KATHOLIEKE UNIVERSITEIT LEUVEN

# LeGIO-WORKSHOP

## 18th of November, 2011

## GIS-education in a changing academic environment

Marianne Hubeau, Thérèse Steenberghen, Koen Van Balen, Jos Van Orshoven, Ona Vileikis (Editors)

WORKSHOP PROCEEDINGS

SADL - Spatial Application Division Leuven

RLICC - Raymond Lemaire International Centre for Conservation

AFDELING BOS, NATUUR EN LANDSCHAP

Leuven SUstainable Earth Research Center

KATHOLIEKE UNIVERSITEIT LEUVEN



ISBN 978-90-8826-217-3

Wettelijk depot D/2011/11.109/51

Printed in Leuven, Belgium by PROCOPIA

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# Keynote paper

# GI-education: the impact of EduMapping

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## ABSTRACT

The creation of a European Higher Education Area during the last 20 years has resulted in a considerable degree of harmonization when it comes to the structure of higher education in the European countries. With regard to geoinformation (GI) education, less progress has been made. Formats for course and curriculum descriptions vary per organization and languages vary per country. For the described content a central reference on domain level seems absent. The reference documents published in the United States (2006: the Geographic Information Science and Technology Body of Knowledge, 2010: Geospatial Technology Competency Model) have not yet been widely accepted in Europe, but seem useful. The EduMapping method aims at concisely characterizing GI course or curriculum content in a label, to be added to existing descriptions. This paper points at a role for EduMapping as a connection between the European multinational and multilingual situation and the American reference potential. Application of EduMapping might help Europe to achieve the objectives of the Europe 2020 Strategy.

## KEYWORDS

Body of Knowledge, GTCM, Europe 2020, EduMapping, EHEA, ECTS, label

## DRIVERS FOR CHANGE

This paper considers two drivers for change of academic GI education in Europe and explores their possible impact. The first driver consists of four strategic steps taken by the European Union during the last 20 years. The steps are: the introduction of a common educational credit system (ECTS[1]) in 1989 (European Union 2009), the start of the Bologna-process in 1999 (Council of Europe 2010) and the launch of the European Qualification Framework in 2008 (European Union 2008). Among other measures, they were instrumental to implement the European Higher Education Area (EHEA). A fourth step is the Europe 2020 Strategy (European Commission 2010), that aims to improve the European economy by means of seven flagship initiatives.

The second driver consists of four American contributions in the same period to align / unify / harmonize GI education. They are: the NCGIA[2] GIS Core Curriculum (Goodchild and Kemp, 1990), the GI Science and Technology Body of Knowledge (DiBiase et al., 2006), referred to hereafter as "GI-BoK", the GIS Certification Institute (GISCI, 2008) and the Geospatial Technology Competency Model (GTCM) (DOLETA, 2010).

This quartet represents the development from academic domain specialists describing GI education as "best practice" all the way to GI as a recognized economic sector with its own workforce. In this workforce the employees need education to develop their geospatial competencies. If they acquired those competencies outside accredited education or training, and need their GIS-capabilities

[1] ECTS: European Credit Transfer System, a unit for study load. On average across the EHEA countries, one ECTS represents about 28 hours of student work.
[2] NCGIA: National Center for Geographic Information and Analysis. http://www.ncgia.ucsb.edu/

recognized, they can follow the certification procedure of GISCI and become a GISP, a geographic information systems professional.

## Top down and bottom up

The European driver results from a top down approach by the European Union: to make education in Europe contiguous and coherent, a structure was implemented to replace the multinational diversity. This structure harmonizes the educational structures of countries and makes diplomas and degrees from the countries in EHEA mutually recognizable. For that purpose, the European Qualification Framework (EQF) (European Union 2008), will provide a translation between educational levels in the countries. To that end EQF has defined eight different educational levels to refer to. It is up to the various knowledge domains in the countries to indicate at which of the eight EQF levels educational programmes in their domains connect with this structure.

A GI-related European structure that does exist is the INSPIRE Directive, entered in force in 2007. Its objective is a European spatial data infrastructure to enable internationally harmonized environmental data availability (European Commission 2007) across all member states. However, INSPIRE is environmental policy oriented and has no educational intentions.

The American driver represents a bottom up approach by consortia (NCGIA, UCGIS[3]) with the intention to improve education in the geospatial domain and make it more relevant to employers. Their approach evolved from describing the GIS Core Curriculum via describing the GI knowledge domain (GI-BoK) to identifying "the foundational, industry-wide, and industry sector–specific expertise that distinguishes, and binds together, successful geospatial professionals" (DiBiase et al., 2010) in GTCM.

GTCM is a product of the American government's Department of Labor. It is the result of the designation in 2003 of Geospatial Technology as a potential job-producing industry (DOLETA, 2003). Although it refers to GI-BoK when dealing with GI-specific competencies, it covers seven other groups of competencies. One of the contributors characterizes the difference as follows: [GI-BoK] "is an exhaustive listing of formal educational objectives related to geospatial information science. The GTCM is more generalized and tries to focus on those competencies and tasks that a geospatial professional may encounter over the span of a career" (Francica, 2010). This sequence shows that - in the US - the bottom up approach has reached the top.

## EHEA progress

The situation is that in the majority of the 48 EHEA countries the majority of the educational programmes are structured according to the Bachelor–Master model (Rauhvargers et al., 2009). Also ECTS is used in most of those programmes (Rauhvargers, 2010) – in a way.

With regard to ECTS, the EU-ideal is: "The use of ECTS, in conjunction with outcomes-based qualifications frameworks, makes programmes and qualifications more transparent and facilitates the recognition of qualifications. ECTS can be applied to all types of programmes, whatever their mode of delivery (school-based, work-based), the learners' status (full-time, part-time) and to all kinds of learning (formal, non-formal and informal)." (European Union 2009), p7.

[3] UCGIS: University Consortium for Geographic Information Science. This group of about 70 American universities created the GI S&T Body of Knowledge. http://www.ucgis.org/

An aspect that the EHEA countries still have to work on is the basis for ECTS-allocation. The application of ECTS should be based on both ‘student workload’ and ‘learning outcomes’ and in 2010 many education systems were struggling with those concepts (German Academic Exchange Service (DAAD) et al., 2011), p.17. In 2009, five different dominant practices were found in 37 higher education systems. In 2009, just 16 of the EHEA countries used Learning Outcomes (LO) as a basis for credit allocation, four of which did not use Estimated Average Student Workload. This EASW was used in 30 countries of which 18 did not use LO. Eleven countries based the ECTS amount on teaching/contact hours (German Academic Exchange Service (DAAD) et al., 2011), p.40.

The Europe 2020 Strategy (European Commission 2010) expects EU Member States, among many other things, to “reinforce cooperation between universities and business” and “enhance cross border co-operation” (p.11). They also need “to enhance the openness and relevance of education systems by building national qualification frameworks and better gearing learning outcomes towards labour market needs” (p.11).

## GI domain in EHEA

No signs have been observed indicating that, at EU level, the GI knowledge domain has been or will be addressed like in the United States. If the European part of the GI domain wishes to support the 2020 strategy, it should take initiatives.

Of course the GI-domain is not sharply defined, as was sketched in the GI-BoK report (DiBiase et al., 2006). Nor is it a single entity: geographers, cartographers, remote sensing specialists and land surveyors have their own professional organizations. The software manufacturers have their followers and conferences. In Europe there is the additional problem of diversity in languages and national organizations. Judging from their websites, Euro-wide GI-oriented organizations like Eurogeographics, EuroSDR or EuroGI seem to have no ambitions regarding GI education. At the other hand there is UNIGIS (http://www.unigis.net/), a Europe-based global network of higher education institutions which offers GI distance learning on MSc and Professional Diploma levels. However, with GI distance learning offers in general the question is which country’s quality standard they comply with and how the courses relate to the GI knowledge domain.

## GI education gap in Europe

The American driver has only a limited influence in Europe. The undocumented impression of this author is, that the NCGIA Core Curriculum in the years after 1990 seems to be present in the collective memory of many older GIS teaching staff. For GI-BoK it is another situation. According to Masik (Masik, 2010), of her 113 survey respondents from 99 different universities in 27 countries (25 in Europe), 40% is aware of GI-Bok,  22% has been using it and 25% intends to use it. GTCM, of a more recent date, seems very much less familiar in Europe, but this is also an undocumented impression of this author.

The conclusion is that the American driver does not (yet?) work in Europe because of the more diverse situation. The European driver does not (yet?) reach the GI domain. The question is: what could be done to bridge this gap?

A bottom up approach in Europe should be more basic than in the US and provide a foundation for more organization, more coherence in the GI domain. It should respect the European driver (i.e. not interfere with, but add to structures under construction) and make use of the American driver where possible.

The AGILE[4] EduMapping Initiative operates along these lines. Started in 2009, its objective is to create an overview of existing GI education offers in Europe, using GI-BoK to characterize their nature and at the same time making courses and curricula comparable on their content.

The idea to create an overview is not entirely new. Presently, Rostock University in Germany hosts a website (**http://www.geoinformatik.uni-rostock.de/ausbildung_map_en.asp**) with a map showing locations of 92 GI education offers in mainly the German speaking countries, with links to descriptive websites. At the EUGISES 2010 conference a similar subject was brought to attention (Kotzinos et al., 2010).

## METHODOLOGY

This project started in 2008 in exploration mode. Gradually, tactical and strategic aspects developed, as is shown in the following concise overview.

The overall strategic objective was and is to contribute to the quality of education in the GI domain by using the GI-BoK domain description. For that purpose, various organisational and technical tactical decisions were made so far. They were intended to generate interest from colleagues and from professional organizations by contributing assessments, help analyse the results or even help to get funds for the work. Of course, to get their interest, the results of the EduMapping work itself had to be shared and reported about.

Organisational:

- workshops arranged at the AGILE conferences of 2009, 2010 and 2011
- got the AGILE Board to accept work on EduMapping as an AGILE Initiative (2009)
- created papers (AGILE 2011) and posters, made presentations at conferences (AGILE 2008, INSPIRE 2010, ISPRS 2010, EUGISES 2010 and at the AGILE workshops)
- meetings with representatives of ISPRS, ICA, AGILE and of BoK2 (2010, 2011)

Technical:

- designed the mapping approach using GI-BoK as a registration form in Excel
- designed the EduMapping label as a concise characterization of a teaching offer
- experimented with visualization of multiple EduMapping assessments in an XY system
- obtained assessments for individual courses and complete curricula on vocational, professional and academic levels
- experimented with obtaining assessments from different persons for the same course
- experimented with applying EduMapping to job descriptions

The subjects to discuss and report about in workshops and papers are the EduMapping assessments. First, the collection method is of relevance. The designed Excel sheet, supported by an overview of the GI-BoK Knowledge Areas and their Units, as well as user instructions for the Excel sheet, was presented to GI teaching staff among the author's acquaintances and to people met at meetings and conferences. Together these materials are referred to as the "EduMapping kit". The approached persons were asked to make an assessment of a course or curriculum they were involved in. The overview of GI-BoK was added to help the respondent in case of insufficient familiarity with GI-BoK.

[4] AGILE: Association Geographic Information Laboratories Europe, http://www.agile-online.org/

Also, each respondent was asked to describe in 9-99 words what they dislike and like in the EduMapping procedure. The limitation was intended as a stimulus to receive comments.

Second there is the mapping method, meant here as connecting elements in a course description with elements in the GI-domain description, i.e. GI-BoK. This mapping activity has two key steps and three challenges. The first is that the person making the assessment, the assessor, has to know what the terms used in the description refer to. Then the task is to select the best matching GI-BoK Knowledge Area, or even better: selection of the more specific Units within a Knowledge Area. The challenge in that is finding prospective matches in the paper document that GI-BoK is. That includes yet another challenge: translating the GI-BoK terminology to what the assessor thinks is meant in the course description. A consequence of this need for understanding the meaning of terms in both the description and GI-BoK is, that the teacher of a course is the best candidate to make its EduMapping. So, the EduMapping form asks for how the assessor is involved with the described course. Answering options, in order of descending course content expertise are: teacher, involved, ex-participant, skilled outsider, other. This is supposed to help judge the weight of an assessment. The necessity for making the distinction became clear after comparing the EduMappings for the same course, made by persons with different degrees of involvement.

## RESULTS

One category of results is what is produced during the work. They will be described here first. Then there is the organizational context. A third category is that of expected future results.

### Products

Actions to generate more interest for the use of GI-BoK to underpin the GI domain and develop EduMapping resulted, apart from the above mentioned EduMapping kit, in a number of papers, reports, posters and presentations at various occasions. They reflect the development of the EduMapping concept since 2008. The important ones are the two papers in which the concept is described (Rip and Van Lammeren, 2010) and a first analysis of the collected data until the end of 2010 (Rip et al., 2011). Access to those papers and a number of other publications is provided via website **http://www.geo-informatie.nl/rip001/edumapping**. From this webpage also the EduMapping kit can be downloaded.

A number of EduMappings has been collected so far: 24 of programmes (Figure 1) and 23 of sets of one or more GI courses outside programmes from eight European countries. As each programme consists of a number of courses, the total number of collected courses is 265. The educational levels included are: “vocational”, “professional” and “academic”. Their size varies between 0.6 ECTS (a two day course offered by ESRI-NL) to 240 ECTS. Content areas include: Geoinformation, Spatial Analysis, Cartography, Geomatics, Earth Observation, Geography, Remote Sensing, Geodesy, Surveying, Spatial Data Infrastructure, Data Mining, Algorithms and Databases. At the moment they are stored locally in Excel sheets, but the intention is to place them in an online repository.

| Assessment summary | ECTS size | share |
|---|---|---|
| **GI subjects in BoK** | **45.6** | **38%** |
| ***AM. Analytical Methods*** | *13.0* | *11%* |
| ***CF. Conceptual Foundations*** | *0.0* | *0%* |
| ***CV. Cartography and Visualization*** | *0.0* | *0%* |
| ***DA. Design Aspects*** | *1.0* | *1%* |
| ***DM. Data Modeling*** | *2.0* | *2%* |
| ***DN. Data Manipulation*** | *0.0* | *0%* |
| ***GC. Geocomputation*** | *5.0* | *4%* |
| ***GD. Geospatial Data*** | *23.6* | *20%* |
| ***GS. GI S&T and Society*** | *0.5* | *0%* |
| ***OI. Organizational & Institutional Aspects*** | *0.5* | *0%* |
| **GI subjects, Not in BoK 2006** | **6.0** | **5%** |
| **Application of GI subjects in generic components** | **39.0** | **33%** |
| **Non-GI subjects** | **29.4** | **25%** |
| sum | **120.0** | **100%** |

Figure 1: Example of an EduMapping label, characterizing the Master of Earth Observation curriculum of K.U. Leuven, assessed in February 2010 by prof. J. van Orshoven, coordinator.

The request for comments, sent out with every EduMapping request, produced a number of remarks and opinions. Out of the 13 assessments received between august 2010 and august 2011, (representing nine individual courses plus four programmes containing 57 courses) seven respondents gave constructive criticisms or made positive remarks. Some errors in the Excel sheet were reported and suggestions were made to improve the instructions. Some assessors of Remote Sensing courses complained about the structure (fragmented subjects) and content (new subjects of last five years missing) of GI-BoK. Others remarked on the ease of use, or about the beauty of the method. In one case two respondents, together teaching one particular course, expressed their satisfaction with the degree of similarity of their independent assessments.

For a number of courses and curricula more than one assessment has been collected. This could be used to compare interpretations of assessors, taking into account their type of involvement. It could also be useful for discussions between teaching staff how to best characterize the courses by means of EduMapping.

Another point of interest is the diversity in course names, which might be confusing for people considering to follow an offered curriculum. In (Rip et al., 2011) is shown how a variety of GI courses could be clustered to a common theme within the GI domain, based on their characterization in terms of GI-BoK (Fig.2).

An interesting side line is the concept of JobMapping. This involves trying to characterize job offers using GI BoK. Some early experiments done by De Bakker (De Bakker, 2011) suggest that this could contribute to a better connection between GI education and GI employers when it comes to job matching.

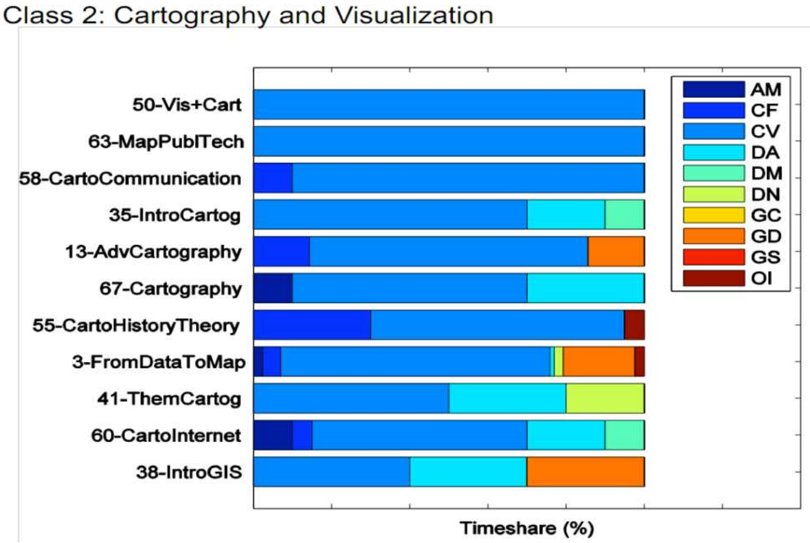


Figure 2: Clustering of course assessments in the GI-BoK Knowledge Area "Cartography and Visualization". The course names are on the left. Source: AGILE 2011 presentation by D.Kotzinos of Rip et al. 2011

## Organizational context

The project started as a one man action in 2008. Gradually, as a result of the AGILE Preconference workshops, a circle of interested colleagues in various European countries came to exist. This helped to get an idea of proposed improvements on GI-BoK, like an ontology based GI curriculum building application (Painho et al., 2007). Other comments on GI-BoK have been formulated by (Reinhardt and Toppen, 2008) and (Toppen and Reinhardt, 2009). Also it helped to submit the EduMapping work as an AGILE Initiative. A further stimulant was the set of meetings in 2010 and 2011 in Zürich, Utrecht and Paris with the BoK2 project leader and representatives of the boards of AGILE, ISPRS and ICA.

