stored, reused and is not dependent on any particular platform. A good LO includes metadata about the content, which makes finding contextually relevant information possible, and fulfills the promise of mobile devices being able to provide the right information to the learner at the right time. For the use of LO's to become universal and using them across different learning platforms to be possible, unified standards must be developed.

As research has shown, mobile learning is an especially promising way to support learning in the field, outside the classroom. To support the use of location-based learning and learning applications, we need to develop easy ways to create location-based learning material. Even though m-learning has been a huge area of interest for quite some time, there has not been much development in the area of content creation for location-based learning applications. This has been considered to be one of the main reasons why location-based mobile learning has not yet been adopted in schools.

Location-based learning activities can be divided into two main groups: indoor and outdoor learning. These scenarios require the use of different technologies and approaches in how learning content can be created. The main technology to detect the user's location in outdoor setting is GPS. Content for GPS based m-learning applications can usually be created virtually using a web map service to help with placement of learning objects, but it was also discovered that sometimes in situ design might also be needed for locations that are constantly changing. Because GPS does not work in indoor situations, several tag-based solutions have been developed. Tags are physical objects that are placed in the environment to provide additional learning content in situ. The use of these technologies and content creation for different learning scenarios was discussed by presenting six different m-learning solutions: (1) QuesTinSitu, (2) Treasure-HIT, (3) Wandering, (4) etiquetAR, (5) Mobilogue, and (6) an unnamed RFID-based learning system.

This thesis also presented the Seek'N'Share platform for location-based mobile learning, developed as a part of the Digital Services research program of the DIGILE Strategic Centre for Science, Technology and Innovation, funded by Tekes – the Finnish Funding Agency for Technology and Innovation [Heimonen et al., 2013]. The platform includes a mobile application for in-field cooperative discovery, knowledge gathering and construction through the activity of creating a joint presentation about the learning activity, and an authoring tool for generating content for the learning activities.

The assignment editor for Seek'N'Share is a generic tool for creating learning experiences in outdoor settings by using location-based learning areas and points of interests (POIs) with different learning tasks connected to them as learning objects. The POIs can also have additional multimedia content connected to them. Seek'N'Share uses text-to-speech conversion to deliver the descriptions for the learning objects in audio format. Audio cues are also used to inform the user when they have entered a learning area or are close to a POI. The platform supports content reuse by providing the opportunity to organize the tasks added to a learning object by different subjects. This way the same assignment can be used in various scenarios. Created learning objects can also be reused and copied to other assignments. To create a more extensive m-learning platform, adding the possibility to connect the learning objects to indoor spaces using tag-based solutions – as discussed in Chapter 3 – should also be considered.

During the research done for this thesis and testing of the content editor, several ideas for future work have been identified. For the mobile application, better support for cooperation should be included by adding communication and feedback possibilities to the application as discussed in Chapter 4. Since the mobile application is now only available for Android, which restricts the use to one operating system, a future goal should be to make it platform independent. This was also requested by the piloting group in Section 5.3.

As research has shown, and based on the comments of the teachers testing the assignment editor, collaborative assignment creation is an important feature and it should be better supported. Adding content from previously created assignments should be improved by including better filtering options and a common resource bank where e.g. multimedia could be stored. In order to support efficient filtering and discovery of learning objects, additional metadata should be added by the teachers. This would also add more possibilities for supporting the context-awareness – discussed in Section 2.5.1 – of the mobile application.

Even though the goal of the Seek’N’Share assignment editor has been to provide a generic and flexible tool for creating location-based learning assignments, in order to offer something really new and to go beyond the novelty factor of m-learning as previously mentioned by Song [2014], support for different m-learning pedagogies should be included. The negative effect of implementing certain pedagogies is the possible added complexity to the authoring side.

To be able to give the tool for free use, better admin tools and different user profiles for administrators, teachers and students should be developed. This way students could also use the editor to create content, as was suggested by one of the teachers in the post pilot interviews. This same approach was also in the studies by Barak and Ziv [2013], Giemza and Hoppe [2013], and Sanagustín et al. [2012]. To support in situ content creation as discussed in Section 3.2, the material gathered using the mobile device should be made available in the editor side.

