

Location Based Learning: lessons learned

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Abstract

By the Dutch National project GIPSY a number of educational experiments concerning wireless learning have been performed. These experiences dealt with geo-information science courses. The main educational results of these experiences are presented. Based on these results a so-called DILICT-matrix (Didactics supported by Location based Learning ICT infrastructure) is designed. The matrix introduces the relations between the didactic approach, the role of locations and the type of wireless ict infrastructure. How this matrix can be used for the preparation of location based learning is explained. Finally some remarks are made considering the ict-factors positioning, transmission and communication.

Introduction

A consortium of three Dutch universities started in 2002 with the GIPSY-project founded by the Dutch National Organization SURF. The GIPSY acronym refers to Geo-Information for Integrating Personal learning environments by web and mobile ICT SYstems and tries to express a more flexible and on movement based way of learning. The reconnaissance of wireless supported learning environment was the main objective of the GIPSY project. As described by van Lammeren et.al. (2002) this environment will exist of two courses which can be followed by students using wireless devices. To support students as well as educators a helpdesk has to be developed.

Figure 1 shows the three main stages (I, II, III) within the project. The choice to create two courses is made on purpose. The “geo-information basics” course is mainly directed to wireless learning forms to support individual learning activities. The other course “integration for environmental policy” focuses more on group-learning processes and the role of wireless facilities in this type of education. Besides, the “integration” course tries to integrate desktop work and practical fieldwork in a cyclic procedure: students make, based on a project planning, fieldtrips to collect geo-referenced data and materials. Directed by the outcome of team-discussions the data are processed, the materials analyzed and results will be checked preferably again in the field.

Now two years later the project has been finished and the project review (Lammeren et.al., 2004) show the results and the lessons learned. For this reason the paper explains first the project procedure considering the development of both courses and especially their wireless concepts. Afterwards the didactic context will be explained to understand how the developed course materials have been used during the courses and finally the lessons learned will be presented. The lessons learned have been accepted as the input for the MANOLO project. The overall objective of this succeeding project focuses on a structural imbedding of wireless environments in de educational infrastructure

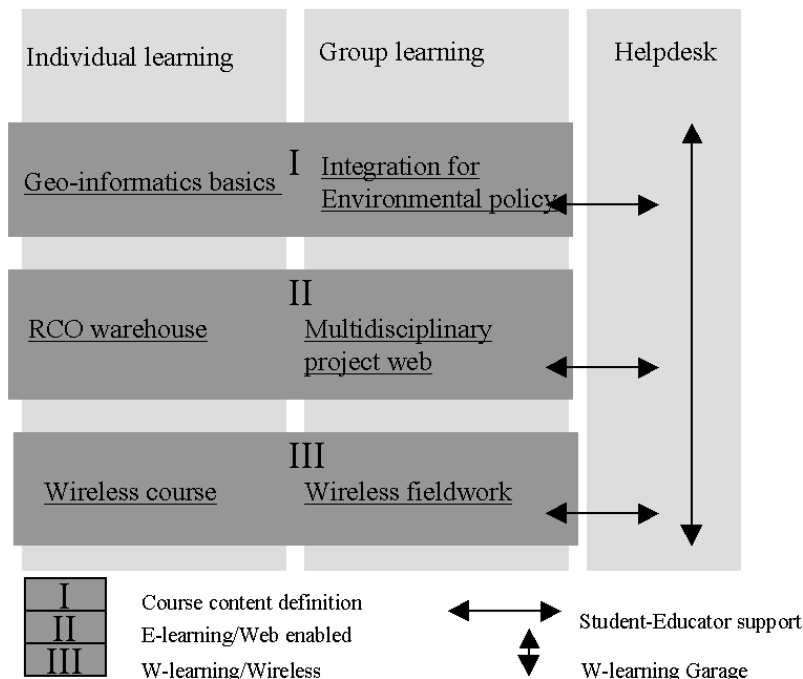


Figure 1: Stages (horizontal rows) and products (vertical columns) of the Gipsy-project

Project methodology

Finally for “The wireless course” the project team decided to focus on the student self-assessment. It means that the student who will use the application will be able to check his or her knowledge-level by performing the self-assessment. The assessment is based on different byte chunks. These byte chunks are questions, correct and incorrect answers on these questions, structure-tree of these questions related to the structure-tree of the learning objectives and learning objects.