## Future

Because EduMapping is new, predicting future impact has a high degree of wishful thinking. In order to give that some credibility, a number of assumptions is listed below. Obviously, before there will be impact, these assumptions will have to become reality. After the assumptions follows a number of aspects of the impact.

The assumptions are:

- GI-BoK, or its next version, becomes more widely accepted among GI education organizations as a reference description of the GI domain;
- GI-BoK transforms from a hierarchical structure on paper into an online facility, more richly structured, better searchable and more interactive and up to date. Sean Ahearn, leader of the American BoK2 team sketched their objective for about 2015 (Ahearn et al., 2011) along those lines during the Paris 2011 meeting with delegates of AGILE, ISPRS and ICA;
- Professional organizations in the GI domain intensify cooperation regarding education;
- The educational accreditation organizations in the European countries welcome a reference description for the GI domain;
- GI employers recognize the value of a domain reference for improving job descriptions;
- The idea to compactly characterize GI teaching offers by means of the EduMapping label is considered useful by educational organizations and by GI students;

- Funding will be in place to stimulate awareness of the GI domain description among GI educational organizations, GI employers and to enable cooperation with the BoK2-team in the United States.

If these points become a reality, then a future scenario for the GI domain is:

- Accreditation organizations will require submitted applications for GI educational offers to contain EduMapping labels to characterize the programme;
- The professional organizations in the GI domain
  - accept GI-BoK and contribute to it from their specialist part of the GI domain;
  - accept EduMapping and ask their members to start using EduMapping labels for characterizing all courses and curricula;
- Educational organizations
  - learn the language of GI domain description and how to apply EduMapping;
  - use the EduMapping label as a component of course descriptions in study guides, and update it yearly;
  - compare their own GI educational offer with programmes elsewhere by means of the EduMapping label, and further develop their GI teaching niche;
  - better profile themselves for prospective students from other cities or countries
- Employers
  - learn the language of GI domain description and how to interpret EduMapping labels;
  - include a reference to GI-BoK in their job descriptions and advertisements, maybe by means of JobMapping.
- It becomes possible to set up an online repository of EduMappings, accompanied by analytical tools to search and compare GI educational offers, or analyse developments.

## CONCLUSION

The description of the results of the AGILE EduMapping Initiative is intended to convince the reader that EduMapping is a valuable concept. Producing a label is a simple procedure. Its outcome will help to overcome the diversity in descriptions of GI education in multinational, multilingual Europe, whereas it also has potential as one of the linking pins between the professional organizations in the GI domain.

A challenge for wide acceptance of GI-BoK as a domain description is the fact that GI-BoK is about to be renovated. Another challenge is that, before GI teaching staff and GI programme directors can use it for EduMapping, users must familiarize themselves with the GI-BoK structure and terminology, just like a new language. As soon as the population of the GI domain has mastered that language, a built-in risk of translation will becomes less serious: subjectivity of assessors and readers.

Work is necessary to help the assumptions mentioned in the previous chapter become reality. The key stakeholders all should play their part. However, as it has not yet been possible to check the reception of the EduMapping concept with the accreditation organizations, or with the GI employers, there is a risk that such work is not successful.

Fortunately, a number of conditions is favourable for starting the implementation of EduMapping in Europe. Presently, in the USA work is being done to prepare the foundation for BoK2, the successor of GI-BoK, funded by the American National Science Foundation. The actual construction - not included in the present project - is planned to start in the course of 2013, if funding will be obtained. In

Europe, the implementation of cross border recognition of GI diploma's and degrees could benefit from that, if GI-BoK would be recognized as the first version of the GI domain reference. Besides, the Europe 2020 Strategy calls for better links between education and business. To achieve that in the GI domain, GI-BoK, BoK2 and GTCM would be helpful, with EduMapping as the link to GI-BoK.

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# Papers session 1:

# Demand for and supply of GI-education

# Geo-information education: for everyone and/or for the specialist?

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## INTRODUCTION

More than 25 years involvement with Geo-information (GI) education and usage has resulted in the formulation of some best practices. In order to apply these best practices in development and executing of GI education several aspects will be discussed in a historical setting: context of GI education, different audiences, objectives of the educational courses and educational formats. Some best practices are related to the above mentioned aspects.

## CONTEXT

The context or environment of GI education has changed rapidly during the last 20 years. From a pre-internet environment with computers almost not existing in the daily practice it changed to an embedded situation. More than 60 % of the bachelor students have a smartphone and everybody is more spatial “GPS” and Google maps aware. This means that form a IT point of view everybody uses the technology all the time. But it does not indicate that everybody understands the technology, although we could discuss if this is necessary on all levels.

The context is especially different if we take into account the paradigm shift of geo-data. Availability has increased (a thousand times?) but also data collection is democratized. Everybody can collect data and share their result, see e.g. the Open Streetmap community.

Another major change is the interface regarding the software. Programming skills are nowadays more directed at the use of building blocks (object oriented programming software like e.g. Python) and you can find a large amount of examples and scripts on the Internet.

Last but not least, the number of people, organizations and domains active using GI increased enormously. Almost every organization with some spatial aspect in their mission has on their website a mapping service. Also the Spatial Data Infrastructures are seen everywhere, in such a way that it becomes more difficult for people to select the results on their relevance.

Above mentioned changes or sometimes revolutions should also influence the GI education. The situation of mostly pioneering educators without good structured textbooks and a data collection mostly from the USA and not their own environment is changed drastically. But has the content of the GI education changed with the context during these years?

Figure 1 gives also the change in context regarding the organizational setting of GI. First it was mostly an individual approach, but nowadays GI is a societal aspect. See e.g. the global approach on SDI’s.

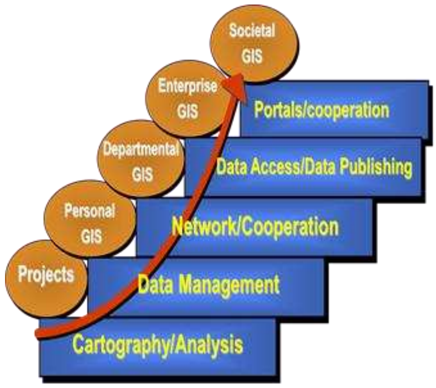

Figure 1: Changing GI context in organizational setting

## AUDIENCE

The audience of a course can be subdivided into five different groups:

- End use (domain driven)
- Visualization
- Data collection and maintenance
- GI Development with IT
- Coordination of GI

The end user is often the driving force of a GI system. This group needs GI as a technological tool for answers regarding their spatial questions. Emphasis is on the relation of GI with their domain. This domain can be e.g. agriculture, spatial planning and history. In Scholten et al (2009) more than 200 domains with a spatial aspect are discussed. A common topic is the visualization of spatial data (the map metaphore) and selection of data. Further spatial topics as discussed in National Research Council (2006) are not relevant in a similar way in all domains. This relative largest group benefit of the increase of GI data and applications available on the internet.

The cartographer is nowadays the person which will update and edit the GI product, especially the map for a specific target group. The main objective is to deliver the information without noise regarding the communication. This group seems to be threatened, because the cartographic process is democratized. Everybody can make a map, but is it a good map for the specific target group? GIS and cartography are not yet fully integrated.

The data collector delivers the main supply for a GI system. Without quality data the process of transforming data into information is impossible. Maintenance of the data is an important subject, because without this, slowly the relevant supply will stop. Collection nowadays includes the aspects of metadata, especially if the data is submitted to a portal or shared in web services. Also the influence of volunteered geography (Goodchild, 2007) makes almost everybody a GI data collector, although not always knowingly.

The GI developer makes the structure of a GI system. Without basic skills in programming he or she cannot cope with the increasing importance of information technology and communication. The demand for an increase of IT skills makes that IT is often not incorporated in GI courses developed by lecturers with a geographical background. The development of the use of GI on mobile devices and e.g. in serious gaming indicates an increasing need. In the Netherlands, almost no relevant courses are available.

The GI coordinator brings the different groups together, including the management of an organization. Without the more organization skills versus the technology background a GI project and organization will fail. Large programs like INSPIRE but also the encapsulation of GI in the general Information infrastructures and services make that coordination and project management are needed.

This subdivision is based on what can be seen nowadays in practice. GI project teams will consist of a coordinator or project manager, data collector, GI specialist (as a generic term for somebody with a technical view and expertise of GI systems), a cartographer and the main client: the end users. The subdivision is not always a fixed one. A person can be in some respect an end user but also a coordinator. The titles of the audience are especially chosen to make a subdivision according the main task. The titles used in job descriptions are not always ambiguous. E.g. the job titles as shown in table 1, used to indicate the subscriber of a GI magazine are certainly not clear. As an educator and researcher I have to classify myself as "other".

Table 1: Choice of job titles

| | | |
|---|---|---|
| Business Consultant | GIS Developer | President/CEO/Manager |
| CAD Drafter-Technician | GIS Specialist | Marketing |
| Database Administrator | GIS production manager | Product Engineer |
| Database Programmer | GIS Technician | Sales |
| Geospatial Analyst | Internet Mapping Manager | Software Developer |
| GIS Administrator | IT Director | Surveyor |
| GIS Analyst | Mapping Analyst | Web Programmer |
| GIS Coordinator | Mapping Technologist | Other |

In figure 2 the relation between these different groups is shown, especially regarding the process of questions (1), analysis/processing/discussion (2) and ad hoc answers (3) or solutions (4). The size of the circles is an indication of the size of the groups.

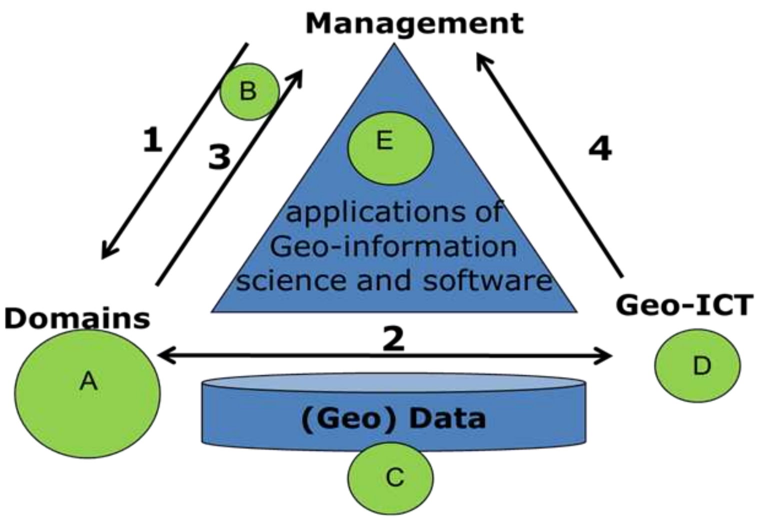


Figure 2: Overview of jobs in relationship with GI process (see text for further explanation)

If we compare the history of GI education we see that in the beginning of the nineties of last century the possible demarcation between the five groups was not as clear as nowadays. A GI specialist (as a person which knows more than others) and their education consist of a total overview and an in-depth discussion of all topics, especially in the stand alone desktop approach. If we use the different audiences as a direction of development of GI educational courses we can proceed with the objectives.

## OBJECTIVES

The objective of a GI course can be different in relationship with the intended audience, the prior knowledge and level of the course. Some objectives can be directed at the use of GI in a specific domain (e.g. GIS in spatial planning, Bakker, M. de et al, 1995) or at GI general (Bakker, M. de et al, 2004).

Most common differences relate to a more conceptual, theoretical approach and/or technology (software and data) driven hands on approach. The development and use of many tutorials related to GI software are examples of the last approach. Good examples of the first can be found in Janelle and Goodchild (Nyerges et al, 2011) and the website of Spatial@ucsb. Most text books (like e.g. Heywood et al, 2011) use a combined approach.

In order to compare the audiences with the content needed for a good knowledge and experience, table 2 is shown. The table is based on the Body of Knowledge of Dibiase et al, 2006 for the knowledge areas, a long term analysis of job advertisements by the author (not published) and several discussions during EUGISES conferences and AGILE workshops. Especially the work of Frans Rip regarding EduMapping (see e.g. F.I. Rip et al, 2011) was beneficial. The table indicates the relative importance of the contents with the job activities as subdivided in the different audiences.

The values in the table can be used to check courses if they are relevant for specific audiences. As seen it will be difficult to define a course where everybody can recognize his or her own goal (intended job description as in the defined audiences). Only the conceptual foundations are important for everybody.

Table 2: Comparison of the relative importance of the Knowledge Areas with intended audiences

| **Knowledge areas** | **Audience** | | | | |
|---|---|---|---|---|---|
| (Dibiase et al, 2006) | End use | Visualization | Data collection and maintenance | GI development with IT | Coordinator |
| Analytical Methods | + | 0 | 0 | + | - |
| Conceptual Foundations | + | + | + | + | + |
| Cartography and Visualization | + | + | - | - | 0 |
| Design Aspects | - | - | + | + | 0 |
| Data modelling | - | 0 | + | + | - |
| Data | 0 | + | + | 0 | - |

| **Knowledge areas** | **Audience** | | | | |
|---|---|---|---|---|---|
| (Dibiase et al, 2006) | End use | Visualization | Data collection and maintenance | GI development with IT | Coordinator |
| Manipulation | | | | | |
| Geocomputation | - | - | 0 | + | - |
| Geospatial data | + | + | + | 0 | 0 |
| GIS&T and society | - | 0 | - | - | + |
| Organizational and Institutional aspects | - | 0 | - | - | + |
| | | | | | |
| - : relative less important<br>0 : Neutral<br>+ : relative important | | | | | |

## EDUCATIONAL FORMATS

GI education formats, similar as general education formats have changed towards a more diffuse methods like e.g. e-learning. So many different courses either purely distance learning or in a blended form are nowadays available. They can be used to enhance the "old fashioned" format (combination of lectures and practicals), especially for more advanced topics. Learning styles of the students should be investigated, because sometime the clicking mode will prevail.

## BEST PRACTICES

Best Practices can only be discussed after a thorough exchange of the context, intended audience and objectives.

The practice to expect of a student that he or she is motivated to study for all the relevant topics is not sustainable. In an introductory course GIS at Groningen University with students with different backgrounds (spatial planning, human geography, biology, arts and informatics, landscape history) emphasis should be on the added value of GI in their own domain. Topics like data models, programming, data design do not motivate the students, or even chase the students away. Many guest lectures and relevant (to their own environment and domain) case studies help the students to evaluate and accept GIS as a tool for their benefits.

A relative new approach to GI education is to bring students with different backgrounds together and work on a project. If the group consists of a mixed audience (as defined above) they can deliver fast e.g. a 3D urban model in a web environment. Knowledge of Geo-ICT, combined with the relevant expertise in urban development and spatial planning, together with visualization techniques will help the client and end user to reach their goals. Such an approach is from an organizational point of view difficult, because the students from different faculties.

## CONCLUSION

Good and reliable GI education should combine the needs of the intended audience with the relevant contents. Nowadays students do not need the total overview of the GI topics, but more specifically the aspects they need in relationship with their activities.

Regarding the question mark in the title of this article the conclusion is that there is a need for differentiated courses, although in practice everyone and the specialist will come together for good results.

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# Geoinformatics education in different disciplines – Challenges - approaches and experiences

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## ABSTRACT

On the one hand side Geoinformatics, GIS or GI Science, and maybe other names/variations, is the main subject of autonomous study programs, but on the other hand side Geographic Information (GI) related issues play a role in more traditional study programs like Civil Engineering, Computer Science or Geography. The requirements in this study programs are quite different concerning the content (methods) as well as the skills the students are supposed to acquire during the program. As Geographers are in general more interested in using GI methods for various analysis tasks, Computer Science specialists should for example be able to design and develop applications which make use of Geographic Information in any sense. But there are basic concepts of space which are (hopefully) relevant for all of them. The question here is if these issues have to be taught in different ways, as the background of the students in the various programs can be very different.

The author of this paper is teaching different GI modules in Civil Engineering as well as in Computer Science and in Business Informatics. In these disciplines GI modules of 3-6 ECTS credit point size are offered and the GI relevant modules have a size of up to 30 ECTS credit points in total, mainly in Master courses. In the paper the challenges of teaching GI in various contexts is discussed. Further the UCGIS GI S&T Body of Knowledge (BoK) is checked whether this approach is suitable to describe the necessary core topics of a GI education within different study programs. It is shown that there are some deficits within the BoK and an extension of the BoK is suggested which allows for a more declarative depiction of the curriculum.

## INTRODUCTION

There are quite a number of terms around, which are related to the education in the field of Geoinformation (GI), some examples: Geoinformatics, Geographic Information Science (GI Science), Geographic Information Systems (GIS), Geomatics, Geomatic Engineering …

It is not the goal of this paper to discuss all of these terms, it should only be mentioned that the relation between the term GIScience (used in BoK) and Geoinformatics (used in this paper) has been discussed in [Reinhardt et al, 2008]. It has been stated there, that both definitions say that it´s the "science behind GIS" but in more easy words one can say that GIScience is a term developed and shaped from the Geographic Society in the US while Geoinformatics better expresses the European view, that GIS is built on three pillars, Geography, Geodesy and Computer Science. For this reason the term Geoinformatics is used here instead of GIScience.