To fully support the idea of a seamless learning environment, the Seek’N’Share platform should also provide means for the students to continue editing their presentations after the in-field learning activity. There have already been plans to add a separate presentation editor for the students. The editor should be connected to the assignment editor, so teachers could contact the groups and give feedback using the platform.

Other planned features are the possibility to add other markers on the map and the possibility to upload own POI icons. To make using resources from other sources possible, the option to add content by URL should also be added, as was requested by the teachers in the pilot group. To be able to create richer learning experiences, the applications should support providing instant feedback and direction to the students based on their actions and the previous routes that have been taken to reach a certain spot [Heimonen et al., 2013].

From the technical point of view the RESTful API should be extended to handle the login and registration events, so that plain HTML-pages could be used for those as well, and there would not be the need for additional resource-files for localization of ASP.NET pages. The option of adding custom map tiles has also been discussed, since this could bring a new interesting layer to the assignments. For example historical maps

could be added as an overlay on top of a present day map to help students learn about historical events [Heimonen et al., 2013].

The content editor has already been extended to support editing content for augmented reality, adding different routes, using YouTube videos for content, using custom markers, and creating more complex quiz-type tasks for another mobile application. The same editor has also been modified to be used to author content for a web-based virtual reality learning application called Citycompass (<http://citycompass.sis.uta.fi/>). This shows that the requirements for extendibility and reusability of the editor and the data model were achieved.

As technologies and pedagogies develop, the direction has started to move more towards ubiquitous learning. It would be interesting to see how we could utilize the content editor, and the assignments created for Seek'N'Share, in the future with these new technologies like Google glasses or Oculus Rift.