In fact the structure-tree of the learning objectives, developed on level 1 and worked out in byte chunks on level II, has been used in a more inverse way to offer the students the assessment tool.

To make an wireless application all questions and related answers are stored in a Perception-QuestionMark database as well as a Blackboard datasets. Because of the inadequacy of Blackboard unplugged version we could use, the wireless application had to be developed ourselves. The application offers the student an assessment-tree (figure 2). The tree exists of the different modules that a student has to learn. As soon as a student selects a module a link with the server that offers the Perception database will be set up. The student will see the related questions and these can be answered. The answers are sent to the Perception server and are checked. The results are sent back to the student’s devices. The student will have feedback by a score per question, a reference to related learning objects. The learning objects will be downloaded as PDF-files for further study.

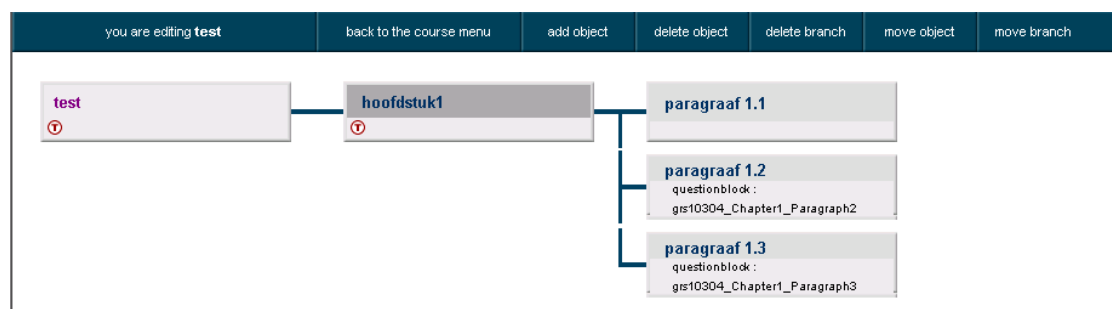


Figure 2: Smartphone assessment-tree interface

Due to problems with Blackboard version we finally run the course by offering the students two options to perform the self-assessment. The first one was completely Blackboard based and not (!) wireless. The second was the wireless possibility by using smartphones (PDA plus GSM/GPRS). Unfortunately only 5 students selected this second opportunity.

For “The wireless fieldwork “ the project team decided to study literature (Beinat, et.al., 2004)) about location based services and to run some clear defined and simple cases to discover the pros and cons of wireless devices and the location based use (Ligtenberg, et.al., 2004). Based on this information and these experiences the project team decided to provide the multidisciplinary student teams with wireless devices (GPS included) that run ArcPad and some ArcPad scripts. Besides, the students were trained in using ArcPad and got instructions to use the ArcPad scripts (figure 3).

Reasons for this approach were several. First of all each student team has to work on its own case provided by a problem holder (Bruin, et.al. 2004)). Secondly each student team has two geo-information science students as team members. It means that each case has a different interest in using the wireless devices. Each student team has to define and implement its location based interest.



Figure 3: A PDA/GPS/ArcPad application to do field work

The geo-data to be used in the project has been provided via a web based project environment. During the wireless fieldwork all student teams work with a project environment implemented in Quickplace/Workplace that has been structured following the good modeling practice (GMP) approach. An IMS server was also provided.

During the project time 13 groups, totally 64 students, worked for maximally four weeks on realizing some results according the problem holders’ interest. The results had to be presented twofold by live presentation and via a poster.

