Location-based Services for Technology Enhanced Learning and Teaching

Christoph Rensing[1], Stephan Tittel[2], Ralf Steinmetz[1]

[1]Multimedia Communications Lab, Technische Universität Darmstadt, Darmstadt, Germany
{christoph.rensing, ralf.steinmetz}@kom.tu-darmstadt.de
[2]Hessian Telemedia Technology Competence-Center, Darmstadt, Germany
stephan.tittel@httc.de

Abstract. Learning does not only take place in a conventional classroom setting but also during everyday activities such as field trips. The increasing availability of mobile devices and network access opens up new possibilities for providing location-based services which support for such learning scenarios. In this paper, we argue the need for providing context aware services for authors of learning content as well as for learners. We present two scenarios and new services which fit to these scenarios. The first is an extension of docendo, an open learning content authoring and management platform, to support teachers while creating location-based learning material for field trips. Second service is a mobile application which allows learners to participate in the creation of learning resources by writing a wiki article and retrieve learning modules from a semantic MediaWiki using a facetted search. Learner location is one search parameter within the search.

1 Introduction

Due to the increasing popularity of mobile devices like smartphones or tablet PCs, and the extensive and increasingly cost-effective availability of wireless Internet connections, mobile learning will become more important. The outstanding importance of mobile learning is reflected in the Horizon Report [1]. An expert survey in [2] shows that mobile technologies offer many opportunities, especially in terms of access to learning and contextual learning.

An important benefit, which can be achieved by mobile technologies, is contextual learning, in which learning content is made available and learning activities are selected depending from the learner's context. The current location or an object, like a building, exhibit or instrument, which is located near the learner are important characteristics of the context. With this kind of contextual learning the authenticity of the learning process can be increased, by learning at the learning object, for example the building. Beyond this, learning can be realized based on learner's needs, if for example the challenge is to repair an instrument like a ticket machine. To support location-based learning and teaching as type of contextual learning is the goal of our efforts.

In this paper we introduce two different scenarios of location-based learning and teaching and describe our technical solutions as well as our experiences in these two different scenarios. The first scenario is a so-called field trip. We extend existing approaches for support of field trips by assisting the teacher in his/her role as the author of learning material, especially during the process of content authoring for a field trip scenario. In the second scenario we place the emphasis on active participation of the learners as authors of learning material which is related to a location or to a stationary object by using a wiki system. Furthermore we consider a semantic description of the location or the stationary objects which are content of the learning task.

This paper is organized as follows. Section 2 introduces the two scenarios, their benefits and resulting challenges in depth. Section 3 summarizes different existing approaches and projects in location-based learning and teaching and in social learning. Social learning means learning where learners participate actively in the learning process especially by using Web 2.0 tools. Section 4 emphasizes our solution to support the first scenario based on an extension of our open learning content authoring and management platform docendo. In Section 5, we look at our solution for the second scenario. The paper ends with a summary of the experiences made during the use of our new services at our university in Section 6 and a summary and an outlook.

2 Scenarios

2.1 Field Trip, a basic Scenario of Location-based Learning

In location-based learning, like in field trips, the mediation of learning content shall be illustrative and will be held outside the classroom, in order to increase the motivation of the learners. In addition, each learner shall make his or her own individual experiences and deepen his or her knowledge him- or herself by interacting with the learning material which is assigned to a location for example by answering and reflecting on test questions. Therefore, the learner has to determine in what order and at what pace learners wish to learn, which means that he has to select the stations of a field trip.

To access the stations of a field trip usually the learners either use a map created by the teacher or search for physical labels which mark the stations. Physical labels are not viable in public space where it is not allowed to put them. In mobile learning using mobile devices the learner usually gets a map on his mobile devices where the locations of the stations as well as her own location are indicated, like shown in Figure 1. This figure is taken from our solution for the first scenario, which is described in Section 4. If the learner has arrived at a station he or she selects the learning resources provided by the teacher for the station on the mobile device.