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Appendix 1

Client	Service	Method	Description
Tablet	/CloneAssignmentByDIJJSON	GET	/RESTInterface/Tablet/CloneAssignmentByDIJJSON?token={TOKEN}&id={ASSIGNMENTID}
Tablet	/DeleteAssignmentByDIJJSON	GET	/RESTInterface/Tablet/DeleteAssignmentByDIJJSON?token={TOKEN}&id={ASSIGNMENTID}
Tablet	/DownloadMediaFile	GET	/RESTInterface/Tablet/DownloadMediaFile?token={TOKEN}&assignmentID={ASSIGNMENTID}&fileName={FILENAME}
Tablet	/GetAllAssignmentsJSON	GET	/RESTInterface/Tablet/GetAllAssignmentsJSON?token={TOKEN}
Tablet	/GetAllAssignmentsXML	GET	/RESTInterface/Tablet/GetAllAssignmentsXML?token={TOKEN}
Tablet	/GetAssignmentByDIJJSON	GET	/RESTInterface/Tablet/GetAssignmentByDIJJSON?token={TOKEN}&id={ASSIGNMENTID}
Tablet	/GetAssignmentByDXML	GET	/RESTInterface/Tablet/GetAssignmentByDXML?token={TOKEN}&id={ASSIGNMENTID}
Tablet	/GetAssignmentListJSON	GET	/RESTInterface/Tablet/GetAssignmentListJSON?token={TOKEN}
Tablet	/GetAssignmentListXML	GET	/RESTInterface/Tablet/GetAssignmentListXML?token={TOKEN}
Tablet	/ListAllAssignmentMediaFilesJSON	GET	/RESTInterface/Tablet/ListAllAssignmentMediaFilesJSON?token={TOKEN}&id={ASSIGNMENTID}
Tablet	/ListUploadedGroupAssignmentMediaFilesJSON	GET	/RESTInterface/Tablet/ListUploadedGroupAssignmentMediaFilesJSON?token={TOKEN}&groupName={GROUPNAME}&assignmentID={ASSIGNMENTID}
Tablet	/SavePresentation	POST	/RESTInterface/Tablet/SavePresentation?token={TOKEN}&presentationID={PRESENTATIONID}
Tablet	/UploadGroupAssignmentMediaFile	POST	/RESTInterface/Tablet/UploadGroupAssignmentMediaFile?token={TOKEN}&groupName={GROUPNAME}&assignmentID={ASSIGNMENTID}&fileName={FILENAME}
Tablet	/UploadLogFile	POST	/RESTInterface/Tablet/UploadLogFile?groupName={GROUPNAME}
WebUI	/CopyAssignmentFile	GET	/RESTInterface/WebUI/CopyAssignmentFile?token={TOKEN}&fromAssignmentID={FROMASSIGNMENTID}&toAssignmentID={TOASSIGNMENTID}&fileName={FILENAME}
WebUI	/DeleteMediaFile	GET	/RESTInterface/WebUI/DeleteMediaFile?token={TOKEN}&assignmentID={ASSIGNMENTID}&fileName={FILENAME}
WebUI	/DownloadMediaFile	GET	/RESTInterface/WebUI/DownloadMediaFile?token={TOKEN}&assignmentID={ASSIGNMENTID}&fileName={FILENAME}
WebUI	/GetAllPresentationsJSON	GET	/RESTInterface/WebUI/GetAllPresentationsJSON?token={TOKEN}
WebUI	/LoginUser	POST	/RESTInterface/WebUI/LoginUser?userName={USERNAME}
WebUI	/PublishAssignment	GET	/RESTInterface/WebUI/PublishAssignment?token={TOKEN}&assignmentID={ASSIGNMENTID}&published={PUBLISHED}
WebUI	/SaveAssignmentJSON	POST	/RESTInterface/WebUI/SaveAssignmentJSON?token={TOKEN}
WebUI	/TextToSpeech	POST	/RESTInterface/WebUI/TextToSpeech?token={TOKEN}&assignmentID={ASSIGNMENTID}&language={LANGUAGE}&fileNameBase={FILENAMEBASE}
WebUI	/UploadMediaFile	POST	/RESTInterface/WebUI/UploadMediaFile?token={TOKEN}&assignmentID={ASSIGNMENTID}&fileName={FILENAME}

The Seek’N’Share data model presented using an example assignment created using the assignment editor

JSON:

```
{
  ,
  "description": null,
  "id": 215,
  "lastmodification": 1431594419,
  "name": "Sights in Tampere",
  "published": 1,
  "subjectlist": [
    "All",
    "History"
  ],
  "area": {
    "audio": [],
    "description": null,
    "east": 23.842864,
    "id": 1,
    "lat": 0,
    "long": 0,
    "marker": [],
    "name": "MapArea",
    "north": 61.514482,
    "poi": [],
    "radius": 0,
    "south": 61.483509,
    "task": [],
    "type": "map",
    "visibility": null,
    "west": 23.718843,
    "zoomLevel": 14,
    "area": [
      {
        "area": [
```

```

{
  "area": [],
  "audio": [
    {
      "type": "audioEnter",
      "url": "defaultEnter.mp3"
    },
    {
      "type": "audioLeave",
      "url": "defaultLeave.mp3"
    },
    {
      "type": "areaDescription",
      "url":
        "speech2014122202014.mp3"
    }
  ],
  "description": "Famous marketplace
    in Tammela.",
  "east": 23.77951,
  "id": 40,
  "lat": 0,
  "long": 0,
  "marker": [],
  "name": "Tammelantori",
  "north": 61.50239,
  "poi": [],
  "radius": 0,
  "south": 61.500982,
  "task": [],
  "type": "rectangle",
  "visibility": "always",
  "west": 23.778083,
  "zoomLevel": 0
}
],
"audio": [
  {
    "type": "audioEnter",