Project Results

To describe some of the wireless learning results from the GIPSY project the division between the individual oriented course ‘Geo-Information Basics’ and the group oriented course ‘Integration of environmental policies’ is made. According figure 1 the wireless course is the name of the wireless basic course support. The wireless fieldwork is the name of the wireless integration course support.

The wireless course

All students (58) who followed the course Geo-Information Basics were asked to evaluate the self-assessment application (Heuvel, et.al., 2004). Thirty students finally evaluated this application. Thirteen of them did all the assessments and ten students did minimally the half. Only four students made use of the self-assessment before they did study the content. Exploring the subject and contents was the main reason to do so. 80% of the students used the application to prepare themselves for the exam and intermediary tests.

From a didactical point of view the students fully agreed (overall score 3.8 on a scale of 1 (strongly disagree) - 5 (strongly agree); 60% of the students scored 4) with effectiveness of the self-assessments to test their knowledge considering the subject matter. They even mentioned that the self-assessment is an indispensable tool for learning purposes (score 3.8).

Also the feedback on the assessment results by linking the questions and answers to the relevant learning objects (pdf-files) scored more than satisfactorily (score 3.7).

The students worked easily with the application and understood them well (score 4.0). However the significance of the feedback could be improved (score 3.4).

The five students that used smartphones were not really satisfied about the connection stability (score: 2.3) and communication speed -max. 256 bytes/s-. Also the number of scrolling movements to perform was too much. Three of the five students did the self-assessment outside a building and during public transport. The students that went through the self-assessment of one course-module in public transport used maximally 9.72 Mb of data-transmission.

However the question "I prefer to do the self-assessment by a mobile device?" scored 2.7 !

The wireless fieldwork

Thirteen student teams worked on thirteen different cases (Bruin, et. al., 2004). The roles of location based applications differed. Eleven teams developed an application to collect location based field data. In two cases of these applications the automatic upload to a geo-data set was included. These cases included also a field check of the existing geo-data set.

Two teams developed a Location Based Service. Both applications support navigation according to a walking route through a certain area. On the route there are different information nodes. Each information node exists of fact data (sound, text and picture). When the user of the application follows the route and reaches the influence sector of a node (an area around a certain geographical position) the fact data pops up on the smartphone.

To collect field data most of the student teams used ArcPad with GPS. A standard ArcPad routine offers the facility to store field data by filling in a database attribute field with numbers or with characters. In some applications the student teams developed a dedicated fill in form. Some teams developed an application by which location based pictures (eg. photos of crops or buildings) are stored too.

To check the geodata the students navigate by ArcPad with GPS to the real world phenomena and checked if the phenomena did exist as a geo-database object. If not a new object was stored in the database by a data collection routine. The check other way around, navigate to a geo-database object and see if it still exist a real world phenomena, has not been performed.

To upload the data means that a connection with any Map Server was needed. Two project teams did develop such a protocol to upload the collected field data. In both cases the IMS server (ArcIMS) had been used.

None of the project teams did develop a download procedure to acquire geo data from a Map server on the wireless device. Even the two location based applications were based on applications that were fully developed on the wireless devices (XDA, Ipaq and Loox). Via GPS the location depended data was geometrically queried and presented on the handheld device via the screen and the audio-speaker.

Both location based service applications (both in the domain of archeology) were based on a route through an area. Both teams developed an application that runs on a handheld computers with GPS. One applications showed by audial and pictorial data the archeological findings on the location you walked over. The other application gave information about buildings and street artifacts that are passed by.

During the field work sessions the students were not able to read satisfactorily and to work with the project site due to the large scripting files that are produced by the project site software and the minimal bandwidth of the GPRS transmission. Also the Internet explorer version on the smartphone could not parse the ActiveX and Javascripts that are part of this scripting.

The smartphones were exclusively used for ArcPad and ArcPad applications. Rarely the students used them as mobile phones and as PC to run Pocket Word and Excel.