The University Consortium for Geographic Information Science (UCGIS consortium) has developed a Geographic Information Science and Technology (GI S&T) Body of Knowledge (GI S&T BoK) [DiBiase, 2006]. This valuable work can be used for many purposes like curriculum development, curriculum review, program evaluation and assessment as well as professional certification and employee screening, just to mention a few examples. The "European discussion" on the GI S&T BoK (in the paper shortly "BoK") started in 2006 after a presentation from UCGIS [Johnson, 2006]. At the

EUGISES 2008 [http:/www.eugises.eu/] conference there was a presentation on a European perspective related to the BoK [Reinhardt, 2008] and in a discussion session around 30 people involved in GIScience education in Europe devised a common view on the BoK. Some of the statements developed there:

- The BoK in general is seen as a valuable work, it is considered to be very important and helpful for quite a number of tasks.
- A BoK of GIScience should not represent primarily a Geography point of view (as the available version of BoK does) because it is believed that mainly Geodesy and Computer Science also play an important role within GI Science. This leads to the request to add Computer Science, web based services, Geodesy and GPS more explicit to BoK, preferable on the top level.
- The definition of topics related to basics in Natural Sciences, Mathematics, Computer Science etc. is as important as the definition of GI Science topics
- The core knowledge e.g. for a Master of GI Science should be defined more explicit.
- Laws, directives, initiatives like INSPIRE, Galileo, available data like the "Amtliches Topographisch-Kartographisches Informationssystem" (ATKIS), Data given policies and also the combination of GI with other disciplines in study programs lead to the fact that regional perspectives (like Europe) have to be considered in a BoK.
- An indicator for the depth of teaching should be added to the topics, e.g. Blooms taxonomy
- …

More details about these issues can be found in [Reinhardt et al, 2008]

In 2008 the BoK was first used for mapping different curricula [Rip, 2008] and this work has been further extended and discussed [Rip et al 2010, Rip et al, 2011]

There are other initiatives which are aiming at the definition of a core curriculum in the "GI field". For example the German Society of Geoinformatics (GFGI) published a draft of a core curriculum for Geoinformatics (in German language) [GFGI, 2009]. The approach of the GFGI is different from the BoK approach. It´s not including a BoK, it defines core competences which Geoinformatics students should acquire, not only in GI itself but also in basic sciences like Mathematics and Computer Science. As the goal of this paper is more related to the topics of the curriculum only the BoK is used as a base for the discussion in this paper.

The paper presented is organized in the following way: In the next section the background and the goals of the paper is explained and the utilization of the BoK for the purpose of the paper is discussed. After this the question of what is "core" in GI education is addressed and it is discussed whether the BoK is suitable for this task or not. Next an extension of the BoK is suggested and 2 cases of curricula from the authors experience are mapped to the suggested extended BoK. Last some conclusions are drawn.

## BACKGROUND AND GOALS OF THIS PAPER

The author of this paper is teaching GI issues in different disciplines like Computer Science (CS), Business Informatics and Civil Engineering (CE). The challenge here is to adopt the curricula to the different competence profiles of these disciplines. This will be discussed in more detail in the following, taking Computer Science and Civil Engineering as an example.

In Computer Science one of the specialisations is “Geoinformatics and Computer Vision” (30 ECTS). The Geoinformatics part includes the following modules:

- Geoinformatics Basics (3 ECTS)
- Geoinformatics I (Reference Systems, datum, map projections .., 3 ECTS)
- Geoinformatics II (Spatial data bases and data types, analyses, quality …, 3 ECTS)
- Geoinformatics III (Basics of services, geo web Services, security …, 3 ECTS)
- Geoinformation programming, project based (3 ECTS)

The Computer vision part includes image analysis, photogrammetry and remote sensing, but will not be further discussed in this paper.

In Civil Engineering there are only 2 Modules related to GI:

- Geodesy, Surveying and GIS (which includes GI Basics and DTM) (6 ECTS)
- Geographic Information Systems (Data bases, analysis, visualization) (3 ECTS)

The competences students should have after having attended the course are:

- In Computer Science they should be able to design and implement applications which also include (among others) any handling of Geographic Information
- In Civil Engineering they should acquire the necessary basic knowledge to use GI methodology in water management and planning

This shows that the requirements in different study programs can be quite different.

It leads to the following questions:

- What is the core of GI topics which should be taught in every program with GI content?
- Is the BoK suitable to describe the content of GI modules in other disciplines than Geography?
- Can the differences in the learning goals and the content be expressed with the BoK?

## BOK AND GI CURRICULUM CORE CONTENT

The BoK describes the content of GI education in a hierarchical manner and it includes 10 knowledge areas (see table 1). These knowledge areas (KA) include 72 Units and around 1330 topics [Rip et al, 2010]. For a complete list of units and topics please refer directly to the BoK [DiBiase et al 2006].

Table 1: BoK – knowledge areas, derived from [DiBiase et al]

| | |
|---|---|
| Analytical Methods (AM) | Data Manipulation (DN) |
| Conceptual Foundations (CF) | Geo Computation (GC) |
| Cartography and Visualization (CV) | Geospatial Data (GD) |
| Design Aspects (DA) | GI S&T and Society (GS) |
| Data Modelling (DM) | Organizational and Institutional Aspects (OI) |

“Core” has been defined in the BoK on the level of units (see table 2). From these two tables we can see that Geo Computation is the only knowledge area with not a single core unit. At all 26 (of 72) units are considered to be core. The knowledge area Geospatial Data contains the most core units (9!).

Table 2: BoK – core units, derived from [DiBiase et al]

| Knowledge Area | Core Unit | Knowledge Area | Core Unit |
|---|---|---|---|
| **Analytical Methods** | Geometric measures | **Data Manipulation** | Representation transformation |
| | Basic analytical operations | | Generalization and aggregation |
| | Basic analytical methods | **Geospatial Data** | Earth geometry |
| **Conceptual Foundations** | Domains of GI | | Georeferencing systems |
| | Elements of GI | | Datum's |
| **Cartography and Visualisation** | Data considerations | | Map projections |
| | Principles of map design | | Data quality |
| | Map use and evaluation | | Land Surveying and GPS |
| **Design Aspects** | Data base design | | Aerial imaging and photogrammetry |
| **Data Modelling** | Database management systems | | Satellite and shipboard remote sensing |
| | Tessellation data models | | Metadata standards and infrastructure |
| | Vector and object data models | **GI S&T and Society** | Ethic aspects of geospatial information and technology |
| | | **Organizational and Institutional Aspects** | Institutional and inter-institutional aspects |
| | | | Coordinating organisations |

With respect to the size of this paper a discussion of core elements is done here on the level of units. In "real" curriculum design of course this has to be done on the level of topics. The main points from a "non-Geography view" which have to be discussed are:

- In general the core for GI studies within the framework of another subject is depending from the number of credit points dedicated to GI modules. But the core topics within AM, CF, CV, DA, DM, DN and GD should be addressed in any case. Of course the extent of the core modules then has to be adapted to the total number of credit points available for GI. Also the subject plays an important role here, as it might be that part of the GI core is already taught within other modules (see further comments in this section).
- The AM core units as well as the CF ones can be accepted as core also in Computer Science and Civil Engineering. CF can be treated shorter than in Geography.
- Related to Computer Science the main focus in this field is visualization of geographic and thematic data, so we decided to include topics which introduce the principles from thematic mapping. In both subjects basic knowledge of map use are important but map production is not really of interest in these fields (besides some very basic things of map legends etc. which can be done with 3-4 slides)
- Design aspects is interesting in these conjunction as it shows extremely how important it is to consider the background and the subjects the students have in their "main subject". In Computer Science of course students are familiar with all aspects of data bases as well as with modelling languages like UML, so it's sufficient to teach about Geographic Data types, Index structures and Geo Data Bases in general. In Civil Engineering it is the opposite, they have an introduction into object oriented programming, but they have no knowledge in Data Bases at all which makes it necessary to include basics about data bases, SQL …

- Data Base Management systems are included in DM but have been discussed already. The two other core unit’s tessellation and vector and object models are important for both subjects although there are differences in the way this is taught, which holds for other topics, too.
- DN covers, from the point of view of the author of this paper, many things which would fit within other modules better, for example interpolation (in AM), vector to raster conversion and vice versa (in DM) but there is no doubt, that this 2 units should be really core.
- GD includes the highest number of core units as already mentioned. According to [Reinhardt et al, 2008] topics like SDI, Services, Metadata, ISO and OGC Standards, Geo Web Services are not represented adequately. This is shown by the fact that all these topics are included in one single unit! (Meta data standards and infrastructures). This is not acceptable. These topics are very important today and can represent around 30% of a curriculum (see below). Consequently this area should be defined as an own KA!
- GS units are considered to be not that important for technical subjects like Civil Engineering and Computer Science. But according to their relevance for other subjects they should be in the list for core units.
- OI core units are for sure important for almost all subjects.
- As the design and implementation of applications which make use of Geoinformation is a major skill of GI experts (and the market requires this), some subjects related to this should be added. In Computer Science and also in some parts of engineering this is a major task, hence this should be a knowledge area. But this is a matter of discussion. It could also be established as a unit.

This leads to a suggestion of the following knowledge areas included in table 3.

Table 3: Suggested knowledge areas, based on BoK

| | |
|---|---|
| Analytical methods (AM) | Data Manipulation (DN) |
| Conceptual foundations (CF) | Geo Computation (GC) |
| Cartography and Visualization (CV) | Geospatial Data (GD) |
| Design aspects (DA) | GI S & T and society (GS) |
| Data Modelling (DM) | Organizational and Institutional aspects (OI) |
| Spatial Data Infrastructure (SI) | Application Programming (AP) |

The suggested new KA´s in more detail:

## Spatial data infrastructures (SI)

SI1 General purpose and background, initiatives, non-technical aspects, laws etc.
SI2 Metadata (purpose, models, challenges)
SI3 Introduction to Interoperability (syntactic, semantic)
SI4 Basics of Services (HTTP, REST, SOAP)
SI5 Services I (basics, WMS, WFS)
SI6 Services II (advanced, WCS, WTS …)
SI7 Security of Services (authentication, access control ..)
SI8 Relevant Standards (GML, Spatial Schema …)

## Application Programing (AP)

AP1 General approaches
AP2 Open Source API´s
AP3 Proprietary APIs
…

The content of the unit have to be defined in more detail on the level of topics. The intension here also was to be as close to the BoK as possible!

As already mentioned the curricula description should also include information how deep the topic is taught. For reasons of simplicity as a first approach only 3 levels are suggested and this describes which competences the students can acquire in the module:

- Students Know about it
- Students can apply it in their domain
- Students are able to use the concepts for the design and implementation of any GI related application

### Mapping of the study course content to the proposed schema

The content of the two cases introduced above has been mapped to the knowledge areas introduced in this paper. For the GI content (9 ECTS) within the Civil Engineering program the result of the mapping is given in table 4.

Table 4: Result of mapping of the GI content of the CE program to the adapted KA

| Knowledge Area | Content (%) |
|---|---|
| GD | 45 |
| AM | 15 |
| SI | 10 |
| DA | 15 |
| CV | 6 |
| CF | 5 |
| OI | 4 |

For the GI content (15 ECTS) within the Computer Science program the result of the mapping is given in table 5.

Table 5: Result of mapping of the GI content of the CS program to the adapted KA

| Knowledge Area | Content (%) |
|---|---|
| SI | 30 |
| AP | 25 |
| GD | 25 |
| DA | 8 |
| AM | 6 |
| CF | 3 |
| CV | 3 |

If the original knowledge area structure from the BoK would have been used, in both cases GD (Geospatial Data) would be 55%. But it would not be clear, that in CS much more SDI related topics are included than in CE. In CE one strong focus is Geodesy/Surveying, which is expressed by the high percentage of GD (45%).

Also the introduction of AP clearly shows that this curriculum is intended to convey programming competencies. For the knowledge areas in general some information should be included about their deepness as suggested above, so that it´s clear if the graduate's know about a knowledge area or are able to apply it.

## CONCLUSION

For the conclusion we should go back to the questions asked above:

- What is the core of GI topics which should be taught in every course with GI content?

The core topics which have to be taught in every course - and we are only talking about courses where GI in not the main subject– can be very well oriented on the BoK core units. But it depends on the amount of credit points dedicated to GI and also on the topics which are included in the main subject. In general at least the core units from Data Modelling, Analytical Methods, Geospatial Data and some Conceptual Foundations have to be addressed.

- Is the BoK suitable to describe the content of GI modules in other disciplines than Geography?

As the BoK is mainly addressing GI within Geography education it lacks in an appropriate consideration of IT related topics like GI Standards, Services and SDI in general. If we would modify the BoK as suggested in this paper a mapping of a curriculum to a modified BoK would be more declarative.

- Can the differences in the learning goals and the content be expressed with the BoK?

It has been shown by [Rip et al] already, that the BoK is very suitable to compare curricula by means of "EduMapping". Some deficits in using the BoK as it is have been identified in this paper. An extension of the BoK as suggested would give a more declarative picture also in this context.

UCGIS is working on a further development of the BoK. It is hoped that the European view can be integrated in the next versions to be able to arrive at a "common BoK" in near future which expresses the US and the European perspective!

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# GIS-training in spatial epidemiology: the role of the private sector in bridging the gap between research and decision making

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## INTRODUCTION

The geographic awareness in epidemiology took a legendary start with John Snows investigations on the cholera outbreak in London in 1854 (Cameron and Jones, 1983). It illustrated how maps can be used in the understanding of, and the fight against epidemiological diseases. Since the early nineties, GIS has been commonly used in epidemiology. Nowadays, the focus of GIS in epidemiology and health studies is twofold: GIS is used in a research-oriented environment to understand a disease (risk factor determination, spatial disease modelling and distribution and prevalence studies) and as a powerful tool in controlling the disease (emergency response, disease detection, operational optimization of the response). GIS is now generally accepted by the scientific community to be a major tool contributing to the understanding of epidemiological processes between disease, vector, host and environment. Figure 1 illustrates the exponential evolution on scientific articles on GIS and epidemiology.

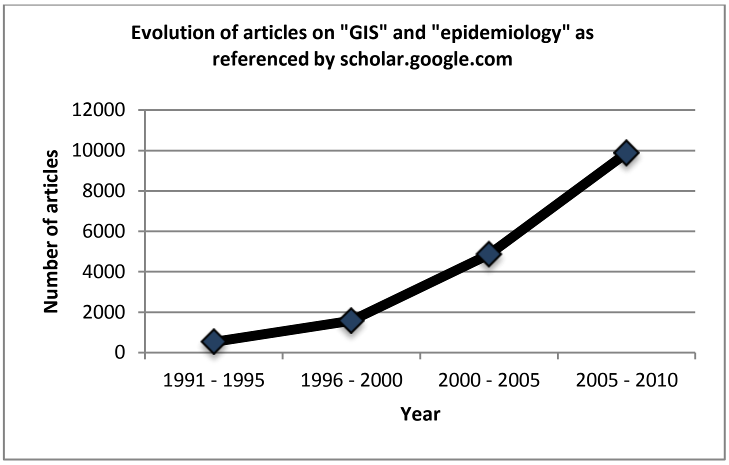


Figure 1: The evolution of the numbers of articles on Epidemiology and GIS since 1991.

Avia-GIS, "Agriculture and Veterinary Information and Analysis", is a Belgian company and well-known research unit in spatial epidemiology in veterinary and human health, consulted by international organizations, governments, research institutions and the industry. It was established in 2001, when GIS was starting to emerge in the community of veterinary and public health research (Fig.1).

The company specializes in the collection, processing and analysis of spatial information as a basis for the development of data driven Spatial Decision Support Systems (SDSS) applied to veterinary and public health in general and emerging vector-borne diseases (VBD) in particular that bridge the gap between research and development using state of the art geographical information systems (GIS), remote sensing and spatial analysis techniques. Avia-GIS offers a range of services to research teams, governments and the industry which include: research and technical development (RTD), consulting, software development and capacity building. Preferred RTD topics are: spatial distribution models, the development of cost-effective spatial sampling strategies, the issue of false-negative trap results, the assessment of spatial uncertainty, and wind dispersal models for air-borne arthropod vectors of disease. Efforts towards understanding and modelling spatial patterns in the lifecycle of vector-borne diseases and other emerging zoonosis are conducted within the holistic context of global change encompassing: climate driven change, increased global traffic of persons and goods, land-use and land-cover change, and socio-economic changes.

From the onset, the project partners of Avia-GIS – veterinary and public health researchers – had a need to be trained in specific GIS-knowledge that enabled them to use GIS in their particular field of expertise. Moreover, since most of the research partners are international, a cost-efficient way to provide this training had to be envisaged. This lead to a training approach within the Research and Development Unit of Avia-GIS, providing several course-formats on GIS and spatial epidemiology.

In this article, the general training philosophy of Avia-GIS is outlined, the training structure of the courses are given and the training modalities of Avia-GIS are detailed.

## THE TRAINING PHILOSOPHY

Answering the simple question "What is a GIS?" is never straightforward. Depending on the users' point of view different replies will be given, each of them focusing on an aspect of GIS that is the most crucial for her/him (e.g. spatial data visualisation, storage, analysis, or geo-processing…). Participants of the training programs of Avia-GIS are all working in the field of epidemiology, enabling us to narrow the focus in our GIS-trainings. Their training needs are indeed very specific and are focused on the use of GIS in spatial epidemiology. Their learning curve should be as sharp as possible and has to reach relatively fast the core of the course: spatial epidemiology. In contrast to the more general courses on GIS that are developed to a broad audience of participants, this "quick-to-the-core approach" has been proven very efficient and successful.

Besides the strong focus, the design of the training programs takes into account as much as possible the current principles of "good learning":

- Knowledge is constructed from experience (constructivism)
- Put the learner in the front seat behind the wheel: let her/him design his own learning path (student-led instruction);
- Work very visual;
- Let the learner share his information with others (connectivism).

### Constructivism

Humans are active agents in the construction of knowledge (Mayer, 2009). The focus should be shifted from systems of delivery of knowledge to the construction of knowledge. By delivering real-world problems to be solved by the participants of the course, participants are urged to take an active role in building their own knowledge.

### Student-led instruction

The student-led instruction is particularly useful in the advanced modules and for those trainings that are project-driven. Participants have already a sound knowledge of GIS and master elementary GIS skills. They are able to design in close collaboration with the course leader(s) and in respect to the common project goal, their common learning trajectory. Course leaders use scaffolding techniques to keep the participants focused.