```

```

        "url": "defaultEnter.mp3"
    },
    {
        "type": "audioLeave",
        "url": "defaultLeave.mp3"
    },
    {
        "type": "areaDescription",
        "url": null
    }
],
"description": null,
"east": 23.78643,
"id": 35,
"lat": 0,
"long": 0,
"marker": [],
"name": "Tammela",
"north": 61.505276,
"poi": [
    {
        "audio": [
            {
                "type": "audioEnter",
                "url": "defaultEnter.mp3"
            },
            {
                "type": "audioLeave",
                "url": "defaultLeave.mp3"
            },
            {
                "type": "poiDescription",
                "url":
                    "speech201451162735.mp3"
            }
        ]
    },
    {
        "description": "Fountain honoring
            the industrialist and
            philanthropist Emil Aaltonen. ",

```

```

    "id": 36,
    "image": [
      {
        "caption": "Emil
Aaltonen",
        "infotext": "See page for
author [Public domain], via
Wikimedia Commons",
        "url": "Emil_Aaltonen.jpg"
      }
    ],
    "lat": 61.502195,
    "long": 23.780401,
    "name": "Fountain honoring Emil
Aaltonen",
    "radius": 5,
    "task": [],
    "video": [],
    "visibility": "always"
  }
],
"radius": 0,
"south": 61.499052,
"task": [],
"type": "rectangle",
"visibility": "always",
"west": 23.774199,
"zoomLevel": 0
},
{
  "area": [],
  "audio": [
    {
      "type": "audioEnter",
      "url": "defaultEnter.mp3"
    },
    {
      "type": "audioLeave",
      "url": "defaultLeave.mp3"
    }
  ]
}

```



```

    },
    {
        "type": "areaDescription",
        "url": "speech201412220365.mp3"
    }
],
"description": "A park located next to
Tampere Hall, with a small pond and lots of
birds.",
"east": 0,
"id": 34,
"lat": 61.497127,
"long": 23.782911,
"marker": [],
"name": "Sorsapuisto",
"north": 0,
"poi": [],
"radius": 160.2,
"south": 0,
"task": [],
"type": "circle",
"visibility": "always",
"west": 0,
"zoomLevel": 0
},
{
    "area": [],
    "audio": [
        {
            "type": "audioEnter",
            "url": "defaultEnter.mp3"
        },
        {
            "type": "audioLeave",
            "url": "defaultLeave.mp3"
        },
        {
            "type": "areaDescription",
            "url": "speech2014122203636.mp3"
        }
    ]
}

```

```

    }
  ],
  "description": null,
  "east": 0,
  "id": 31,
  "lat": 61.495796,
  "long": 23.782182,
  "marker": [],
  "name": "Tampere Hall",
  "north": 0,
  "poi": [],
  "radius": 97,
  "south": 0,
  "task": [
    {
      "audio": [
        {
          "type": "taskDescription",
          "url": null
        }
      ],
      "description": "Task 1.",
      "topic": "All"
    },
    {
      "audio": [
        {
          "type": "taskDescription",
          "url": null
        }
      ],
      "description": "Task 2",
      "topic": "All"
    },
    {
      "audio": [
        {
          "type": "taskDescription",
          "url": null
        }
      ],
      "description": "Task 3",
      "topic": "All"
    }
  ]
}
```

```

        }
    ],
    "description": "Task related to
history.",
    "topic": "History"
}
],
"type": "circle",
"visibility": "always",
"west": 0,
"zoomLevel": 0
}
]
}
}

```

XML:

```

<?xml version="1.0" encoding="utf-8"?>
<assignment xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <id>215</id>
  <name>Sights in Tampere</name>
  <published>1</published>
  <lastmodification>1431594419</lastmodification>
  <subjectlist>
    <subject>All</subject>
    <subject>History</subject>
  </subjectlist>
  <area>
    <id>1</id>
    <type>map</type>
    <name>MapArea</name>
    <north>61.514482</north>
    <east>23.842864</east>
    <south>61.483509</south>
    <west>23.718843</west>
    <zoomLevel>14</zoomLevel>
  </area>