Charges of the smartphone batteries were an important hiccup for smoothly running the applications in the field. The average of four hours capacity seemed to be too low for extensive use in courses. Of interest is the durability of the handhelds. During the course all handhelds performed well without any damage or failure. However the students prefer the handhelds during the fieldwork especially concerning the portability, the weight and the functionality of these devices in comparison with the bigger laptops.

Thirty students did evaluate the course Integration of Environmental sciences. From a didactical point of view the students fully agreed (overall score 4.1 on a scale of 1 (strongly disagree) - 5 (strongly agree)) with the student team objectives, namely to develop an application. They even mentioned that the development of the application was very well supervised and tutored (score 4.0). Further discussion with the students and supervisors showed that this type of supervision is really of need.

Even the role of ICT in the course scored extremely high (overall score 4.7) !

In scope of the wireless fieldwork fifth teen GPRS licenses of 15 Mb per month were in use. Only one student team exceeded this contractual limit.

The DILICT matrix

The GIPSY project put forward the variety of wireless learning opportunities. The scope of wireless learning ranges from the well-known E-learning approach by wireless devices to Location Based Learning that could be seen as another way of location based services.

This scope is, of course, primarily based on the didactical objectives but the type of available information and communication technology does support the didactics substantially. Positioning via GPS or Cell-ID, transmission of data by GSM, GPRS or UMTS and the nature of communication (synchronous and asynchronous via data and voice) seem to be important factors. To discuss and to delineate a wireless learning environment and infrastructure to run or support a course will start by an opinion about these factors.

Based on the GIPSY-project experiences the DILICT-matrix could be defined. DILICT refers to Didactics supported by Location based Learning ICT infrastructure. This matrix shows the kind of didactical approach on the horizontal axis. The didactical approach is divided in either individually oriented learning contents and feedback by teachers and peers, or group oriented contents, feedback and student co-operation protocols like in problem oriented learning. Contents, feedback and co-operation have to be all in line with the learning objectives and competences to be realized during a course or through out a curriculum.

The vertical axis shows two aspects: the importance of the location for learning and the ICT-factors (positioning, transmission and communication). The location for learning could be either well-defined indoors and outdoors or ill-defined of objects (learning content) and subjects (students and educators). Figure 4 displays, like a top view, the location variety. An example of well-defined location indoors is the daytime and classroom schedule of courses (considering lectures and dedicated practical). An example of a well-defined location outdoors is the specified outdoor location where a student has to do fieldwork (eg. boring hole, soil profile study) or to learn from the location phenomena (eg. architectural style of a building, tree species). An example of a relaxed or ill-defined indoors location is the location for discussion between group members (like in problem oriented learning) or poster presentation. Studying the learning content during public transport or other off-campus moments are outdoors examples of ill-defined location. Restricted indoors and outdoors locations form a third location interest group. The adjective "restricted" refers to a certain extended area but the exact locations within that area have to be worked out via the students work. Outdoors examples are the field works to validate remote sensing data, to work out a hydrologic map or to describe traffic intensities. Indoors examples could be related to define a production chain in a factory, or to track the use of laboratory devices by laboratory assistants or personnel customer behaviour in a shopping mall.