## Visual

Screenshots and screen casting of actions that need to be undertaken with the GIS-software are interspersed throughout the learning materials (see Figure 2 as an example on how to define the coordinate system in QGIS).

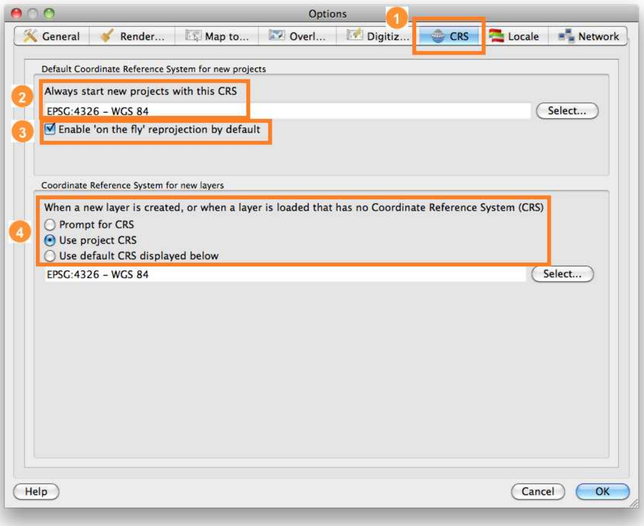


Figure 2: An example of visual support in performing software operations

A screenshot of the outcome from a requested operation is given so that students can verify if they completed the exercises correctly (see Fig 3 as an example on how to delineate a zone where traps will be placed at a certain distance of forests).

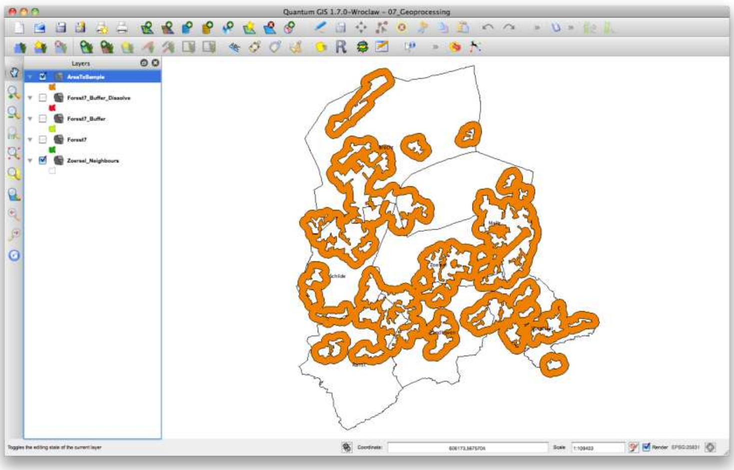

Figure 3: An example of visual support for self-evaluation: the outcome of a series of geo-processing operations in QGIS

Conceptual knowledge construction is richly supported by graphics (see Fig 4 as an example to illustrate the effect of resolution)

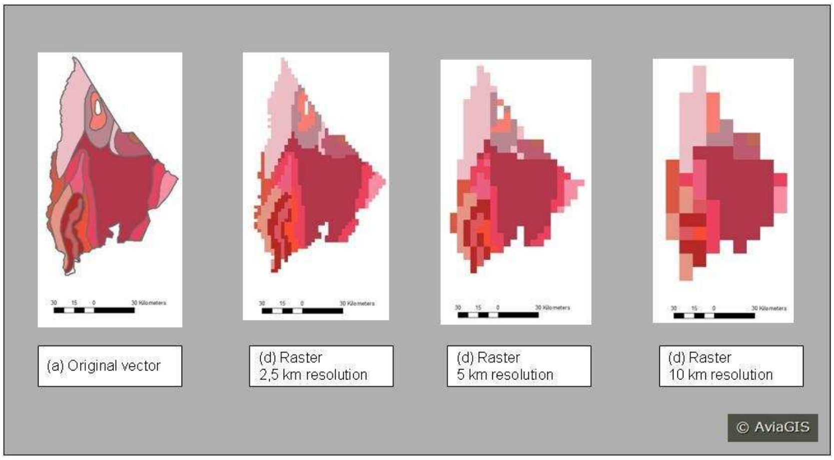


Figure 4: An example of visual support for conceptual knowledge construction: the effect of raster resolution

### Stay connected

If learning is viewed as socially situated in nature (Lea & Nicoll 2002, Lave & Wenger 2002), then dialogue becomes an important means by which meaning is negotiated and knowledge constructed. Siemens (2005) suggests that learning is based on experiences and because first-hand experience is not always feasible, competence is gained from forming connections and sharing the experiences of others. Therefore, a community of inquiry is an extremely valuable, if not essential, context for higher-order learning. Such a community involves (re)constructing experience and knowledge through the critical analysis of subject matter, questioning, and the challenging of assumptions. This is consistent with the premise that an educational learning experience is both collaborative and reflective (Garisson et al, 2001). Laurillard's (2001) conversational framework, drawing extensively on educational theory, proposed that technologies should foster dialogue between teachers and students, and between students themselves, so that dialogic processes were supported, and knowledge was co-constructed. A major challenge facing educators using Computer-Mediated Communication (CMC) is the creation of a critical community of inquiry—the hallmark of higher education—within a virtual text-based environment. A community of inquiry is an extremely valuable, if not essential, context for higher-order learning. Such a community involves (re)constructing experience and knowledge through the critical analysis of subject matter, questioning, and the challenging of assumptions (Dewey 1959; Lipman 1991 – cited in Garisson et al, 2001). This is consistent with the premise that an educational learning experience is both collaborative and reflective (Garisson et al, 2001).

## THE TRAINING STRUCTURE

Generaly speaking, a course is organised around different topics (e.g. Raster Modelling). The learning cycle of each topic is characterised by a successive contextualization and de-contextualization of the learning materials. The contextualisation part of the course is of utmost importance for the course developers at Avia-GIS. Much attention, effort and care is devoted to embed exercises and examples into a course specific context. The learning cycle can be dissicated into three parts that are tightly interwoven:

- The first part can be considered as a theoretical one, in which participants acquire insights in spatial thinking, combined with a conceptual understanding of the role GIS can play in epidemiological studies;
- The second part consists of hands-on exercises using a particular GIS-software package with datasets that are relevant to the field of study of each cohort of participants. In this part it is envisaged that participant complete their conceptual knowledge with hands-on GIS-skills using a particular GIS-software. Once the participants master the required GIS-skills, a “real life” casus is presented to them. They need to solved this casus by applying the conceptual insights ànd GIS skills they acquired sofar. In this stage, their creative thinking is stimulated and their knowledge on GIS and epidemiology is elaborated;
- The third part facilitates the interaction between students – and depends on the strong user engagement. Participants are encouraged to interact with each other and thus stimulate creative thinking around the topic.

Avia-GIS has no commercial link with GIS-software vendors. Training is organized in standard GIS-software such as Arc-GIS (http://www.esri.com/software/arcgis/index.html), Quantum GIS (http://www.qgis.org), ‘R’ (http://cran.r-project.org), IDRISI (http://www.clarklabs.org/). Besides the standard GIS-software, Avia-GIS is also offering specific trainings as part of its in-house developed software tools including VECMAP (a One-Stop-Shop for vector mapping) or Vet-geoTools (a disease management control software). See also www.avia-gis.com.

## THE TRAINING MODALITIES

The training programs are offered as (i) residential courses; (ii) under blended format (workshops at regular intervals supported by distance learning tools), (iii) as distance education program s.s. or (iv) on-demand training for specific tasks. Learning goals are defined in close collaboration with curriculum developers, clients or to highlight the specificities of software packages. Participants are exposed to conceptual frameworks and learn to apply them through hands-on exercises, both at a basic and an advanced level. Their critical thinking is stimulated through actively applying the concepts and techniques into their own field of expertise. Case studies as well as scientific articles are discussed. Training programs are compliant to high academic standards.

In the distance learning programs, state-of-the-art Web2.0 tools are commonly used. Web 2.0 refers to what is perceived as a second generation of Web-based services emphasizing online collaboration and sharing (Collis and Moonen, 2008). Through discussion fora, participants are encouraged to share their experiences, to post request for help from fellow-participants or from course leaders. Synchronous and a-synchronous communication takes place. The most important format of synchronous communication is through screen-sharing facilities supported by audio: the course leader can assist individual participants to overcome difficulties in the processing of their data. This has proven very useful and is a valuable learning tool: the course leader can see what the participant is doing and can give hints to overcome the problem, or the participant can see what needs to be done by following the screencast of the course leader.

The learner-as-co-designer works very efficiently in the individual trainings. In these trainings, an individual PhD-students receive a tailored training for his research, based on her/his own research questions. In the group trainings, there is a discrepancy between in the expectations of the students themselves and the course leaders. In groups, people are more “more prepared to have a teacher-centered course than a learner-centered course”. This is conform with the findings of Zurita (2006).

## Residential courses

Resident training courses are organized as part of existing MSc programs, as a stand-alone workshop or workshop series focusing on a specific theme, or as workshops supporting distance learning. During residential courses maximum advantage is taken from direct interaction between students and tutors.

Relevant examples:

Avia-GIS organizes each year the three week GIS and Epidemiology module of the Master of Science in Tropical Animal Health at the Institute of Tropical Medicine, Antwerp, Belgium;
Avia-GIS organizes advanced workshops on the use of 'R' in spatial modeling;

## Distance learning modules

Distance learning courses are geared for post graduate students who are professionally active. These courses are spread over a sufficiently long period (3 to 6 months) and can be attended in parallel with other professional activities. Ample occasion is given for interaction with course leaders and between participants. Typically, an exercise starts with an introduction to the theoretical concepts followed by a problem-based learning setting. Participants are given two week time to submit their results. Individual feedback is given after each assignment. On-line chats with participants are permanent and course leaders reply to questions during agreed time slots. Avia-GIS operates all its DL courses through its own electronic distance learning platform (http://learning.avia-gis.com/).

Relevant examples:

- Avia-GIS developed the GIS Distance Learning Module on Spatial Epidemiology for the University of Pretoria, South Africa with funding from the Institute for Tropical Medicine. This course is now operated and further developed by the University of Pretoria.
- Avia-GIS provides tailored Distance Learning Modules for a series of large international research projects: EDEN and ICONZ.
- Avia-GIS provides tailored Distance Learning Modules for its software packages Vet-geoTools and VECMAP.

## Blended learning

In the blended learning formula, the best of both worlds are combined. In a starting 2-3 days workshop, face-to-face lectures and trainings are held and a community is established. During the GIS-clinic specific problems of participants are be tackled. The follow-up of the workshop is ensured during the distance learning track.

Relevant examples:

- Avia-GIS organizes annual workshops as a support to the GIS distance learning course as part of the EDENext project.

## Individual training

As part of our multidisciplinary research projects Avia-GIS staff members are invited by partner research institutes as co-promotor for PhD students. More recently the opportunity was given by the Flemish Regional Government for companies to hire PhD students as full time employees. The Baekeland program is funded through IWT and aims at promoting innovation in the private sector. The PhD degree is obtained in a close partnership of Avia-GIS with a University. In both cases this enables a very personalized training approach.

## CONCLUSION

The GIS trainings of Avia-GIS are based on an active and problem-based approach with datasets originating from true veterinary and public health examples. Participants use GIS-software (proprietary or open source) to work-out solutions for several case studies. Their spatial analysis skills are developed through a set of hands-on exercises with gradually increasing complexity. This approach helps participants with constructing their own conceptual knowledge of GIS in their particular field of interest. During this highly interactive process of requiring skills and knowledge, course facilitators guide the students through the conceptual framework of spatial epidemiology using an individual approach, giving hints and cues, and using scaffolding techniques. Discussions between participants are stimulated continuously. In the advance course formats, the student-led approach is still more explicitly present: participants bring in their own datasets/research question and form a community of inquiry.

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# Papers session 2:

# GI-education tools

# Interactive tools to learn geostatistical basic concepts, as part of GIS-education

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## ABSTRACT

GIS-software integrates numerous different concepts and approaches, and allows the user to apply them relatively easily. For some GIS-applications, geostatistical interpolation techniques can be applied. Although that the concepts of geostatistics are commonly difficult to understand, it is not that difficult to use the geostatistical buttons in most GIS-software packages. On the one hand, this is good; however, there is a risk involved in applying geostatistics without knowing the necessary details and background. Although numerous good textbooks about geostatistics exist, not everyone who uses geostatistics has the time to really study these books, or is prepared to do so. That is the main reason that some interactive tools based on the free public domain software R have been developed. They aim to assist individual first time users, but also regular students and teachers to get a feeling of the importance of the various aspects in conducting a good geostatistical study. Specific items that are being addressed are (i) the link between the variation of the parameter value in space or time, and the calculated experimental semivariogram as a function of the interdistance, (ii) the link between the sampling geometry and the experimental semivariogram, and (iii) the benefits, but also the limitations of kriging as an interpolation technique.

## INTRODUCTION

The concepts of geostatistics are commonly difficult to understand for students, even for those with a strong mathematical background. A main problem is certainly the link between the variation of the parameter value in space or time, and the calculated experimental semivariogram as a function of the interdistance, but over the entire area investigated. Furthermore first time users of geostatistics often do not want to struggle through different books with the whole geostatistical background before using it. Too often this leads to using geostatistics as a black box with all the risks linked to it. This is in particular a risk when using integrated software packages, like for example GIS-software. A geostatistical study should not be a trial and error process in which some buttons are hit at random or tried out to see what the effect could be. The risk is that one aims to get the nicest map but not the best result.

Although kriging claims to be the best linear unbiased estimator, it only fulfils this role when the spatial variation is properly translated in a correct semivariogram model. And the latter is significantly affected by the sampling campaign and the way the semivariogram is calculated and modelled afterwards. Quite often the data is blindly imported in a software program, which calculates an experimental semivariogram, determines the 'best' semivariogram model and computes kriging estimates. These results are then considered as the only and best results, and often get a high quality label as they are based on geostatistics, while the opposite is true.

The developed R-based interactive modules aim to assist students and teachers of geostatistical courses, but also of GIS-courses. Individual first time users can use these modules too, i.e. to get a feeling of the importance of the various aspects in conducting a good geostatistical study. In this way, valuable experience can be gained prior to starting real estimation projects, without being confronted with the consequences of a bad study. The geostatistical interactive modules can be accessed through: www.bwk.kuleuven.be/geostatistics. A manual is compiled to facilitate the use of the modules and to guide the user.

## R-BASED INTERACTIVE MODULES

The statistical package R, which is free and open source software, is used to develop the modules presented in this paper. The benefits of this package are: (1) it is available for free; (2) it is available for multiple operating systems; (3) R has a large active community and all the programs written in R are shared with the other R users. At the start of the project it was also considered to use Java instead of R. Java offers the advantage that the modules can be used through an internet browser. Moreover, Java offers many opportunities for visual interactive applications. The disadvantage is that, when Java would have been chosen, all mathematical calculations should be programmed. After a thorough study of the capabilities of R, it was clear that R has sufficient opportunities to develop interactive, visually appealing modules. In this case the tcltk package of R was used to develop the modules. In addition, the already existing 'packages' in R can be re-used for the mathematical and (geo)statistical calculations.

This paper describes a number of generally accessible R-based (www.r-project.org) interactive modules, developed by the authors, which can be used as part of a geostatistical or GIS-course, but also by an individual user getting familiarized with the key concepts of geostatistics, e.g. as part of a GIS-application. These modules should allow the student or practitioner to see directly the impact of deleting, moving or adding data points, of changing parameters when calculating an experimental semivariogram (e.g. lag distance, lag tolerance, directional tolerance, etc.), of changing parameters of the semivariogram model and of the geometrical parameters during kriging.

The modules are compiled in such a way that they work completely autonomously. This means a.o. that it is not required to have a dataset of your own. Those modules are therefore not meant to do a geostatistical study on a certain dataset (for this purpose there exists already a broad spectrum of good software packages). After being familiarized with the key concepts of geostatistics it should be easier for the user to do a good quality geostatistical study on their own dataset and to do a good interpretation of these results.

The development of these modules is based on experience with web-based tools for teaching statistical concepts, namely ‘Vestac’ and ‘env2exp’ (see http://lstat.kuleuven.be/java/ and http://lstat.kuleuven.be/env2exp/) (Darius at al., 2007). Those tools got several good critics and are already used in statistical courses all over the world (Cobb, 2007 and Wild, 2007).

## BASIC CONCEPTS OF GEOSTATISTICS

A geostatistical study always starts by determining the semivariogram(s), based on a number of sampling points (e.g. Journel and Huijbrechts, 1978 and Webster and Oliver, 2007). The experimental semivariogram is defined as a function of the lag distance h. It equals half the quadratic average of the difference between data at a particular lag distance h:

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} \left[ F(x_i + h) - F(x_i) \right]^2$$

where x = the coordinates in space; N(h) = the number of data pairs separated by h; F(x) the parameter value in x. Hence, the experimental semivariogram describes the correlation of two values of the same parameter in space (or time). Each individual point of a semivariogram must be based on enough data pairs. The obtained semivariogram is fitted by a model. Most often the range, the sill and the nugget value are the three most important parameters describing these models. The range is the maximum lag distance for which the values at the two points are still (partly) dependent of each other. The sill is the plateau that the semivariogram reaches at the range. The nugget is the vertical jump from value 0 at the origin to the semivariogram value at extremely small separation distances. Four models are available in the interactive modules (Govaerts and Vervoort, 2011): spherical, bounded linear, power and periodic. The formula for the spherical model (used further) is:

$$\gamma(h) = n + b\,(3h/2a - h^3/2a^3)\ , \text{ if } h < a$$

$$\gamma(h) = n + b\ , \text{ if } h > a$$

where a is the range, n the nugget and b the sill of the spherical part.

As the individual estimated points of a semivariogram are significantly affected by the sampling geometry (size of the sampling campaign and absolute and relative location of the individual samples), the final chosen semivariogram model is also influenced by these parameters. The interactive modules allow to get a better understanding of the link between sampling geometry and semivariogram model for different spatial variations.