```

```

<id>35</id>
<type>rectangle</type>
<name>Tammela</name>
<north>61.505276</north>
<east>23.78643</east>
<south>61.499052</south>
<west>23.774199</west>
<visibility>always</visibility>
<audio>
  <type>audioEnter</type>
  <url>defaultEnter.mp3</url>
</audio>
<audio>
  <type>audioLeave</type>
  <url>defaultLeave.mp3</url>
</audio>
<audio>
  <type>areaDescription</type>
</audio>
<area>
  <id>40</id>
  <type>rectangle</type>
  <name>Tammelantori</name>
  <north>61.50239</north>
  <east>23.77951</east>
  <south>61.500982</south>
  <west>23.778083</west>
  <visibility>always</visibility>
  <description>Famous marketplace in
Tammela.</description>
  <audio>
    <type>audioEnter</type>
    <url>defaultEnter.mp3</url>
  </audio>
  <audio>
    <type>audioLeave</type>
    <url>defaultLeave.mp3</url>
  </audio>
</audio>

```

```

        <type>areaDescription</type>
        <url>speech2014122202014.mp3</url>
    </audio>
</area>
<poi>
    <id>36</id>
    <name>Fountain honoring Emil Aaltonen</name>
    <lat>61.502195</lat>
    <long>23.780401</long>
    <visibility>always</visibility>
    <radius>5</radius>
    <description>Fountain honoring the industrialist
and philanthropist Emil Aaltonen. </description>
    <image>
        <caption>Emil Aaltonen</caption>
        <infotext>See page for author [Public domain],
            via Wikimedia Commons</infotext>
        <url>Emil_Aaltonen.jpg</url>
    </image>
    <audio>
        <type>audioEnter</type>
        <url>defaultEnter.mp3</url>
    </audio>
    <audio>
        <type>audioLeave</type>
        <url>defaultLeave.mp3</url>
    </audio>
    <audio>
        <type>poiDescription</type>
        <url>speech201451162735.mp3</url>
    </audio>
</poi>
</area>
<area>
    <id>34</id>
    <type>circle</type>
    <name>Sorsapuisto</name>
    <lat>61.497127</lat>
    <long>23.782911</long>

```

```

<radius>160.2</radius>
<visibility>always</visibility>
<description>A park located next to Tampere Hall,
with a small pond and lot's of birds.</description>
<audio>
  <type>audioEnter</type>
  <url>defaultEnter.mp3</url>
</audio>
<audio>
  <type>audioLeave</type>
  <url>defaultLeave.mp3</url>
</audio>
<audio>
  <type>areaDescription</type>
  <url>speech201412220365.mp3</url>
</audio>
</area>
<area>
  <id>31</id>
  <type>circle</type>
  <name>Tampere Hall</name>
  <lat>61.495796</lat>
  <long>23.782182</long>
  <radius>97</radius>
  <visibility>always</visibility>
  <audio>
    <type>audioEnter</type>
    <url>defaultEnter.mp3</url>
  </audio>
  <audio>
    <type>audioLeave</type>
    <url>defaultLeave.mp3</url>
  </audio>
  <audio>
    <type>areaDescription</type>
    <url>speech2014122203636.mp3</url>
  </audio>
  <task>
    <description>Task 1.</description>

```

```

    <topic>All</topic>
    <audio>
      <type>taskDescription</type>
    </audio>
  </task>
  <task>
    <description>Task 2</description>
    <topic>All</topic>
    <audio>
      <type>taskDescription</type>
    </audio>
  </task>
  <task>
    <description>Task related to
    history.</description>
    <topic>History</topic>
    <audio>
      <type>taskDescription</type>
    </audio>
  </task>
</area>
</area>
</assignment>

```

Add new user to the system

Primary actor: Administrator

System: SeekNShare backend

Precondition: SeekNShare server up and admin user set

Scenario:

1. Log in as an administrator
2. Add new user to the system
3. Fill in required information (+ set role as teacher)
4. Save new user
5. Display users with options to edit information or delete user
6. Log out