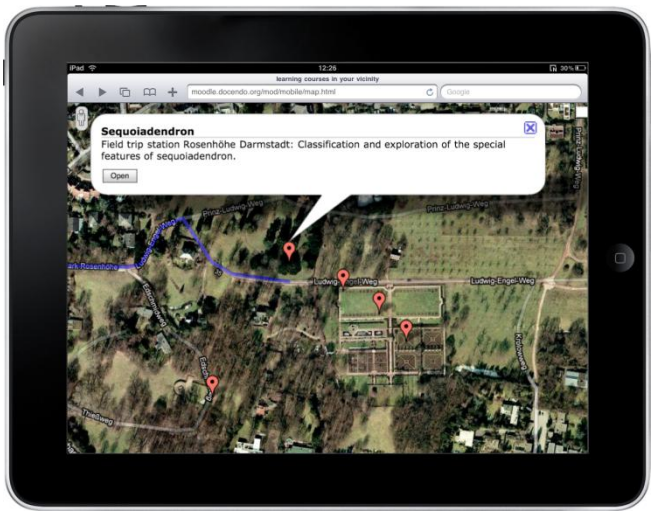

Fig. 1. Map View of field trip stations

Stations presented to the learner in the map have to be filtered if the clarity is compromised by a multitude of stations in the range of a learner or if stations are not equally suitable to reach the individual learning goal. Therefore we want to allow the filtering of stations presented to the learner, like shown in Figure 2 which is taken from the realization of our second scenario. The definition of features differs for different scenarios. Therefore it shall be adaptable by the authors. In our example the learner can filter the stations, which are bridges, in the basis of different criteria like Bearing, form of construction or period of construction.

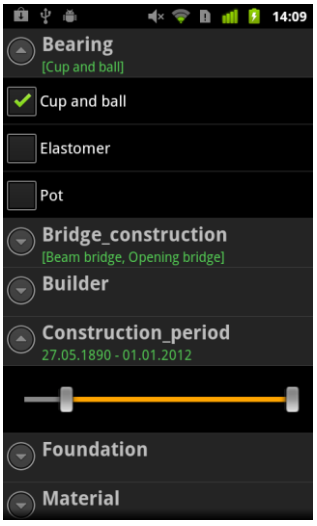

Fig. 2. Filtering of different features for selection of stations

2.2 Authoring of Learning Content for Field Trips

Preparing a field trip is a challenging task for teachers. They have to determine specific learning stations to be visited by the learners and have to document the location of the station, for example by highlighting them on a map, so that they will be able to locate the learning material correctly. The teachers also have to collect relevant information about the stations which will be presented in processed form as learning material to the learners at the various stations later on. Information collection can be done by taking photographs or films of the stations and by writing down instructions or questions for the learner.

In a second step, back in the classroom or office, the teachers have to prepare the information collected to provide learning material to the learners. First they have to retrieve the resources they collected, such as the pictures they took on their camera or instructions they wrote down and assign these to the respective stations. The various stations will also need to be located electronically on a map for the learners to be easily accessible.

As shown in this scenario, the preparation of the resources for each station without technical support is very time-consuming and tedious. The teachers have to associate every resource to a station and have to document the location of the station manually.

We therefore want to support this scenario in the following manner: The teachers create resources using their mobile devices by making photos and noting down questions using a mobile authoring application. They can do this initially in form of a draft, and revise it at a later stage. When a resource is created, the location is automatically determined and assigned to the resource. The allocation of resources to a station is done by matching the location information of the resource to the location of the station. The resources collected are automatically transferred and stored in a repository. These resources can thus be easily retrieved later by the authoring system when the teachers do the final authoring of the learning material back in the classroom or office.

2.3 Learner Participation in Authoring of Content for Location-based Learning

The scenario described above is characterized by the activation of the learners at the different stations. The creation of learning content is solely done by the teacher. Greater participation of learners offers further potential. This potential is demonstrated by different experiences made in the use of so-called Web 2.0 applications in learning [3]. Learners actively take part in the learning process and become content producers sometimes. Our goal is to combine the advantages of mobile learning with the advantages of activation which can be achieved by participation of learners in the content preparation process.

Due to very good motivational experiences in creation of wiki articles by learners [4], we also want to use a wiki system. In the wiki learners can create the learning resource which belongs to a station as wiki page. At the same time we want to motivate the learners in using their mobile devices to collect and localize information and

pictures for the wiki pages like the teachers in the preceding scenario of authors support.