The information of the semivariogram model is used to estimate or krige the parameter at a specific location. Geostatistical estimation, or kriging, refers to techniques that provide the best linear unbiased estimators (BLUE) of unknown properties (Journel and Huijbrechts, 1978). In other words, kriging determines the weights for which the estimation variance is the smallest. In comparison to classical statistical interpolation techniques (e.g. inverse distance weights, 1/n, etc.), the spatial information is explicitly taken into account to determine the weights. Referring to the remarks formulated above, it is logic that the quality of kriging depends on a well defined semivariogram model, which needs an accurate estimation of the individual points of the experimental semivariogram. Apart from the quality of the semivariogram, the geometry between the samples and point(s) to be estimated plays a role also.

## PRESENTATION OF THREE DEVELOPED MODULES

It has been demonstrated, especially within the statistical domain, that complementary to traditional course material, providing more interactive visual tools increases the efficiency of learning and the enthusiasm of the students (Anderson and Dorai, 2001, and Marasinghe et al., 1996). By using the modules students without extensive mathematical background and experience with statistical software programs are more easily able to understand the underlying concepts of geostatistics. The purpose of the modules is that, without programming and implementing all calculations necessary for a real data analysis, the student is able to (1) understand the relation between the input (data and analysis parameters) and the results of an analysis; (2) understand why a particular method results in good or bad results; (3) compare different methods. For a number of successive steps in a proper geostatistical study a module, in which students can interactively see what the results of changes in data or analysis parameters are, is developed. To ensure that the level of difficulty starts low there is a separation between 1D and 2D problems. 1D problems are often easier to understand for students. They are presented in the first module. 2D datasets, for which effects like the influence of the direction are playing a role, are presented in the second and third module.

## Module 1, experimental semivariogram in 1D

The first module shows the experimental semivariogram of different datasets in 1 direction. The main aim of this module is to make the link between some simple variations of the parameter value along a line and the resulting calculated experimental semivariogram. Although this module is limited to 1D, the contour plots in 2D are also presented, so that the user gets already familiarized with this. Making the link between contour plots and a classic graph F(x) vs. x is not always that easy for students, apart from the link with the experimental semivariogram.

In a first screen the user can choose one out of three datasets (Figure 1): (1) a dataset with an alternation of high zones (one constant value) and low zones (one constant value); (2) a linear rising dataset; (3) a stepwise rising dataset. For each dataset it is possible to adjust different parameters describing the datasets (e.g. minimum x, length of the dataset and number of data points).

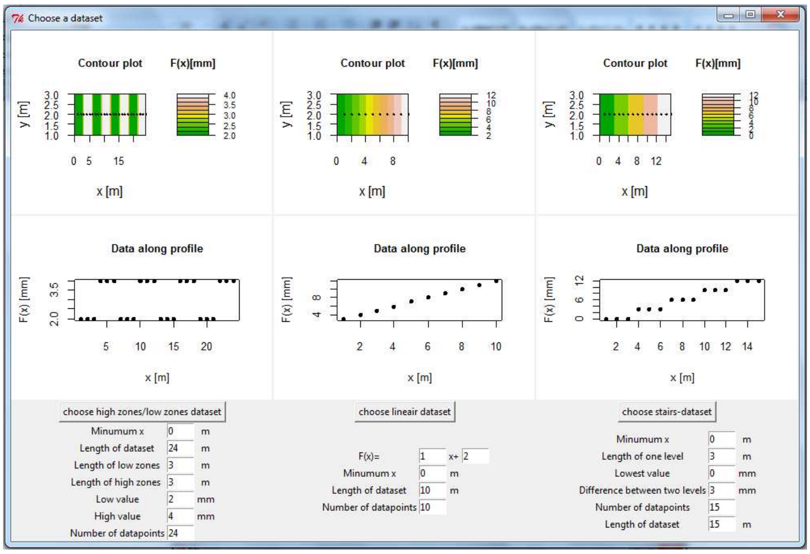



Figure 1: First screen of Module 1: selection of one of the three dataset provided (i.e. simple variations in 1 direction).

A second screen displays afterwards the selected dataset (Figure 2.a). It was decided not to show the experimental semivariogram immediately; it is only visible after ticking a box. This encourages the user to first reflect on how this semivariogram could look like. One can make some small hand calculations (e.g. number of pairs for each lag distance or semivariogram value). In this screen the user can also change or delete data points, and one immediately sees the effect on the experimental semivariogram. As an illustrative example, the linear trend is presented in Figure 2.a, whereby x varies between 1 and 10 m and F(x) between 3 and 12 mm (F(x) = 2 + x). Ten samples are considered at equal distance. The resulting experimental semivariogram corresponds to the quadratic function $h^2/2$. For h=1, 9 pairs are present, while for h=9 only 1 pair is available (connecting the first and last sample). The number of pairs is presented on the graph, but a table can also be generated with all information of the calculated experimental semivariogram. In Figure 2.b, the value of two samples is changed (one higher and the other lower than the linear trend), but the x-coordinate remains the same. This has no effect on the number of pairs, but the effect on the calculated semivariogram values is very clear. The quadratic variation has completely disappeared; the semivariogram approaches nearly a pure nugget effect. In Figure 2.c, the linear trend is not adapted, but two out of the 10 samples have been deleted, affecting the number of pairs for most lag distances. The example given in Figure 2 is only an illustration of some of the features, one can analyse in the first module, but many other questions can be addressed (Govaerts et al., 2011).

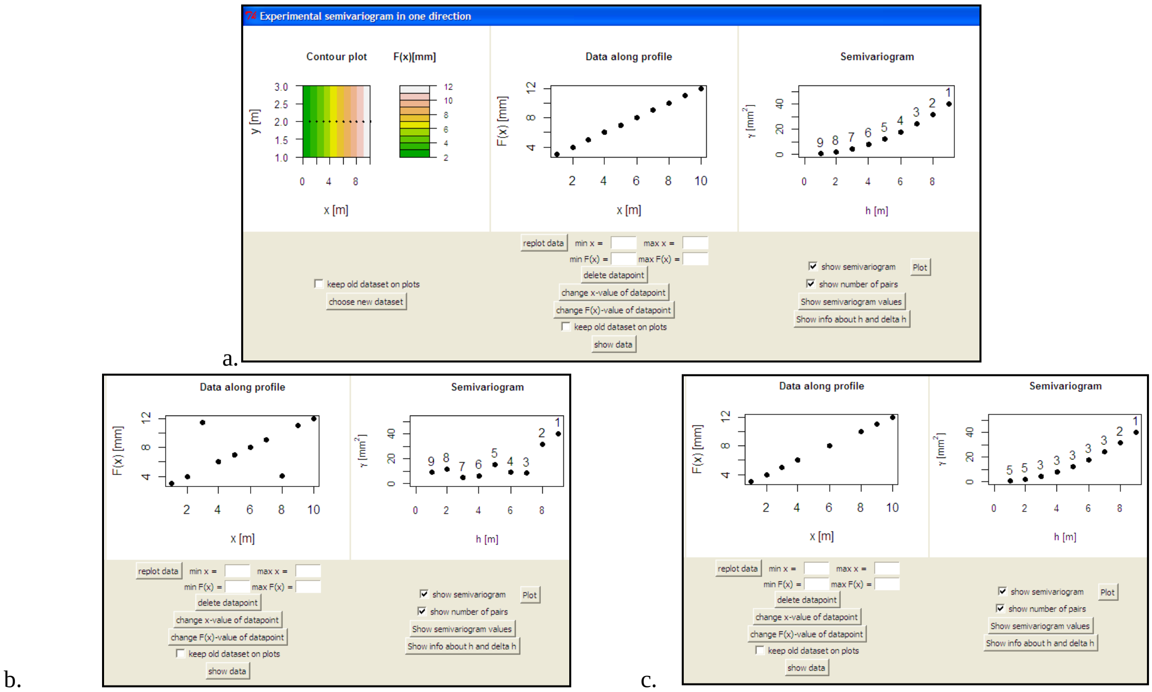



Figure 2: Second screen of Module 1: computation of the experimental semivariogram in 1 direction (a. Linear trend with 10 samples at equal distance); b. Two samples deviating from linear trend (10 samples at equal distance); c. Linear trend, but two out of the 10 locations not sampled).

## Module 2, modelling of experimental semivariogram in 1D and 2D

Module 2 shows the experimental semivariogram of different datasets in 1D or 2D (Vervoort et al., 2011). There are four datasets readily available, but the user can also change the datasets. The four datasets are: a first artificial dataset which is constant in the y-direction and linear in the x-direction; a second artificial dataset which is constant in the y-direction and showing an alteration of high and low zones in the x-direction; a realistic lognormal dataset (based on simulated lead contamination dataset using data from Houlding, 2000); a realistic normal dataset (based on data of elevation measurements from Isaaks and Srivastava, 1989). Each dataset contains 10,000 points at a regular grid within a zone of 10 m X 10 m. Hence, the separation distance is only 0.1 m along x and y. Every point is clickable. For simplicity, mm is used as unit for all four datasets, as there is no direct link with the original application.

Unlike the first module, where everything is kept as simple as possible, the sampling points are not determined in advance at certain positions with equal spacing. The user can choose the positions of the sampling points (Figure 3.a) and the way that the semivariogram is calculated (directional vs. omni-directional, tolerance on angle, lag-distance and maximum lag). In this way it is shown to what extent the number and positions of the samples affect the calculated experimental semivariogram and in which way the mentioned parameters have an influence on the calculation of the semivariogram. As for Module 1, one can also extract a table with all relevant values of the experimental semivariogram (i.e. lag-distance, calculated values and number of pairs for each lag-distance).

A second important element of this module is to model the experimental semivariogram. This modelling is done in real-time on the screen. The user selects a particular type of model and the values of its parameters. The model is plotted and one can immediately see whether it matches well the calculated experimental semivariogram values or not. One can then start adjusting these parameters until a good fit is reached. To assist the user the variance of the samples is also plotted, as it gives an indication of the sill value (if applicable). A help screen is available with information on the various available semivariogram models.

To illustrate this, the third dataset is selected (Houlding, 2000). As one can see on the contour plot (see Figure 3.a), the values are mainly situated in the range of 0 to 4 mm, except in the bottom-left corner there is a zone with values higher than 4 mm. First, 500 at random samples are selected. This corresponds to an extensive dataset. In most practical application, one has less information available (see further). This dataset corresponds to a variance of the samples of 0.92 mm². A good fit of the calculated omni-directional experimental semivariogram is a spherical model with a range of 2 m, a nugget of 0.5 mm² and a sill for the spherical part of 0.42 mm² (Table 1). Even that this dataset of 500 samples is very extensive, one should remain critical: the overall variance of the 10,000 points in the original dataset corresponds to 0.75 mm². In Figure 3.b and 3.c, two different sets of samples are taken; their size corresponds to a more realistic sampling campaign. In Figure 3.b, 50 at random samples are considered, while in Figure 3.c 100 regular spaced samples are selected (10 x 10 grid). In Table 1, the most characteristic values are presented, showing significant differences between the three sampling sets. The reason why the variance of the regular set is much higher than the others is that this is the only set, whereby a sample is situated within the zone with high values. The aim of this and other exercises is not to criticize a geostatistical approach, but to give the user a good feeling about the limitations of sampling and the effect it has on characteristic values. The same limitations are valid, if one would use a non-geostatistical approach.

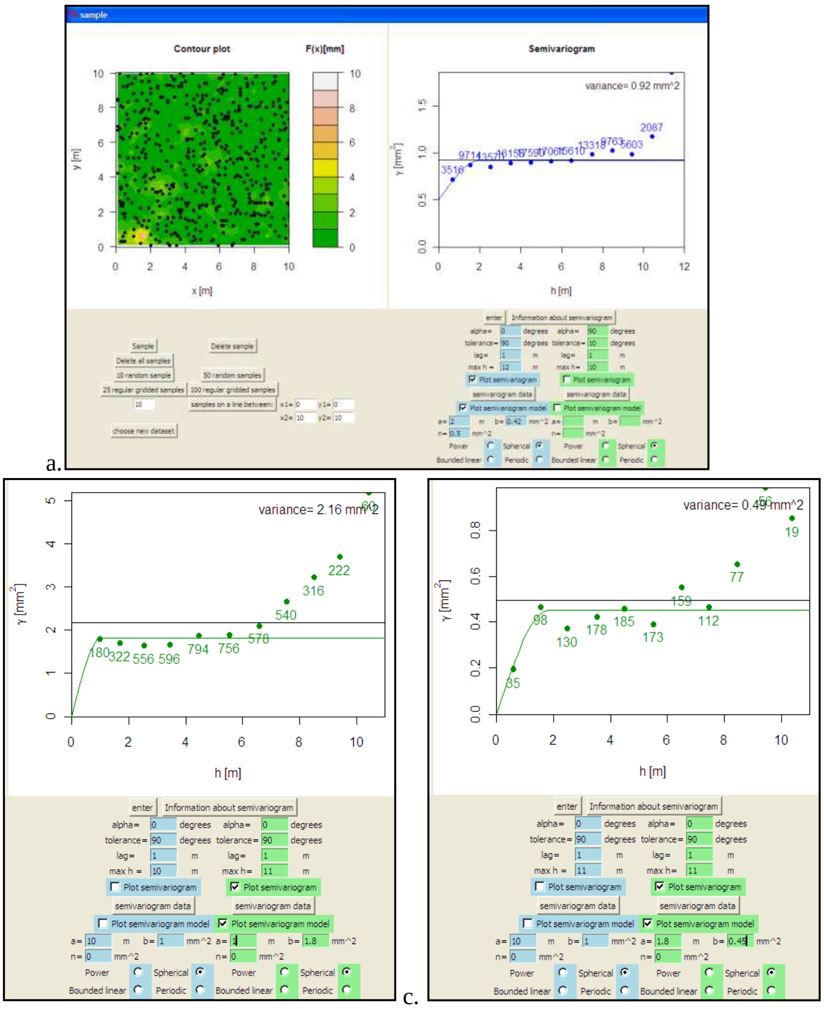



Figure 3: Second screen of Module 2: sampling and modelling an omni-directional semivariogram (a. 500 samples at random; b. 50 samples at random; c. 100 samples on a regular 10 x10 grid).

Table 1: Characteristic values for the three sets of samples considered in Figure 3.

| | 500 samples at random | 50 samples at random | 100 samples on a regular 10 x10 grid |
|---|---|---|---|
| Variance of samples | 0.92 mm² | 0.49 mm² | 2.16 mm² |
| Spherical model: | A | B | C |
| Range | 2.0 m | 1.8 m | 1.0 m |
| Nugget $C_0$ | 0.50 mm² | 0.00 mm² | 0.00 mm² |
| Sill $C_1$ | 0.42 mm² | 0.45 mm² | 1.80 mm² |

## Module 3, estimating values in 1D and 2D

The third module is about kriging. For the moment, only points can be estimated. The module contains the two real datasets of the second module. The parameters of a suitable semivariogram model should be noted when using module 2 and introduced in the second screen of module 3. In module 3, one chooses new samples, which can be again along a regular mesh, at random, or individually determined (see Figure 4). One also selects an unknown point, but this can be repeated a large number of times in successive steps. As the spatial frequency is 0.1 m in the x and y-direction, each possible position of an unknown point by clicking corresponds with a known value. This means that it is possible to compare the estimated value by kriging to the true value. The user can also compare the variance of all possible points, the variance of all the selected samples (calculated within the module) and the kriging or estimation variance (i.e. of the error). And these values can then be situated against the selected value for the sill value for a spherical or bounded linear model. By repeating such estimations, one gets a good insight in the meaning and limitations of kriging: what does it really mean that kriging is called the best linear unbiased estimator, that the average error is equal to zero, but that the individual error is in most cases different from zero and that kriging results in an estimation error. Typical questions that can be addressed in this module are:

- Take 25 regular samples, and choose the position of the unknown point. Use the semivariogram parameters of the directional semivariograms of the major directions you defined using module 2. Compare the error and the kriging variance with the results of taking an average. Which results are the best and why? Try the same for different positions of the unknown point. Is the conclusion the same for all positions of the unknown point? Why (not)? Overall, is kriging better than taking the average?
- Compare the results of an isotropic model with the results of the anisotropic model.
- Compare the results for the case where there are 100 gridded samples.

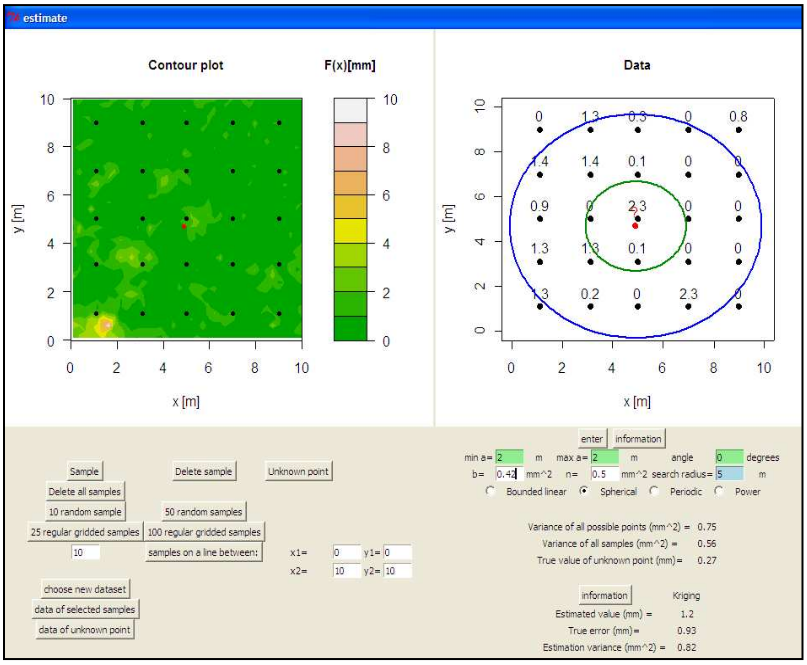
Again, the user can make an extensive sensitivity analysis, e.g. what is the effect of the various parameters of the semivariogram model (e.g. no nugget in comparison to a 50% nugget of the sill value), the effect of the position of an unknown point in comparison to a grid of samples, the effect of increasing or decreasing the search radius, and the effect of increasing the number of samples. When one of these parameters is changed, the results are automatically recalculated.