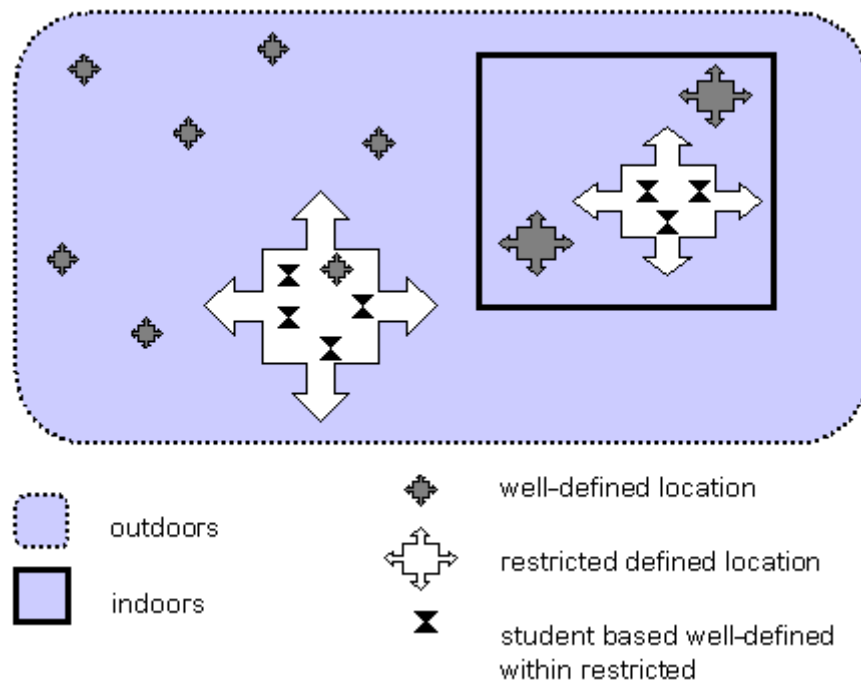


Figure 4: Role of location (of objects and subjects) in didactical approaches

The ICT-factors positioning, transmission and communication are important items to establish the improvement of education. Positioning has to do with the quality (precision and accuracy) of the description or capturing the location (Beinat, et. al, 2004). Transmission is a crucial factor if the educational idea has a high (video) or low (simple structured ascii files) data-transmission (up- and downloading) demand. Communication has to do with single (1:1) or multiple user (N:M) protocols in asynchronous (A) and synchronous (S) modes and the need for the exchange by data or voice during these protocols.

The DILICT matrix gives a preliminary framework to discuss the role of wireless technology in courses.

DILICT matrix		didactics				
		Individually content	feedback	Group content	co-operation	feedback
Fieldwork						
learning location						
	well defined					
	ill defined					
	restricted					
ICT factors						
positioning						
	no					
	low					
	high	GPS		GPS		
transmission						
	no					
	low		ascii	ascii	ascii / bmp	
	high					
communication						
	no					
	1:1 / A-S	A	S	A		
	1:N / A-S				S/A	
	N:M / A-S				S/A	S/A

Table 1: The DILICT matrix: filled in for fieldwork (as an example)

Table 1 shows the matrix and in the meanwhile gives an idea how to use it. The table is filled based on project experiences (Bruin et.al., 2004; Wagtenonk et. al., 2004). By this table the items of interest for the wireless support of a fieldwork course can be discussed as follows. The didactics interest put forward that the assignment of the students has an individual and a group component. In both components the learning location is restricted. However when the restricted locations have been described and the data has been captured the co-operation and feedback will be based on the captured locations. So, the positions of these originally restricted locations have to be traceable. To capture the locations the positioning has to be of high quality. In this example the quality of a global positioning system (GPS) is chosen. The transmission demands are however low because the captured data can be exchanged via a simple and limited ascii format and small bitmap files (bmp). Most of the field work data will be stored on the handheld device and will be copied by to a central computing facility (server) by a fixed and high transmission line. In the final stage of the course the student teams have to integrate the location data into a result that covers the whole area. For that part of the course higher demands of transmission could be necessary. When the students start the fieldwork the communication will be little and most of the time the communication will be to check asynchronously data or websites. In some cases the individual student will ask the supervisor for advises. Considering the fieldwork time the feedback has to be given immediately and synchronously (S) in some situation the supervisor needs to be informed by the position and the collected data of the other students before an advise or instruction will be given to one or all the students (S/A). For the last mentioned communication option the supervisor has to know where each student is located, which field conditions (by geo-data) the students are surrounded by and what has been collected on the restricted location.

Discussion

The GIPSY project offered a lot of information about wireless computing opportunities in education. The experiences have been translated into the DILICT matrix. The DILICT matrix could be used as a framework to discuss the type of wireless computing and to set up the infrastructure to support a course.