3 Related Work

There is a huge amount of projects in which mobile learning scenarios and technologies have been developed and have been evaluated. The museum and tourism sectors have been active early on in developing material and systems for contextualized location-based learning. In examples from these sectors quite often specialized devices are needed, for example in a museum environment, or physical markers are used to detect the location, for example in guided city tours. In recent years, there are several approaches to use everyday devices like smart phones in location-based learning. These approaches focus on supporting the learner by detecting his context, especially her location, and thereby delivering learning content that fits to the location of the learner, meaning the base scenario introduced in Section 2.1.

Examples which address the mobility of the learner in this base scenario are manifold. In ARLearn [5] learners, as they move within a city, get information about learning resources which are related to objects like buildings or monuments in the nearby environment of the learners. Not only textual content but also audio and video documents are presented.

As example for the integration of playful elements in location-based learning [6] has to be mentioned. The authors realize a game in which students explore the university campus and city. They have to visit different stations within the site and solve tasks at the different stations. Sensor technology is acquired, to prove that they are at the correct station.

Activation of the learners at different stations or objects is also done in MyArtSpace [7], which supports mobile learning during school trips to museums or art galleries. Students take pictures, make voice recordings and take notes on a smartphone and send the collected material to a personal weblog. The collected material can be worked on later in the classroom. A similar approach is used in [8], where learning activities both outside the school and in the classroom are supported. Learners use PDAs to record observations in an ecosystem in a park and to localize them by using GPS coordinates. Tasks, which have to be fulfilled, are presented to the learners in form of cards. Due to the lack of an Internet connection of the PDAs, cards and observations are exchanged locally by using a laptop as server. Ambient Wood [9], MOBIlearn [10] or Math4Mobile [11] are other examples for mobile learning projects.

Apart from these projects in the area of mobile learning there are many activities to use Web 2.0 applications for learning and teaching, which are also important to highlight in the context of this paper, pursuing the goals of our second scenario. The term Web 2.0 was originally used in 2003 and has been given broad notice since 2006, when it has been used in [12]. It refers to technologies and applications that facilitate creativity, information and knowledge sharing, and collaboration. These attributes are assumed to be useful in learning processes too [13]. By now, different experiences

have been made, especially in using wikis [14] [15] [16] and blogs [17] [18] [19] in learning scenarios.

Building on these general experiences and the excellent experience gained by our project partners in the application of wikis we decided to combine location based learning and participative learning as presented in Section 2.3. Besides MyArtSpace [7], to the best of our knowledge, none of the existing approaches supports Web 2.0 content creation by the learner in a mobile scenario. Our approach to collect information and photos by the learner for preparation of a wiki page will be described in Section 5 in detail.

Also there exist no tools which actually support the mobility of the author during the creation of learning material for a field trip in the sense of collection of information and material in a repository and description of the information by geo-coordinates. In order to meet these needs of the author, we extended our existing learning content authoring and management platform docendo. This approach will be presented in the next section.

4 Location-based Learning Content Authoring

As we have explicated before, there exist no tools which support authors in creating learning resources for location-based learning regarding the requirements we collected in Section 2.2. Hence we developed a new tool, which is an extension to our own authoring platform docendo. Below we will first introduce docendo, followed by a description of the extensions for location-based content authoring.

4.1 The Open Learning Content Authoring and Management Platform docendo

docendo is an open source web-based platform for the authoring of web-based trainings (WBT), which can be complex trainings but small modules also. In addition it has functions for management and exchange of resources to support collaborative authoring.

The different functions of docendo are shown in Figure 3. The authoring component of docendo is composed of different editors (the Course Structure Editor, the Section Editor, the Testitem Editor, and the Reference and Glossary Editor). By using these editors the author creates resources of different granularity and type. Only the creation of assets, like images, videos or animations, takes place outside the docendo platform using external tools. A course using the edited resources is structured using the Course Structure Editor, which is shown in Figure 4. Complete courses are exported using an XSL-transformation to generate a content package which is compliant with SCORM (Sharable Content Object Reference Model) [20]. These are offered to the learner generally by using a separate learning management system. docendo provides in addition to the SCORM-export the facility to generate small modules in form of HTML pages. We assume that for location-based learning small modules are used most of the times.