In Figure 4 and Table 2, an example is given to illustrate some of these possibilities. Twenty-five regular spaced points (5 x 5) are sampled, whereby once a centrally situated unknown point (Figure 4.a and Table 2.a) is estimated and once an unknown point close to the zone with high values is considered (Figure 4.b and Table 2.b). For each unknown point, the three semivariograms determined in Module 2 (see Figure 3 and Table 1) are considered. For both unknown points the samples within a search radius of 5 m are used for kriging, but this is one of the parameters which can be adapted. In comparison to the centrally situated unknown point (21 out of the 25 samples within the search radius), only 8 samples are considered for the second unknown point (case b). Without conducting a complete analysis, it is clear that estimating a larger value in case b, combined with less samples available within the search radius, results in a negative error and a larger error. However, in case a, the unknown point is closely situated to a sample with a value of 2.3 mm, resulting in a higher estimation than in case b. A larger total sill value (semivariogram C) results in a larger estimation variance, but considering a large relative nugget effect (semivariogram A) increases the estimation variance too. Apart from the calculations conducted by the programme, one can also do hand calculations. For example the weighted (1/n) average of all 25 samples is for both unknown points equal to 0.60 mm. The 21 samples within the search radius give a weighted average of 0.61 mm, while the 8 samples of the unknown point in case b results in a value of 0.64 mm. Based on these two small examples one should be careful in drawing incorrect conclusions: it is not because the two weighted average values in case a are both closer to the true value in comparison to kriging with the three semivariograms considered, that one can conclude that kriging is not the best linear estimation. First, it is only one unknown point and second kriging provides the most expected estimate, which one should combine with the estimation variance. By considering all information, kriging should always be as good or better as one of the conventional interpolation techniques (Webster and Oliver, 2007).

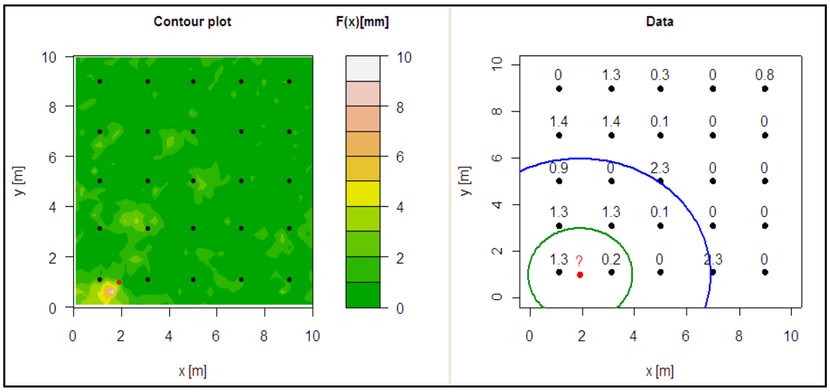
Table 2: Information on a point estimation (a. Estimation of a centrally situated unknown point (see Figure 4.a); b. Estimation of an unknown point close to the zone with high values (see Figure 4.b)).

| a. | True value (mm) | Estimated value (mm) | Error (mm) | Estimation variance (mm²) | Number of samples |
|---|---|---|---|---|---|
| Semivariogram A | 0.27 | 1.20 | 0.93 | 0.82 | 21 |
| Semivariogram B | 0.27 | 1.85 | 1.58 | 0.21 | 21 |
| Semivariogram C | 0.27 | 1.53 | 1.26 | 1.29 | 21 |

| b. | True value (mm) | Estimated value (mm) | Error (mm) | Estimation variance (mm²) | Number of samples |
|---|---|---|---|---|---|
| Semivariogram A | 2.30 | 0.73 | -1.57 | 0.93 | 8 |
| Semivariogram B | 2.30 | 0.83 | -1.47 | 0.39 | 8 |
| Semivariogram C | 2.30 | 0.68 | -1.62 | 2.00 | 8 |



a.




b.

Figure 4: Second screen of Module 3: kriging of an unknown point based on 21, respectively 8 samples within a search radius of 5 m (blue circle) from a set of 25 regular spaced samples (a. Centrally situated unknown point; b. Unknown point close to the zone with high values).

## EXPERIENCE WITH GIS-STUDENTS

Experience in lecturing basic geostatistical courses during the past 20 years to university students of different background (mining, civil, agricultural and environmental engineering and geology, geography and biology), but who have also followed GIS-courses, has shown that it is not always that easy to teach the basic concepts of the successive steps in a geostatistical study. For this, insight is needed, which can only be gained by practice. The problem starts already by making the link between the full variation of a parameter in space or over time, and a plot of the variation of a limited number of samples in 1 or 2D. Secondly, translating this variation of these samples in an experimental semivariogram as a function of the lag distance is not that easy. The whole concept of working in a new dimension, being the interdistance, is not easy. The first two modules help a new user to gain experience and insight. The translation of the calculated experimental semivariogram values into a semivariogram model is of course important, even the central step in a geostatistical study, but it is not the most difficult step. However, it is important for the user to understand that there is a lot of uncertainty in the calculated values and hence in the model, especially when there are a limited number of samples. Module 2 helps to illustrate this well, as one can easily add additional samples and see the effect on the semivariogram. Finally, it is not that easy to understand the meaning of an average error equal to zero, combined with an error variance different from zero. In other words, even that kriging results in the best linear unbiased error, one could claim that mostly the most expected estimation is different from the true value. For a good interpretation of the error variance it is important to compare the latter to the variance of all samples, which is possible using the third module 3. The latter module helps also to quantify the effect of the various parameters in an estimation procedure (sensitivity analysis of the model parameters, effect of search radius and other geometrical parameters, etc.).

Experience when using the modules in a MSc-course has shown that these modules have a significant added value to get familiarized with the basic concepts of geostatistics, but that a certain supervision when using the modules is needed. A manual has been prepared where specific problems and questions are presented, which can be solved by using the different modules (see Govaerts and Vervoort, 2011 and www.bwk.kuleuven.be/geostatistics). Experience showed that students have the tendency to read the questions, try it out immediately by clicking the various buttons, and concluding that it all looks logic. The added value of working in this way is very limited. One has to force the students to first think about the various questions and to estimate the answers, before applying the various modules. Often, the most is learned when students can further reflect on the difference between the answer they thought was right and the answer given by one of the three modules. This requires some self-discipline, i.e. to go through a difficult and sometimes confronting process. However, once the students realize that this is the right process, the modules become very useful for teaching a geostatistical course.

So far, the modules have been used as part of a geostistical course for students who have already followed a GIS-course. It would be interesting to learn how these modules would be appreciated by students who only follow a GIS-course without having a geostatistical course. Everyone is welcome to share with the authors their experience using the three modules.

The original intention of developing the three modules was aimed at users with no or a limited amount of geostatistical experience. However, these modules are also very useful to remain critical for experienced users. One should never forget that in a real application one does not have a complete view of the phenomenon studied; for example for the dataset in Figures 3 and 4 one is often not aware of the zone with high values at the bottom-left, till a sample is taken within that zone. Once such a sample has been taken, one is confronted with the question if it is representative for the entire area or not. The short examples presented in this paper have provided an illustration on how the various parameters interact and influence the final estimation.

## ACKNOWLEDGEMENTS

The financial support by the Office for Educational Policy of the K.U.Leuven (Project OWP2009/06) is greatly appreciated. The MSc students of the K.U.Leuven in the programmes Geotechnical and Mining Engineering (course H0C92A, Geostatistics) and Earth Observation (course I0D56A, Practical Geostatistics) are thanked for providing the necessary feedback and pointing out some basic programming bugs in the first version of the modules. The modules have also been used recently by the students of the Anton de Kom University of Surinam, who follow a geostatistical course in the MSc on Sustainable Management of Natural Resources; they also provided useful feedback.

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# The use of videos within GIS e-learning. An experience in an undergraduate program in Environmental Science

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## ABSTRACT

The education of GIS in an e-learning system is a challenge even in rapidly changing academic and societal environments. The aim of this work is to evaluate the effectiveness of the use of videos in the students learning outcomes in a GIS e-learning course within an undergraduate program in Environmental Science, taught at Universidade Aberta (UAb). UAb is a distance learning university whose teaching activities follow a pedagogical model, through the use of an e-learning platform. The students are guided by a curricular unit plan, digital resources, formative activities and a continuous assessment. In this work we analyze the results obtained in separate classes, held in different academic years, by using different teaching strategies, in particular for a topic of the GIS Course – Exploring ArcGIS software. In one of the classes a written document with ArcGIS tutorials was made available to the students and the doubts about the resolution of the proposed exercises were asynchronously answered by the teacher within a discussion forum. In the other class besides the tutorials and the forum it was made available to the students a set of videos (about 15 min each). The proposed exercises were solved by the teacher in the videos that could be seen at any time during the semester. The videos' effectiveness was assessed by comparing students written assignments in the different classes. To the students that had access to the videos an American-type test was applied with questions that were directly related to the subjects taught in the videos. Furthermore open questions were also part of the test and the students were asked to give their opinion about the use of the videos in the learning outcomes. From a preliminary analysis of the results it can be seen that the students that had access to the videos were able to develop better GIS projects and showed a better exploitations of the software functionalities than their colleagues of the other class.

## INTRODUCTION

Despite the promise of GIS, substantial barriers have prevented its better and earlier widespread use in undergraduate science education. Among the key factors are technical impediments, stemming from software complexity, pedagogic issues related to the lack of experienced faculty and the short-age of curriculum materials. Reaching out to students across the Web, empowering them to discover new ways to learn geography at a distance is certainly an attractive idea (Lloyds, 2001).

A lot of ways for taking advantage of e-learning and for improving the teaching process are arising. To insert static images helps to improve the information. Accompanying text with audio enriches considerably the text. To produce a combined video image and sound is the most comprehensive offering that can be done to anyone seeking information. Nevertheless the challenge to improve the effectiveness of learning by using video lessons has become urgent as web-based materials contain more and more video and control tools for the learner (Bilbao et al., 2009).

The increasing availability of computers and related equipment such as smartboards and mobile devices, as well as the fact that videos and computer simulations have become available for a wide range of science subjects, have led to these tools becoming an integral part of many science curricula. This raises the question of how these tools can be better used to contribute to improved learning of science (Rutten et al., 2011) and if they really improve the learning outcomes (Boer et al., 2011).

In this work we evaluate the effectiveness of the use of videos as creative learning tool, in the students learning outcomes in a GIS e-learning course within an undergraduate program in Environmental Science, taught at Universidade Aberta (UAb), Portugal.

## THE ENVIRONMENTAL SCIENCE UNDERGRADUATE E-LEARNING PROGRAM

Since 2007, the Universidade Aberta (UAb) has offered a 1st cycle degree in Environmental Sciences (ES), according to Bologna Process principles. UAb is a distance-learning university where the pedagogical model (Pereira et al., 2007) is based on e-learning and relies on the use of online communication tools. The model promotes interaction between students and teachers and is deeply focused on students as individuals who actively build their own knowledge. The model includes principles permitting teaching and learning activities for each curricular unit to be performed at a distance, in a virtual learning environment, using an e-learning platform. The students are guided by a curricular unit plan, a virtual class, digital resources, formative activities and a continuous assessment. Students have a learning card that allows them to visualize at any time the marks obtained in the continuous assessment activities (e-folios) during the semester. These e-folios are complemented by a p-folio which is performed in a face-to-face location. The final grade of the curricular unit will be the sum of the marks obtained in both the e-folios and in the p-folio. At each course students can choose at the beginning of the semester to not enroll a continuous assessment (CA), and only be assessed through a final face to face exam (larger in length than the p-folio). The open source Moodle-software (www.moodle.univ-ab.pt/moodle) is used as the course management system (CMS). Students of the undergraduate programmes have access to the virtual spaces of the courses and also access to coordination and socialization (cafe) spaces.

The UAb has developed a 180 ECTS undergraduate b-learning programme in Environmental Sciences (ES) directed at an adult audience (over 21 years) who are typically working individuals seeking professional development.  The purpose of the course is to promote and develop a set of professional skills and competences within environmental sciences. The first two years are composed of mandatory curricular units of Science and Environmental Technology (40 ECTS), Biological Sciences (22 ECTS), Earth Science (22 ECTS), Mathematics (12 ECTS), Chemistry (12 ECTS), Physics (6 ECTS) and Legal Sciences (6 ECTS), for a total of 20 compulsory curricular units. This structure provides the student with a broad based curricula. In the final year the student can then study one of three minors that are as follows: Natural Heritage, Environmental Health, and Environmental Management and Sustainability. Each of these courses comprises a 60 European Credit Transfer System (ECTS) (Oliveira et al., 2011).

## THE GIS COURSE

Geographical Information Systems (GIS) is a compulsory course organised in the second year of the ES programme. This course introduces fundamental concepts for the development of Geographical Information Systems and the techniques and tools for a GIS-project implementation. Some practical exercises are conducted using a GIS-software. The competences that students should acquire are the following: i) apply concepts associated with geographical information science; ii) identify GIS-potentialities and current problems during their implementation; iii) use techniques and tools for a GIS-project implementation; iv) design GIS-projects applied to Environmental Sciences.

The course is divided in two parts. The first part is mainly theoretical related with basic concepts on Geographic Information Science where students have to read e-book chapters complemented by power point presentations. Students have available formative activities, like american-type and true-false questions and also open questions. On the second part of the course written documents with ArcGIS desktop software (an ESRI company product) tutorials are made available to the students. ArcGIS is a complete system for designing and managing solutions through the application of geographic knowledge, being one of the GIS softwares used worldwide. Students should conduct the exercises on the ArcGIS following the tutorials about spatial representation and GIS-tools. Doubts about the resolution of the proposed exercises are asynchronously answered by the teacher within a discussion forum. Other fora are also available in the first part of the course. At the beginning of the semester students have access to a one year evaluation version of the ArcGIS-software, according to a protocol of ESRI with the University.

In a five minutes video (produced with a web camera recording), available at the start of the virtual environment class, the teacher explains the contents and synopses of the course and highlights the importance for competences acquisition to choose the continuous assessment. The students have to do two e-folios, one at the end of the first part (e-folio A - assignment about the theory) and another at the end of the second part (e-folio B - development of a GIS-project applied to environmental science). Feedbacks of the e-folios A and B are done by the teacher in individual written comments and through a web camera recording video with global class observations.

## METHODOLOGY

As previously mentioned, the ES-programme started in 2007/08 and therefore the GIS course had its first edition in the scholar year of 2008/09. Due to students complains in the first two years, about difficulties in conducting the ArcGIS-exercises, in the scholar year of 2011, eleven vocast videos of about 15 min each, accessible through the virtual learning space, were produce as a tool to improve the learning process. The first two videos are about a brief summary of the theoretical concepts and explanation of the functionalities of the ArcGIS software, where the teacher explains the contents with the help of a power point presentation like in a regular face to face class. On the other nine videos the more important practical exercises are solved by the teacher using ArcGIS, like in a practical face to face class. All the videos can be seen at any time during the semester. Six of the videos were produced with a professional video camera and five with Camtasia Studio screen recording software (version 7.0).

The videos effectiveness was assessed by analysing students written assignments (e-folios) in the classes of 2008/09 and2009/10, compared to 2010/11, the class where the videos were available. To the students that had access to the videos, an American-type test was applied with five questions that were directly related to the subjects taught in the videos. This questionnaire was incorporated in the e-folio B (for students in continuous assessment). Furthermore three open questions were also part of the test (not for evaluation purpose) and the students were asked to give their opinion about the use of the videos in the learning process. The questions were the following: i) Complete the sentence "the display of videos on ArcGIS was helpful because ..."; ii) Complete the sentence "The display of videos on

ArcGIS did not help me in my learning because ..." iii) Complete the sentence "I wish the videos on the ArcGIS had included...". A content analysis was conducted on the answers of the open questions, according to Bardin (1977) methodology. Categories and related subcategories about educational, technical and content related issues were developed, integrating the answers to the three questions according to an analysis of student by student.

To access the level of understanding, interaction and doubts about the ArcGIS-tutorials without and with the videos, analysis on the forum discussions of the second part of the course (practical exercises) were also conducted in the different scholar years.

## RESULTS AND DISCUSSION

The number of students that have enrolled in the GIS-course increased along the academic years due to an increase of the total number of students that enrolled in the ES-program from 2007 to 2010 (Table 1). The percentages of students that choose the continuous assessment have decreased in 2010/11, but values are still higher when compared with the other courses of the ES-program. As explained earlier at the beginning of the course students are encouraged by the teacher to choose continuous assessment, aiming to learn better how to develop a GIS-project. However at the time students choose the assessment regime in 2010/11, they were not aware of the use of the videos, so students thought that the educational materials were the same as the previous years.

Table 1: Number of students in the GIS course along the academic years.

| | 2008/09 | 2009/10 | 2010/11 |
|---|---|---|---|
| Total | 14 | 29 | 50 |
| Continuous assessment | 12 (86 %) | 25 (86 %) | 38 (76 %) |
| Final exam | 2 | 12 | 12 |

The students mark of the e-folio A (0 to 3 points), from the academic year of 2008/09 to 2010/11, didn't show too much difference as shown in figure 1. The average values were around 2.2 marks (2.28 ±0.48, in 2008/09, 2.21±0.35, in 2009/10 and 2.25±0.45 in 2010/11).

The e-folio B, compared to e-folio A, is related with the development of a GIS-project using ArcGIS within environmental science. Students results in e-folio B show an improvement pattern with regard to their marks (0 to 5 points) (Figure 2). Also the average value increased in the last academic year compared to the previous year (3.86 ±0.98 in 2008/09, 3.64±1.40 in 2009/10 and 3.88±0.85 in 2010/11). According to teacher's perception, in the class where the videos were used (2010/11 academic year) the GIS-projects developed by the students show a better knowledge and exploration of the spatial analyses and tools, resulting indeed in better results.