Via the MANOLO project this matrix will be elaborated upon especially to develop course related blue prints. These blue prints have to make clear out of which components a wireless (mobile or transportable) ict infrastructure needs to exist for supporting students and teachers flawlessly. During the GIPSY project it turned out that all four components of an ict-infrastructure, hardware – software – data – support, could obstruct the demand for a flawless and inspiring use.

Of course it will be unclear what kind of ideal device students will use in the near future. Wireless computing can be realized on any computing device with a wireless network card (preferably for all type of protocols (ranging from blue tooth via Wifi to GPRS/UMTS)). However the device need a certain size and weight when it has to be portable and usable under field conditions. In some situations the educational institute may provide the devices but in other situations the students have to bring themselves. According the responses on questionnaires students still make a difference between mobile phones and internet enabled computers. The successes of wireless computing will accelerate the integration of mobile phones and computers either in devices like smartphones and tabletPC's. For the time being the differences between operating systems of tabletPC's and smartphones do cause lots of discussion. The difference has impact on the functionality of the smartphones, the link with IMS (in general server-client application) and the transmission protocols. Though the promises of XML, GML, SVG and IMS client-server concepts are appealing, during the project none of these concepts could be (easily) implemented. Automatic transformation of operating and transmission protocols including device oriented applications (via .Net concepts) will relief some of these implementation problems. However if the power supply for all the portable equipment indoors and outdoors isn't sufficiently arranged then these previous worries are minor things.

Most of the educational institutes did invest in cable networks for client-server networks. These cable networks have to be extended with wireless access points (WiFi) to support indoors wireless computing. Outdoors the different mobile phone providers did set up their cellular network by beacons (figure 5). Both networks do not match. It means that students and teachers who work in the field (outdoors) with a smartphone network connection (think of UMTS) will come back to the institute (indoors). To change automatically (without losing connections and running applications) from the mobile phone providers UMTS protocol (outdoors) to the educational institutional WiFi network

(indoors) will be in a lot of courses an important condition. For the time being this automatic switch is not applicable at all and still an educators dream.

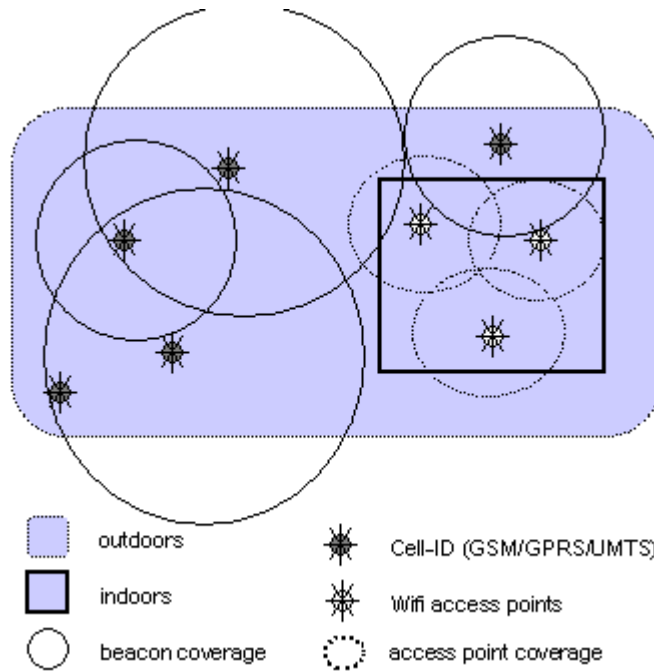


Figure 5: Indoors and outdoors wireless transmission systems

Location accuracy of learning objects and subjects, in terms of the ability to precisely locate a handset device determines the range and variety of services that can be deployed. With low accuracy, the choice of suitable services is limited (e.g. weather forecasts or local news). As accuracy increases, the range of possible services widens, up to the point at which with location technologies such as assisted GPS virtually all LBL services can be implemented.

Accuracy has two sides. First, it determines if a service can be deployed or otherwise; second, it determines the quality of the service. The vast majority of services can be deployed for a range of accuracy levels, with the quality of service increasing with better location capabilities.