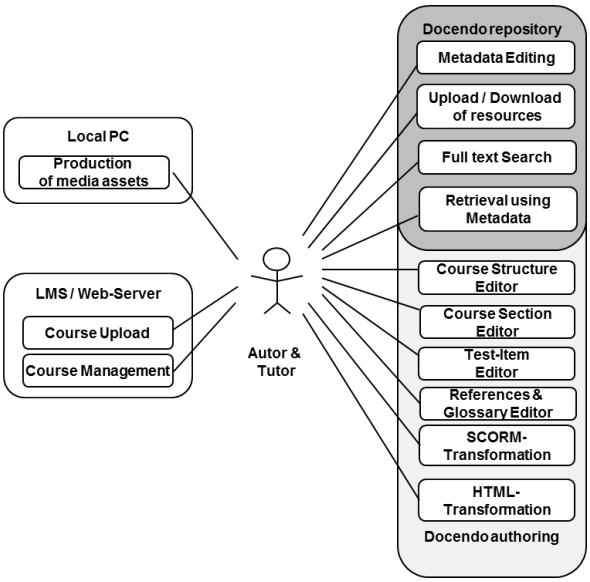

Fig. 3. docendo Use Cases

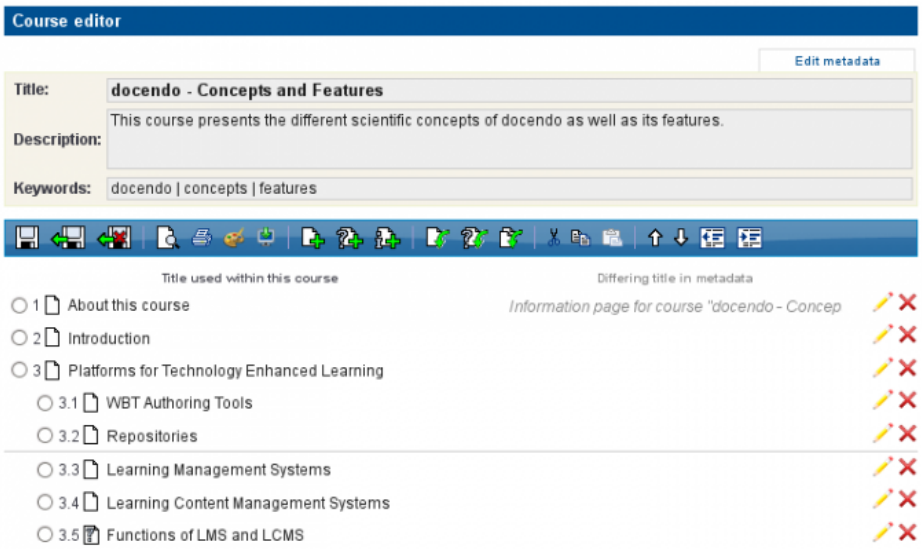

Fig. 4. Course Structure Editor

All resources, which are edited using the different editors mentioned before, are stored in the docendo repository. Same applies to multimedia assets, which are integrated in a section of a course. Resources and assets are described by metadata using the LOM (Learning Object Metadata) set [21]. The resource repository offers search,

upload and download functionalities. These functionalities are integrated in the Section Editor and Course Structure Editor likewise to allow usage of existing resources while creating a section or course.

In summary docendo can be characterized by the following properties, which are described in [22] in detail:

- The provision of resources in a repository. Resources can have different aggregate levels, from assets to entire courses.
- The support of modular reuse and authoring by aggregation [22], which means that all existing resources from assets to sections can be modified by any author and can be integrated in a new course.
- The integration of metadata editing in the authoring process in a transparent fashion and thus providing a high level of user friendliness.
- The support of collaborative authoring in groups.
- The strict separation of content from layout, thereby enabling instructors without specialized knowledge of HTML editors and multimedia tools to create self-study material by themselves.
- The adoption of data format standards such as Sharable Content Object Reference Model (SCORM) and Leaning Object Metadata (LOM) for content and metadata respectively to support the exchange of learning content across different platforms.

4.2 Location-based Content Authoring in docendo

After introducing docendo we want to explain how we support authors in creation of learning resources for location-based learning as required in Section 2.2. For that we have to extend the docendo use case by the support of mobile devices, as shown in Figure 5. Authors need functionalities which allow the editing of notes, which are stored as drafts of docendo sections in the docendo repository, and the creation and upload of assets, photos and videos in particular. Learners need location-based access to courses or sections of a course to realize the advantages of contextual learning which have been explained in the motivation.