Add new assignment

Primary actor: Teacher

System: SeekNShare backend

Precondition: Teacher added to the system

Scenario:

1. Log in
2. Select 'Add new assignment'
3. Give a name to the assignment
4. Search for a location where you want to place your tasks
5. Update the map according to search
6. Add elements to the map:
 - a. Add new area
 - i. Add task(s) to area
 - ii. Set visibility
 - b. Add new POI
 - i. Set visibility
 - c. Add new marker
7. Save for later without publishing the assignment
8. Log out

Edit and publish an assignment

Primary actor: Teacher

System: SeekNShare backend

Precondition: Teacher logged in and assignment added

Scenario:

1. Select previously created assignment for editing
2. Move to edit-view and show all added elements on the map
3. Select an element to see tasks connected to it

4. Edit task information
5. Delete an area from the map
6. Move tasks and POIs connected to that area on an upper level
7. Delete a POI from the map
8. Undo delete
9. Set assignment as published
10. Save
11. Show all assignments

View presentations

Primary actor: Teacher

System: SeekNShare backend

Precondition: Teacher logged in and presentations send to server via the SeekNShare app

Scenario:

1. Go to results-view
2. Display all results from all assignments
3. Select an assignment to view only presentations under that assignment
4. Filter results
5. Select a presentation to view
6. Show presentation to the class

Feature list for the Seek'N'share assignment editor

View	Feature	Done	Tested
All	Login information		
All	Navigation menu (content: frontpage, add new assignment, results)	x	x
Frontpage	List all assignments created by the person logged in	x	x
Frontpage	Copy an assignment -> new assignment (e.g. Tammerkoski copy) added to the table of assignments	x	x
Frontpage	Delete an assignment	x	x
Frontpage	Undo delete	x	x
Frontpage	Select results for an assignment in the assignments table -> move to the results view and open the results for that assignment	x	x
Frontpage	Publish an assignment	x	x
Frontpage	Create new assignment -> move to assignment view	x	x
Assignment	Edit assignment name	x	x
Assignment	Publish an assignment	x	x
Assignment	Force task order	-	-
Assignment	Draw a new area on the map and save data	x	x
Assignment	Edit an area on the map and save changes	x	x
Assignment	Give a name to an area	x	x
Assignment	Set visibility of an area (Options: always, entering the area)	x	x
Assignment	Give the area arrive and leave sounds (if not given, use default sounds)	x	x
Assignment	Listen the selected sound	x	x
Assignment	Give the area a description	x	x
Assignment	Listen the area description converted to speech	x	x
Assignment	Add a task to the area	x	x
Assignment	Rearrange the order of tasks/areas by dragging		
Assignment	Drop a new POI to the map	x	x
Assignment	Drag the POI to a new location	x	x
Assignment	Give a name to the POI	x	x
Assignment	Set the radius of the POI by using a slider	x	x
Assignment	Add a picture from the computer to the POI and give it a caption and infotext	x	x
Assignment	Add a video to the POI	x	x
Assignment	Add an audio file to the POI	x	x
Assignment	Drop a marker on the map (options: start, finish, pin)		

Assignment	Drag the marker to a new location		
Assignment	List all the areas, tasks and POIs in a tree view menu	x	x
Assignment	Set an area/point as not visible/visible from the tree view menu	x	x
Assignment	Save the assignment -> show 'Saved + time'	x	x
Assignment	Undo previous 5 changes	x	x
Assignment	If a user has made changes to an assignment and tries to move to another page -> pop-up asking for saving changes (save, cancel, do not save)	x	x
Assignment	Delete the assignment -> back to frontpage with undo link		
Results	List all assignments in a menu	x	x
Results	Show all assignments and their results	x	x
Results	Select an assignment from the menu and show its results	x	x
Results	Watch an assignment -> pop up video that can be watched fullscreen		
Results	Set video as watched after a presentation has been watched (at least 90%?)		
Results	Set video as unwatched manually		
Results	Download presentation		
Results	Upload presentation to Facebook		
Results	Delete presentation		