The teacher’s feed-back video to the students for e-folio B-results in the academic year of 2010/11, congratulates the students for their good and in some cases excellent GIS-project development. According to Crook et al. (2011), brief feedback videos for students are an important and effective way to contribute to student’s engagement and learning improvement.

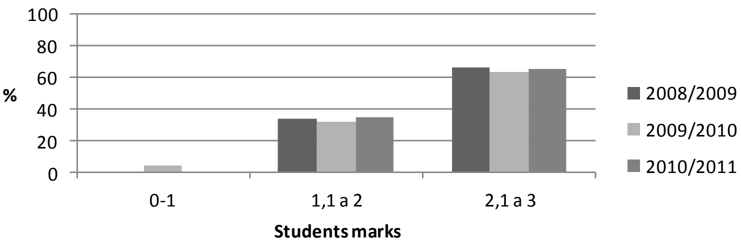


Figure 1: Students marks (0 to 3) in e-folio A along the scholar years.

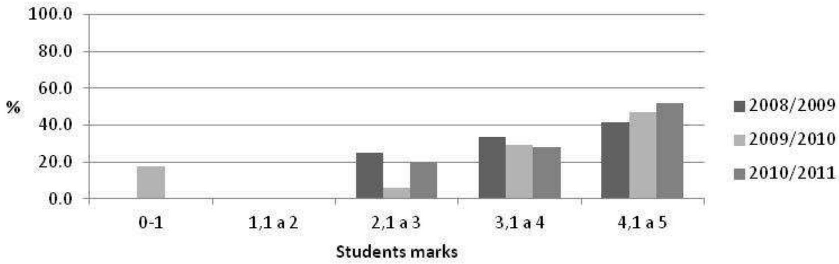


Figure 2: Students marks (0 to 5) in e-folio B along the scholar years.

The discussion forum for the practical exercises (second part of the course) show a decrease of interactions along the academic years (figure 3), what can be related to the fact that less doubts appear when the students are doing the exercises in ArcGIS with the help of the videos. The number of students that participated to that forum also decreased along the academic years (50 % on 2008/09; 34 % on 2009/2010 and 20 % on 2010/11). Furthermore, in the first two academic years the questions were more simple and basic, related to the beginner's tasks of the tutorials.

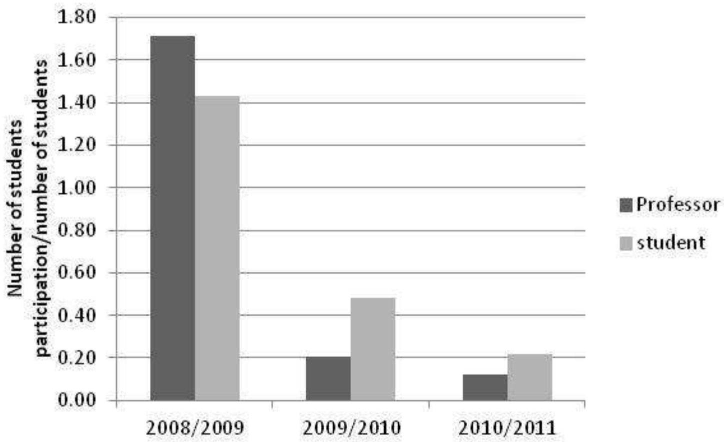


Figure 3: Students' and teachers' participations in the discussion forum along the three academic years. Number of participations were normalized by the number of students to allow the comparison.

Nevertheless it is important to highlight that the class of the academic year 2008/09 was special. It was the first group of students who enrolled into the ES-program and who passed the grade from a large group of 111 students. Also it was the first year the course was open to students and the dynamics of this small group of students could be different compared to those in the following academic years. In fact they were a very participative group in the undergraduate program. In that year a 100 % approval rate for the GIS-course was observed. In the academic year of 2009/10, the approval rate was 65.5 %. It was not possible to compare the approval rate after the use of the videos (in the academic year 2010/11), since this data was not available at the time this work was written.

The students' results in the American-type test in e-folio B, in the year 2010/2011, show that most of the students had only one question wrong (48 % of the students) while only one student just got one question correct (4 % of the students). 24 % of the students got all the questions correct compared to 12 % that answered two questions wrongly and 12 % with three wrong answers.

The content analysis of the three open questions allows to define the categories and subcategories presented in table 2: educational, technical and content of the didactic materials. Educational issues are the ones more pointed out by the students (23 students from a group of 25) compared to technical issues only indicated by a limited number of students. Most of the students that answered the test (in continuous assessment), think that the videos help the understanding of the practical exercises and contents. Nevertheless 2 students state that the videos do not replace face to face classes.

Since not all the exercises of the ArcGIS-tutorials were supported by video, 17 of the 25 students that conducted the e-fólio B would like to have other videos with additional practical exercises within environmental science. Also two more students would like to have videos with a complete development of a GIS-project. In the students answers and also within the request of more practical exercises, a limited number of students indicate that they would like to have a video explaining how to install the ArcGIS-software. However, students do have another forum related with the support learning system, for communicating about technical doubts and problems. On this forum it is possible to see that installation of the software is one of the first problems students have to face and that these are mostly related to computer's limitations and incompatibilities. Even so, ESRI has a technical support service that students can have access to since the academic year of 2010/11, to help them with the installation problems, besides a detailed written tutorial for software installation.

Table 2: -Results of the content analyse of the open questions (year 2010/11).

| Categories | Subcategories | Number of students |
|---|---|---|
| Educative | • Videos help the understanding of the practical exercises and contents | 24 |
| | • Videos are similar to a face to face class | 1 |
| | • The videos do not replace face to face classes | 2 |
| | • Student did not point to any educative issue in their answers | 2 |
| Technical | • Quality of the video (interaction and value of the images) | 3 |
| | • Develop the exercises in other GIS-software | 1 |
| | • Duration of the videos | 1 |
| | • Student did not point to any technical issue in their answers | 21 |
| Contents | • Need of other videos with more practical exercises within environmental science | 17 |
| | • Need of videos with a complete development of a GIS-project. | 2 |
| | • Student did not point to any content issue in their answers | 9 |

The technical issues students indicated on the questionnaire (pointed out by only 5 students), were mainly related to the quality of the video image and lack of interaction in the videos. Part of the videos about the practical exercises that were not recorded with Camtasia, had a worse image quality since the computer screen was recorded with a video camera. Also, the fact that the videos were only related to the development of ArcGIS practical exercises can explain the student observation about lack of excitement. However the main aim of the videos was to help the students with the understanding and development of the practical exercises, allowing them to be able to develop a GIS-project as it was requested in e-fólio B. One student also indicated that exercises should be conducted in another GIS-software. This comment is due to the fact that some students have Macintosh computer, and ArcGIS is more difficult to install on this computer's operating system, so students prefer to use other open source software's. Moreover one student remarked that the time of the video should be longer, instead of producing one video per group of exercises . But too long videos are heavier and harder to run on the computers.

An overall preliminary analysis of the questionnaire data points to good learning results as well to the improvement of the marks of e-fólio B and to a student's satisfaction with the videos. All this allows to say that videos have the potential to be used as an important tool in GIS-education in a e-learning system. As video is a visual medium it has the potential to support learning in different ways than other technologies do, including the potential for demonstrations and through the use of screen-capture technology. A further advantage is that, like audio, video files provide a permanent record, which can be stored and replayed at the students' convenience (Crook, et al., 2011).

Nevertheless the GIS-course is still seen by the students as a difficult course, as can be inferred from the students' conversation in the virtual cafe of the ES-program, and from talks between students and teachers or the ES-program coordinators. Actually, from the 38 students that opted for continuous assessment in 2010/11, only 25 (66 %), submitted the e-fólio B. The other did not deliver this assignment. A similar observation was made in 2009/10 (68 %). So continuous improvement of the course is desirable, e.g., by introducing more videos and continuous interaction with the students. The latte seems to be an important motivation issue for students at a distance. According to a study by Paechter et al. (2010), one of the main aspects which contribute to the students' learning achievements and course satisfaction are the teacher's support and expertise.

## CONCLUSIONS

The preliminary analysis of the results of a questionnaire among students in a distance learning programme indicates a positive trend about the effectiveness of the use of videos in a GIS-course. The students that had access to the videos were able to develop better GIS-projects and showed a better exploitation of the software functionalities than their colleagues of the previous classes. In fact the main aim of the videos as a creative learning tool, is to complement the text tutorials but not to replace the practical exercises made by the students. GIS like most of the courses in science do need a lot of practice to allow a well understanding of their contents. To improve the course additional videos should be developed with more practical exercises within environmental science. Also students recommend to improve the video quality. Videos of the theorical part of the course can be developed, since students in the socialization cafe and also in informal conversations with the teachers, usually complain that e-books of the theoretical part are not too much stimulating.

Nevertheless more deep studies with more data and data treatment need to be conducted to evaluate the true effectiveness of the use of the videos in GIS e-learning. For example viewing scenarios, viewing behaviour, and viewing styles, as developed by Bouher et al. (2011) should be conducted for a more deep analysis of the videos' effectiveness.

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# Teaching FOSS-GIS at Technical University of Vienna – gvSIG vs. QGIS

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## 1. INTRODUCTION

The Institute of Geoinformation at the Technical University of Vienna offers a wide variety of GIS-courses at both Bachelor's and Master's level, traditionally embedded in the surveying curriculum. Currently, we offer four courses (lecture and lab) at Bachelor's level, directly related to Geoinformation Science and Technology, i.e, Introduction to Geoinformation, Advanced Geoinformation, Implementation of a GIS, and Feasibility Study for GIS. At Master's level, we also offer courses on the mathematical theories underlying GIS (GI-Theory), Ontology, Database Systems, and functional programming with Haskell.

We are anxious to provide our students not merely a training in a specific software product but to offer them an education that emphasizes fundamental GIS-principles. For a discussion of the differences between education and training in GIS see Moore (1998) and Longley et al. (2011). Most of the curriculum uses free and open-source software (FOSS) to achieve this goal. Open-source GIS-software allows students to experience such systems without the need to acquire costly licenses. Also, changes to the software can be made, should improvements or adoptions to a particular application be necessary.

In this article we discuss and evaluate two popular open source GIS-packages, namely gvSIG 1 and Quantum GIS2 (QGIS). The goal is to compare and analyze both systems based on various geo-analysis tasks, typically taught in a first year's course on GIS. All presented examples and tasks were part of the lab section of an introductory GIS-course taught in the summer term 2011. This work discusses whether one product is to be favored over the other in terms of "ease of use" and suitability for teaching. Particularly emphasized is the fact that students had no prerequisites in using such a system.

The paper is organized as follows: First both software packages are introduced, including their add-ons and extensions. This is followed by a listing of exercises and tasks that were solved in the lab, utilizing both GIS-packages (Section 3). Section 4 talks about experiences made by both lecturers and students while working on the exercises. In the last section (5) we evaluate both software products in respect to their use in higher-level education.

## 2. UTILIZED OPEN-SOURCE GIS-SOFTWARE

This section describes the two GIS-software products used to carry out the evaluation. In addition, the add-ons and extensions used in this work are listed, ensuring repeatability of the results. All analyses were performed on a PC with an Intel Atom Processor (2 GB RAM), Windows 7 Starter N (32 bit), and Java VM 1.6.0 installed.

[1] gvSIG and extensions are available via http://www.gvsig.org/
[2] QGIS is available via http://www.qgis.org/

The open-source GIS-software gvSIG is written in Java and largely funded by the Spanish government (Acevedo, 2011). QGIS is written in C++ and based on the GRASS toolkit (Athan et al., 2011). Both systems provide support for raster and vector analysis and are widely extensible via plug-ins. Also, both software products are distributed as free software under the GNU distribution license, therefore free to study, develop, and improve. See Table 1 for details on the versions and extensions we used in our comparison.

Table 1: Utilized software, including extensions

| **gvSIG** | **Quantum GIS** |
|---|---|
| gvSIG 1.10 (Build 1264) with extensions:<br>- Sextante Toolbox 0.6.0-1232<br>- Network Analyst Redes 0.1.0-1238 | QGIS 1.6.0 Copiapó with extensions:<br>- fTools 0.5.10<br>- GDAL Tools: 1.2.16<br>- Raster-based terrain analysis<br>- Georeferencer GDAL 3.1.9<br>- RasterCalc 0.2.1 (in development)<br>- GRASS Toolbox |

## 3. TASKS & LAB EXERCISES

The tasks listed here were utilized to compare the problem solving capabilities of open-source GIS-software. The exercises were part of the lab "Introduction to Geoinformation" (1st year) for which students used gvSIG. As part of an advanced course (2nd year), QGIS is used for a different set of exercises. For this paper, however, the first year's exercises were carried out in both gvSIG and QGIS to allow for a better comparison. The lab exercises consisted of four main topics:

- Geo-referencing of aerial images;
- Data capture (Digitizing);
- Spatial analysis (Raster and Vector analysis);
- Navigation and Routing (Network analysis).

### Task 1: Georeferencing of aerial images

In this task, students were asked to geo-reference an aerial image based on a number of control points they had to determine from cadastral data (parcels and houses). The utilized dataset consisted of an orthoimage of the city of Eisenstadt (Austria) as well as buildings and parcels from the digital cadaster of Austria, provided by the national mapping agency. To verify the results, students had to provide a screenshot of the georeferenced image, the respective world file, and a table of control points.

### Task 2: Data capture

This exercise dealt with the collection of spatial data, making use of on-screen digitizing based on an aerial image of the village Rastenberg in Austria (see Figure 1). Students were asked to generate a spatial data model that contained several layers with polygonal objects and appropriate attributes (e.g., several road classes). The objective of this exercise was to create a "complete" dataset without covering the whole test area. Also, students had to apply various generalization methods where necessary.

Figure 1: Aerial image of the village Rastenberg, Austria.

## Task 3: Spatial analysis

Spatial analysis is one of the core functionalities any GIS offers. We defined three sub-tasks to cope with the wide variety of analyses possible. Exercises included analysis of both vector and raster data.

### Sub-task 3a - Spatial analysis of raster data:

In this task raster data (wind speed and vegetation classes) for the continent of Africa were analysed. The main objective of this exercise was to extract geographic areas prone to erosion. Students had to retrieve "high-wind" areas (wind speeds > 3 m/s) and combine them with designated desert areas to identify the potential regions of interest. This task required students to utilize a raster buffer tool, reclassification (extraction of vegetation classes), and raster calculus functionalities (combining the layers).

### Sub-task 3b: Spatial analysis of vector data – Geoprocessing:

Parts of this exercise were based on Richard E. Plant's qGIS labs, available on his Web site (Plant, 2011). The main task consisted of finding a suitable location for a new football stadium in the state of California (USA). The data-sets contained county borders, interstate highways, and urban areas. The location of the new stadium should satisfy the following criteria: (a) within Solano or Yolo County, (b) within a 3 kilometer radius of an urban area – but not inside an urban area, and (c) within 1 km of an interstate highway. The geoprocessing task consisted of the extraction of data, combination of several layers, as well as attribute queries.

### Sub-task 3c: Spatial analysis of vector data – Classification:

Geo-demographical and election data of Austria were both mapped and visually analyzed. First, a map displaying the population below the age of 19 for each district was created, using equal intervals and natural breaks classification. Second, a map of the Austrian national election 2008 had to be created showing the winning party for each district. This task included data classification and table joins. In another exercise, students had to work with Viennese census data and identify areas based on various demographical factors (e.g., family-size, unemployment rate), as well as create population density maps for each district.

## Task 4: Navigation and Routing

This exercise introduced students to spatial analyses based on navigation and routing methods, i.e., network analysis. It consisted of finding a solution to the traveling salesman problem and the creation of service areas.

### Sub-task 4a: Traveling Salesman Problem:

Based on a data-set of the Austrian road network and various Austrian cities, students had to create an optimal shortest route of a virtual person visiting all provincial capital cities in Austria. The start and endpoints were fixed (Vienna) and cities could only be visited once. These tasks resembled a typical Traveling Salesman (TSP) problem.

### Sub-task 4b: Service Area:

The calculation of Service Areas is an important tool for both business geographers and spatial planners alike. In this task, students should calculate and visualize potential Service Areas for public and private hospitals in Vienna.

## 4. RESULTS

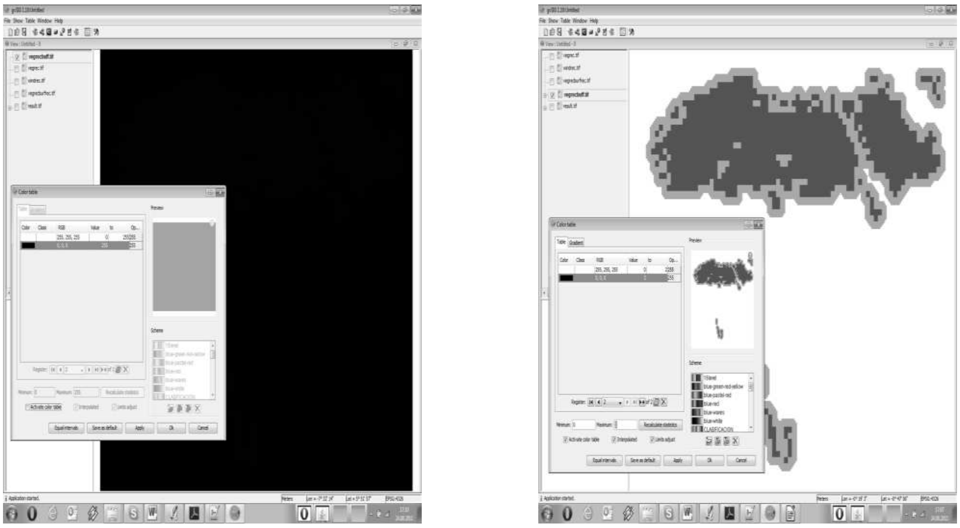
In this section, the results of the comparison between gvSIG and QGIS are discussed. Based on the exercises, carried out with both software products, we evaluate and discuss the performance accordingly. The following subsections elaborate on the results of the tasks achieved as well as possible errors, and bugs.