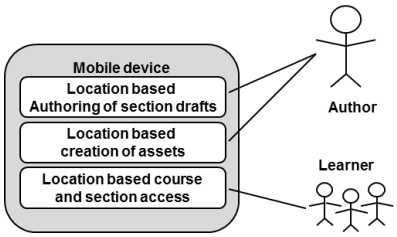

Fig. 5. Extension of docendo Use Cases for mobile devices

To realize the use cases supporting the author we developed a mobile docendo editor for authoring on the Android operating system. The author can use this editor for writing descriptive texts, work orders or questions for test-items using his or her mobile device, see Figure 6. These drafts of sections are stored in the docendo repository.

The stored section can be revised and complemented at a later date using the existing docendo editors. In addition teachers can assign one or more assets, which they created with his mobile device, particularly photos or videos, to the section. Assets are uploaded to the repository also.

All sections and the resources are described by the location. To detect the location we usually use the GPS coordinates. If these are not available, we use the coordinates of a query with HTML 5.0. Since this can be inaccurate, it is possible to adjust the position in docendo later, like shown in Figure 6. The location information is stored in the LOM metadata set using the field General/Coverage, which is also shown in Figure 6.

To realize the use case “Location-based course and section access” we do not need a new application. The existing browser on the mobile device can be used to access courses and sections. Hence the sections are presented on a map, based on Google maps. The current position of the user and all sections are displayed, as shown in Figure 1 (where the current position of the user is panned out of view and the shortest route to the selected learning object is highlighted in blue). The sections in either view can directly be opened by the learner with a single click or tap.

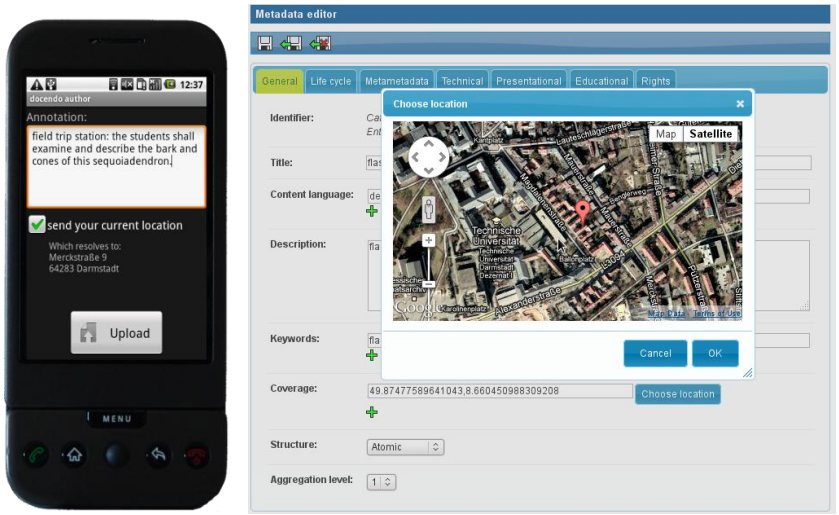

Fig. 6. Upload of notes and later editing of their geo-location in docendo

5 Semantic MediaWiki for Location-based Learning

As we said before, to the best of our knowledge there exist no approaches which support wiki content creation in a learning scenario in which the content is created by the learner in a mobile scenario. To support the requirements described in Section 2.3 we developed a mobile app for the Android operating system which is used by the learner to collect notes and photos in a wiki page. To allow the filtering of learning resources regarding different aspects in addition to the current location we use Se-

mantic MediaWiki. Next we describe how we use Semantic MediaWiki to realize a flexible domain model and how the filtering of resources can be done by using this domain model. We explain the domain model using our evaluation scenario from civil engineering as example. In this scenario the objects used for contextual learning are bridges. The app for mobile content collection in wiki pages is shown at the end of this section.

5.1 Realization of a flexible domain model using Semantic MediaWiki

Semantic MediaWiki [23] is an open source extension to the MediaWiki software, providing means for semantic labeling of wiki content using explicit mark-up, so-called semantic properties. Semantic properties allow further characterization of links and data by semantically annotating the relationship between two wiki pages or between wiki page and data. Thus, content that has been annotated by semantic properties can by interpreted by a computer [24].