For services that demand accuracy in the range of meters, GPS, assisted GPS or beacon networks are necessary. The lack of them would prevent the deployment of the service. For most other services, however, the service can be deployed with various degrees of accuracy, which in turn determine its quality. Services such as person location, friend finder, nearest POI, advertising, dating etc. can be deployed with rather simple LDT. The improvements in accuracy would determine a clear improvement in quality of service, but not the possibility of deploying the service.

On the contrary, find field locations and field plot tot field plot navigation and the like require precise location determination. If the location cannot be determined with accuracies in the range of 10-100m the service itself becomes of little or no use. GPS appears to be the best solution for the location determination in the fieldwork context.

Table 2 enables a comparison between the different technological solutions in terms of functionality, accuracy and advantages and disadvantages.

In case of location based learning most of the data and software applications used in (geo-informatics related) education has to be converted into formats that are usable in client-server applications based on smartphones formats. Some dedicated formats (eg. GML, SVG) and source code generators (eg. .NET) are already available but their benefit to support educational contents will take some time.

Technology	How it works	Accuracy	Advantages	Disadvantages
Basic Cell ID	The network tracks that base station delivers the best reception to a phone. It determines that the phone is somewhere within that coverage Cell, but not precisely where.	Depends on cell size: 150m (typical city) to 2 km (typical rural area)	<ul style="list-style-type: none"> No new handsets required Cheapest of all technologies for operators 	<ul style="list-style-type: none"> Poor precision
Network-enhanced cell ID	The network uses additional information from wireless signals (e.g. timing advanced) to calculate where the phone is within the cell	Up to 50% improvement over basic cell ID	<ul style="list-style-type: none"> Boosted precision, especially in rural areas No new handsets required 	<ul style="list-style-type: none"> Requires homogenous network infrastructure for operators to contain costs
E-OTD	Mobile signal passes from base station to phone with special chip and then to fixed location known to operator. Location is triangulated among these 3 points.	5 to 50 m	<ul style="list-style-type: none"> Highest accuracy of non-GPS solutions 	<ul style="list-style-type: none"> High network investment – costs for the operator Requires new handsets
GPS	Orbiting GPS satellites send positioning signal to phone equipped with GPS chip, which calculates, it's own location	1 to 10 m	<ul style="list-style-type: none"> High accuracy 	<ul style="list-style-type: none"> Only outdoor use New handsets required with expensive chip sets and high battery consumption
Assisted GPS	GPS location information works with enhanced cell id technology or E-OTD. This allows GPS accuracy and indoor usage and pinpoints vertical location as well	Same as GPS, but allows for similar precision within building	<ul style="list-style-type: none"> High accuracy 	<ul style="list-style-type: none"> Requires same high network investment as E-OTD Requires even more expensive handsets than basic GPS.

Table 2 Summary of the different positioning technology solutions (Beinat, et.al., 2004)

In a lot of location based learning courses Mapservers in relation with client applications could fully support the didactic approaches. However the Mapservers tested during the GIPSY project are still limited to support wireless applications (Bergsma, et.al, 2004) on smartphones and even on tabletPC's. Currently, during discussing the DILICT-matrix, the decision to offer an up- and downloading procedure via a client-server application has to be well underpinned. Sometimes it is better to start with discussing a 'thin' smartphone application that could support the educational demand.

It is obviously clear that geo-information science can both benefit from and support to wireless learning. Support exists of using principles of and developments in location based services that can be modified for location based learning. Benefits can be gained from the communication protocols and smartphone related software and hardware considering mobile and wireless E-learning. However developing a wireless course with location based learning components is just in its childhood. Elaboration of the DILICT matrix into course specific blue prints with definitions and relations of educational contents, technology means and ict-support could help to surpass the most obstructing ict-elements.

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URL: <http://www.geo-informatie.nl/gipsy/> for downloading the above mentioned references

URL: <http://www.surf.nl/projecten/index2.php?oid=133> for the MANOLO project information

Credits

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