The application-specific domain model, which is used for filtering relevant learning material, is realized using semantic properties within Semantic MediaWiki. For that, it is only necessary to label concepts of the domain model within the running text of the wiki page with the extended wiki mark-up of corresponding semantic properties. Thus, the sentence

```
The Main-Bridge, the so-called Eiserner Steg, was built
in 1868 from a blueprint of J.P.W. Schmick.
```

becomes the semantically annotated sentence:

```
The Main-Bridge, the so-called Eiserner Steg, was built
in [[Construction period::1868]] from a blueprint of
[[Architect::J.P.W. Schmick]].
```

Effectively, this creates two semantic properties `Construction period` and `Architect` with values `1868` and `J.P.W. Schmick`, respectively. The data type of these properties is `Page` by default, which means that these properties are being rendered as links to wiki pages. Semantic MediaWiki however supports further data types, most notably `Number`, `Date` and `Geographic coordinate`, which can be set on the corresponding property page using the instruction `[[Has type::<data type>]]`. In this manner, all features of the domain model get mapped to specific semantic properties within the wiki.

5.2 Using the domain model for location-based, facetted content provision

For realization of location-based learning and filtering of learning material as claimed in the base scenario described in Section 2.1 the domain model is exploited. The Android application, used by the learner during the field trip, communicates with a Semantic MediaWiki server as shown in Figure 7.

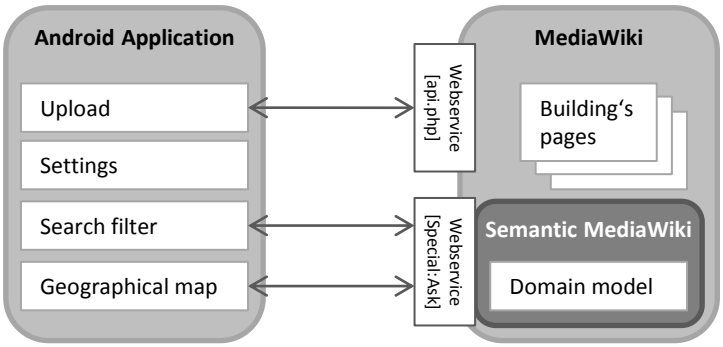

Fig. 7. Architectural overview of the software components involved

As soon as the the Android application is started it retrieves all semantic properties and their existing values as JavaScript Object Notation (JSON) formatted data from a web service, i.e. the page `Special:Ask`, which is provided by Semantic MediaWiki. These properties are then presented to the learner as filter facets, as shown in Figure 2 in Section 2.1. The active facet values, together with the learner's current location, are being used to define the parameters for searching for learning materials, buildings in our case, to match the learner's current information need.

Retrieving the filter facets is a two-step process. First, all semantic properties are requested from the wiki, that have the label `[[filter::true]]` defined on their property page. This way, it is possible to use semantic properties on wiki pages that do not necessarily serve as filter properties for the Android application. Second, all currently used values of the properties gained in the first step are retrieved. Hence the user interface for configuring search facets is domain independent and dynamically acts in accordance with the properties currently being employed in the wiki. Another advantage of this method is that changes in the content of the wiki are immediately reflected in the filter facets of the Android application.

The filter properties are being used to confine the search results to match the current information need of the user. To also embrace the current location of the user, all wiki articles are annotated with the geo-coordinates of the corresponding buildings. For that, we define a special property `[[Has coordinates]]` with data type `Geographic coordinate`. This data type allows defining latitude and longitude both in decimal and degree/minutes/seconds formats. The web service provided by Semantic MediaWiki, that is being used for semantic search, already contains an algorithm supporting perimeter search around a geographic coordinate. The radius being employed for this perimeter search can be configured in the settings of the Android application. The current location of the user is determined via GPS or, if not available, via Wifi- or GPRS-based localization. In summary, the request to the web service is comprised of the active filter properties, the current location of the user and the search radius.

The results of the location-based, facetted search are displayed as markers in the environment of the user on a Google Maps view, as shown in Figure 1. Tapping on one of these building markers opens a dialog containing the name of the building, its semantic properties of the domain model and a button for opening the corresponding wiki page. The wiki page will be opened in the internet browser of the mobile device, not in the Android application itself.

5.3 Location-based Content Collection on a Wiki page

Besides content provision, the Android application supports location-based content collection as kind of learners participation, as mentioned in Section 2.3. The learners are to use the Android application to take photos and make notes of buildings on site. Hence in the first step, the type of medium to be created is being chosen, as shown in Figure 8. At this point we decided to support all media types that modern smart phones are capable of, including the creation of videos. These however cannot reasonably be embedded on wiki pages without format conversion and further adaptations of the wiki itself. For creating photos and videos, existing Android applications specialized for this are being used and the result is then further processed, as is common practice with the Android operating system.

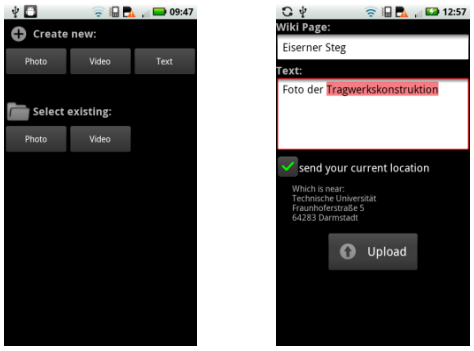

Fig. 8. Selection of photo and Wiki page

After selecting the medium to upload, the user then chooses on which wiki page the medium and the additional text is to be inserted (Figure 8). In case this wiki page does not yet exist, it will be created. Otherwise the new content is appended at the end of the existing page. The text is meant to be in the form of a short note and due to the often tedious text entry interfaces of mobile phones, it intentionally does not support wiki mark-up. The final editing and formatting of the text is intended to be done by the students using conventional PCs. The current location is automatically appended to the text in the form of the semantic property `[[Has coordinates]]` when being transmitted to the wiki. This causes the corresponding wiki page to get extended by that property with the given location.

The entire communication between application and wiki uses, as shown in Figure 7, MediaWiki's web service „api.php". This service provides means for authentication, upload of media and modification of wiki pages. This way, the version history feature of MediaWiki can be used to inspect who did when what changes to a specific wiki page. All information needed for using the web service, namely the web address of the wiki and user account information, can be configured by the students in the settings of the application.

6 Experiences

We have proved the second scenario within two classes in civil engineering at Darmstadt University. In both classes each student has two select an existing building which is physical available to him or her. The student has to visit the building, has to make photos and has to write a wiki page about this building. In this wiki page he or she has to explain details about the construction of the building. Therefore a structure of the page was predefined. Photos have to be general views and have to show details.

In one class, which is about steel construction, the same task has been given to the students in previous semesters also. Then it was accepted from the students and they have been highly motivated [4]. In the last semester the use of smart phones and the app, described in Section 5 have been offered to the students to fulfill the task. The demand to use a smart phone, which was lent to the students for free, was low. Apparently the benefit to use a smart phone seems to be low for the students. They do not see an incentive to use it.

The second class is about history of constructive civil engineering. Students had to select a road bridge in the Rhein-Main region as building which has to be described. In this class more participants used our app even though the number of students in the class has been less. In this class collaborative authoring was a new method. Maybe students hence did not see an alternative to using the app.

In both classes students who use our app mentioned that the app works well in general but they are impatient of the quality of the pictures. They also said that they had to redact the page at home using a browser on a PC. The app has been used for collection of notices only.

7 Summary and Outlook

In this paper, we have presented two approaches to enhance location based learning and teaching. In the first scenario the focus is on the support of teachers which prepare resources for a field trip, which are used by the learners at a later time. The main novelty is the continuous support of the authoring process in docendo. Resources created by the teacher are stored at the docendo repository with assigned geo location automatically. Although a comprehensive evaluation has yet to be made, individual feedback received from teachers using docendo has been positive thus far. Teachers like the facility to create notices at the stations of the field trip, but they are restricted in editing these notices by the possibilities of the smart phones used.

In the second scenario a combination of participative content creation using a wiki system and location based content creation is realized. From technical point of view the software works well but it is not accepted by the learners. Compared to location based content access location based content creation lacks on incentives. Learners prefer to create high quality content, esp. making photos by using a digital camera and editing images before integrating them in a wiki page. They want to customize their wiki pages which can't be done on a smart phone. Maybe these hitches can be avoided using smartbooks as end device in both scenarios. Hence we want to do a study by using smartbooks in the near future.

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