### 4. 1 Evaluation of gvSIG

Task 1 can be achieved by utilizing gvSIG's built-in geo-referencing tool. Control points can be selected from the image to be geo-referenced as well as the reference data set, both displayed side by side. This makes the usual layer transparency control and repeatedly switching between layers unnecessary. The interface is consistent, straight-forward, and easy to use. With some assistance from the lecturers, most students had little problems in carrying out this task.

The "data capture" exercise was also completed using the built-in functions of gvSIG. It was necessary, however, to create a new shapefile with corresponding attributes beforehand. In addition, the on-screen digitizing of polygons is possible with the help of the snapping function, similar to the ones known from various proprietary software products. Unfortunately, students reported a number of unexpected errors and bugs – especially null pointer exceptions, making the digitizing process difficult and frustrating. Often, the instructors could not find the cause of the problem and tasks that worked on one student's computer failed on another, despite the fact that the exact same steps were carried out.

The raster analysis task (task 3a), can be completed using gvSIG's Sextante Toolbox. The toolbox is fully integrated into gvSIG's user interface (UI) and offers 286 spatial data analysis functions to date. For this task the following functions were used: "Reclassify", "Raster Buffer", and "Raster Calculator". Basically, the functions worked as expected, but some drawbacks concerning the overall handling were encountered. Below is an example of using the raster buffer that frustrated students in the lab. The creation of a buffer in a raster layer results in a black map window, making the user believe the buffer was specified incorrectly. The generated color table does not consider the values of the layer and resulting in a black map window. Consequently, the correct results were not visible due to an automatically assigned color table (see Figure 2).

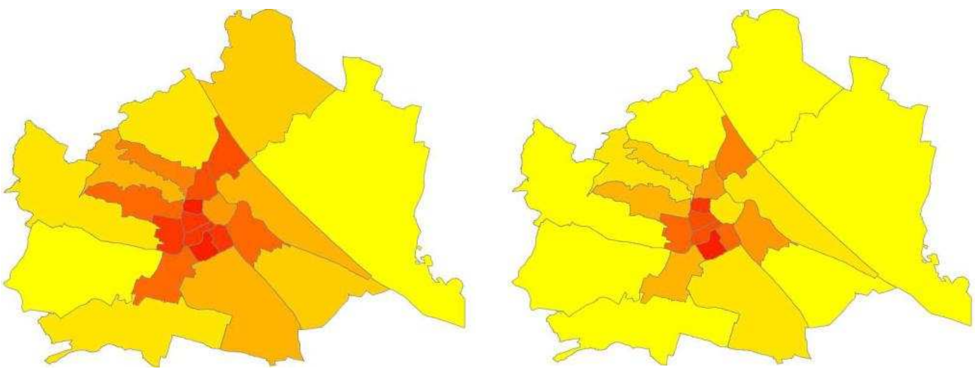


(a) (b)

Figure 2: Misleading results of Sextante Toolbox – buffering example in (a). Adjusting the color table in (b) reveals the results that were correctly calculated.

Task 3b can be achieved by either using the build-in Geoprocessing Toolbox or the Sextante library. Students encountered that the buffer algorithm of Sextante does not offer the possibility to dissolve the buffer zones automatically after buffers were created. Therefore, this process must be carried out manually. A general problem of vector analysis with gvSIG concerns the homogeneous coloring (light blue) of resulting layers. This is not intuitive and facilitates problems when visually inspecting the result.

The classification assignment (task 3c) can also be achieved using the built in functions of gvSIG. First, election data (table) had to be merged with spatial data in order to generate a spatial dataset, using the join function. Second, results were analyzed using different classification methods, e.g., natural breaks and equal interval. Sample results displaying the population density for the city of Vienna are visualized in Figure 3. We encountered no problems with this exercises.



(a) (b)

Figure 3: Maps showing the population density of Vienna: Natural breaks (a) and Equal interval (b).

In order to perform network analysis in gvSIG, the extension “Network Analyst Redes” needs to be installed separately. This allows the generation of a network topology, based on polyline layers. In addition, the calculation of shortest paths between nodes is possible. Hence, the provincial capitals of Austria were defined as stops in the Network Analyst. Furthermore, the calculation of a round-trip, with start and destination in Vienna, was required. The result of such a simple TSP calculation, as carried out by our students is shown in Figure 4.

Figure 4: One solution to the Traveling Salesman Problem.

Task 4b required students to calculate Service Areas for both public and private hospitals in the city of Vienna. This can be accomplished using the functionalities of the Network Analyst in gvSIG. Using the extension allows the modeling of simple Service Areas based on travel costs of the road network, i.e., time or distance. Calculated Service areas were defined as regions within 3000 meters (network distance) from any hospital.

In general, gvSIG's network extension offers a wide variety of features on networks analysis. We experienced, however, some minor inconsistencies and unexpected crashes. Students seemed to appreciate the functionalities but were a little frustrated with the overall handling.

## 4.2 Evaluation of QGIS

The geo-referencing task can be completed with the extension “Georeferencer GDAL 3.1.9”. This add-on enables the geo-referencing of an aerial image by selecting control points interactively or manually (direct coordinate input). Additionally, the reference points can also be selected from the main map window. Nevertheless, the aerial image to be referenced cannot be viewed side by side with the main map, so only one of them is fully visible. In this regard, gvSIG provides a much better user interface and handlingmaking the process of geo-referencing easier.

“Data capture” requires no additional extensions, thus, on-screen digitizing of the aerial image of Rastenfeld could be completed with the built-in functionalities of QGIS. Especially useful was the snapping tool, facilitating the generation of “clean” geometries.

The raster analysis of task 3a can be achieved using the GRASS Toolbox available as extension for QGIS. Unfortunately, built-in functionalities of QGIS do not provide appropriate tools to analyze raster data accordingly. The GRASS toolbox offers a variety of tools integrated into QGIS. In this task the following tools were used: “r.mapcalculator”, “r.reclass”, and “r.buffer”. Fortunately, we did not experience any errors or bugs while working with these extensions.

Geoprocessing (task 3b) can only be completed using the extension fTools, allowing the user to carry out basic geoprocessing, such as buffering, intersection, and difference. In general, the extension worked well and is very intuitive to use. One encountered drawback concerned the deletion of duplicate field names. fTools cannot deal with duplicate field names – which may occur with two intersecting features. However, the extension “Table Manager” can be used to fix duplicate field names before running the spatial analysis.

The classification assignment, (task 3c) can be completed using standard functionalities QGIS offers in combination with fTools. In order to join datasets, i.e., combining plain text (table) with spatial data the extension fTools is needed. For analysis and visualization the standard functions of QGIS are adequate. In addition, QGIS offers a great range of symbology possibilities (in comparison to gvSIG).

In theory, solving an advanced spatial analysis task (e.g., TSP) should be possible in QGIS utilizing the GRASS toolbox. It offers functions to create a topologically clean road network from Shape-data using the modules “v.clean” and “v.build”. They would serve as basis for further calculations of the TSP. In the experiments conducted for this paper, however, the TSP algorithm in GRASS (“v.net.salesman”) failed. Results could not be computed because the module module crashed unexpectedly. Unfortunately, the error messages do not help in finding the reason for the module crash (see Figure 5). Generally, using the GRASS extension and GRASS layers results in a slower performance of QGIS compared to using layers directly loaded into QGIS. Especially, when working with large data-sets (e.g. road network of Austria), the user is able to notice the decreased performance.

Task 4b required the calculation of service areas for all hospitals in Vienna. In order to achieve this task we used the GRASS toolbox (module “v.net.alloc”). It offers the possibility to calculate subnets that are closest to a given point (in our case: hospitals). Unfortunately, it was not possible to define a threshold value for allocating subnets, e.g., travel time. Thus, the results depicted in Figure 6 differ from the definition of “real” service areas.

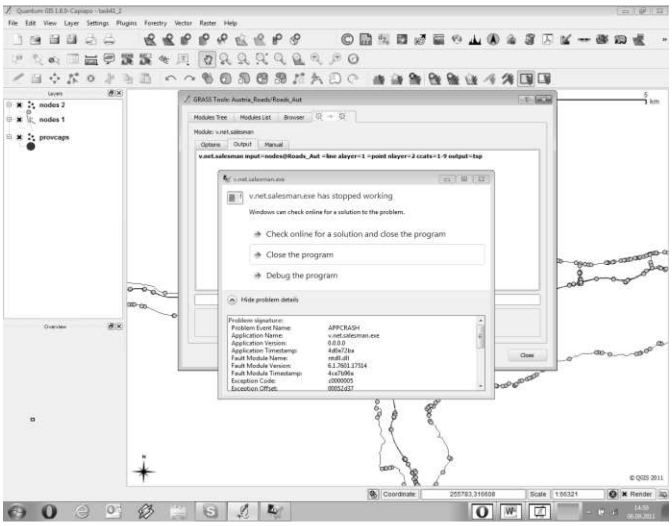


Figure 5: Error message indicating the crash of the TSP calculation in QGIS.

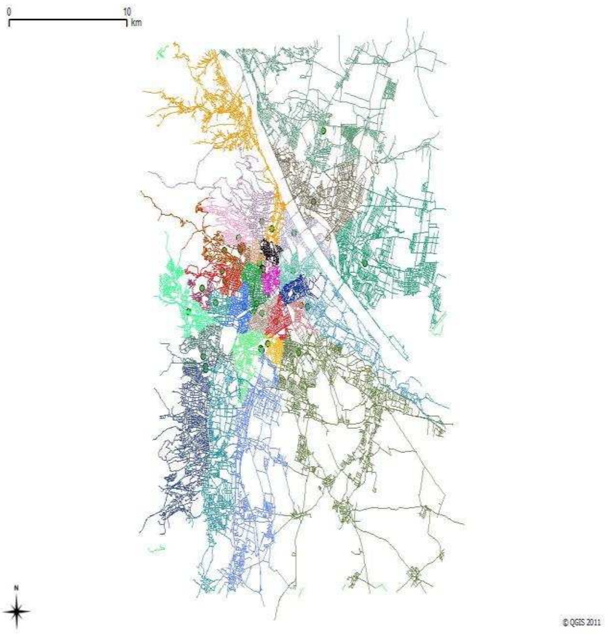


Figure 6: Service Areas for Vienna’s hospitals (green dots), calculated with the QGIS “v.alloc module”.

## 5. CONCLUSION

Unfortunately, gvSIG proved to be quite unstable. Also, user interface and input forms tend to be largely unclear and inconsistent. Even though the Sextante library comes with over 250 useful functions, most of them are poorly documented. Therefore, an exact knowledge of each algorithm is required, making it difficult for students to “just play around”. Furthermore, we experienced several major problems with Sextante's raster functionality. Sometimes the results even appeared to be different depending on the PC’s operating system and/or system's specifications.

We found most students forced to concentrate on workarounds to a great extent, in order to achieve reasonable results. Thus, they could not spend much time on trying out and working with algorithms and data. This, however, would have been a crucial process to intensify the knowledge gained in the lectures. While we experienced these problems mostly when working with raster data-sets, vector analysis worked reasonably well. In general, we found that one should avoid working with temporary layers. Every time some geo-processing task is completed gvSIG asks the user to either store the result as a temporary (RAM) or permanent (Disk) layer. Working with temporary layers often lead to Null-Pointer exceptions and similar unpleasant error messages and crashes.

Initially, QGIS comes with a very small set of functionalities, thus, at a first glimpse it simply appears to be a data-viewer (although with rich functionality in comparison to other viewers like uDig). Unfortunately, any form of spatial analysis is impossible before installing some of the extensions mentioned in this article. There are, however, plenty of plug-ins available, helping to overcome this issue. The GRASS toolbox provides a considerable number of algorithms, but the user interface of the toolbox remains an issue of improvement. Also, the slow computation speed of the GRASS toolbox can be annoying when dealing with big datasets. As with gvSIG, we witnessed unexpected crashes, leading to situations where we were unable to open GRASS mapsets. Apparently, this was caused by a “.gislock”, a file created by GRASS, not automatically deleted during the program’s shut down. Also, QGIS's documentation seems to be more extensive and reliable compared to gvSIG's.

Students spent a considerable amount of time on finding certain functions and/or figuring out how to use them. This was mainly due to the lack of a comprehensive documentation or support. This is particularly true for gvSIG since some parts of the manual are written in poor English, others are only available in Spanish. Such resources are crucial for any GIS-user, particularly for beginner's. This makes it especially difficult for students who want to understand the theory behind the functions and make sense of the data. From a instructor's perspective it proved quite difficult to work with both systems. Preparation of lab exercises was tedious and little satisfying. Some subjects had to be omitted due to unexpected program behaviour, others because the software would not allow to carry out specific functions.

In conclusion, we believe that the current state of both systems is suited for advanced GIS-courses only. That is, courses where the task is not to understand the basics, but to enhance the applied skills of the students. In our opinion, courses on an introductory level are better off with established, stable and well documented GIS-software products. This ensures a motivating teaching environment, such that students can focus on experimenting with data and functionalities, rather than having to struggle with workarounds and ambiguous interfaces. We believe, however, that the two compared GIS-software products can, under certain constraints, be utilized for teaching. Currently, however, they are not mature enough to completely replace proprietary systems.

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# Papers session 3:

# SDI and data-issues of GI-education

# An SDI for the GIS-education at the UGent Geography Department

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## ABSTRACT

The UGent Geography Department (GD) (ca. 200 students; 10 professors) has been teaching GIS since the mid 90's. Ever since, GIS has evolved from Geographic Information Systems, to GIScience, to GIServices; implying that a GIS specialist nowadays has to deal with more than just desktop GIS. Knowledge about the interaction between different components of an SDI (spatial data, technologies, laws and policies, people and standards) is crucial for a graduated Master student. For its GIS education, the GD has until recently been using different sources of datasets, which were stored in a non-centralized system. In conformity with the INSPIRE Directive and the Flemish SDI Decree, the GD aims to set-up its own SDI using free and open source software components, to improve the management, user-friendliness, copyright protection and centralization of datasets and the knowledge of state of the art SDI structure and technology.

The central part of the system is a PostGIS-database in which both staff and students can create and share information stored in a multitude of tables and schemas. A web-based application facilitates upper-level management of the database for administrators and staff members. Exercises in various courses not only focus on accessing and handling data from the SDI through common GIS-applications as QuantumGIS or GRASS, but also aim at familiarizing students with the set-up of widely used SDI-elements as WMS, WFS and WCS services.

The (dis)advantages of the new SDI will be tested in a case study in which the workflow of a typical 'GIS Applications' exercise is elaborated. By solving a problem of optimal location, students interact in various ways with geographic data. A comparison is made between the situation before and after the implementation of the SDI.

## INTRODUCTION

Since the beginning of teaching GIS, the meaning of this acronym has evolved in time from Geographic Information Systems, to GIScience, to GIServices. It is not that GIS is restricted to one of the meanings, but it has become broader. While in the beginning years, a GIS was a computer-based centralized system, it has more and more become an internet or web based decentralized service; the view of a GIS has been evolving from a technologically dominated view to a more science oriented view (Jiang and Yao, 2010). As such, necessary skills for graduated geospatial Master students have evolved in time too. Scholten et al. (2009) mentioned more than 110 different domains that use GI technologies. De Bakker and Toppen (2009) predict that geospatial education will evolve due to a growing diversion of demanded skills resulting in graduated students with different focuses: (i) a user of GI information in a specific domain, (ii) a data manager, (iii) a Geo-ICT expert and (iv) a coordinator.

In 2007, the European Commission ratified the INSPIRE Directive (Infrastructure for Spatial Information in Europe) aiming for the set-up of a European Spatial Data Infrastructure (SDI), based upon components of SDI's at the national and sub-national levels. The INSPIRE Directive should assist policy-making in relation to policies and activities that may have an impact on the environment (European Commission, 2007). This Directive resulted in the Flemish SDI Decree (Flemish Parliament, 2009), with the set-up of the SDI Flanders partnership as one of the most comprehensive initiatives to coordinate and facilitate the exchange of data between all kinds of Flemish organizations (Dessers et al., 2011). Vandenbroucke et al. (2009) give a review of the many definitions of SDI and indicate that almost all definitions are related to their components. That is also the way Steiniger and Hunter (in press) define an SDI, containing the following components: (i) Spatial Data (or spatial information), (ii) Technologies, i.e. hardware and software, (iii) Laws and Policies, (iv) People, i.e.: data providers, service providers, users, and (v) Standards for data acquisition, representation and transfer.

As a lot of SDI aspects are quite technical and complex (e.g. standards of services, metadata and data specifications), a good education is crucial to foresee a smooth transfer of knowledge in the future. This training for working with spatial data can be provided by governmental institutions such as AGIV (Flemish Geographical Information Agency), by companies and by knowledge institutions, such as universities. As geography students are potential future employees that will be involved in the set-up and use of SDI's, geography education at universities should focus more on the different SDI aspects, which until now have been treated in a limited way.

The widespread use of Free and Open Source Software (FOSS) is apparent in the GIS field (Steiniger and Bocher, 2009). The FOSS components are perfectly valid for building an SDI is demonstrated by Steiniger and Hunter (in press).

The aim of this paper is to demonstrate that the set-up of a proper SDI for the GD is an important step towards an adapted GIS education that is conform to the strong evolving needs.

## MATERIAL AND METHODS

Two scenarios have been used for the GD in general, and for the case study of the paper more specifically. In the old scenario, a simple architecture consisted of a desktop GIS with the input datasets stored on a file server (Figure 1a). In the new scenario, a basic SDI was set up, consisting of a spatial database and an application server connected with a desktop GIS (Figure 1b). In the first scenario, ArcGIS has been used, while in the second scenario the FOSS packages PostGIS, GeoServer and QuantumGIS (QGIS) with GRASS plug-in have been used respectively.

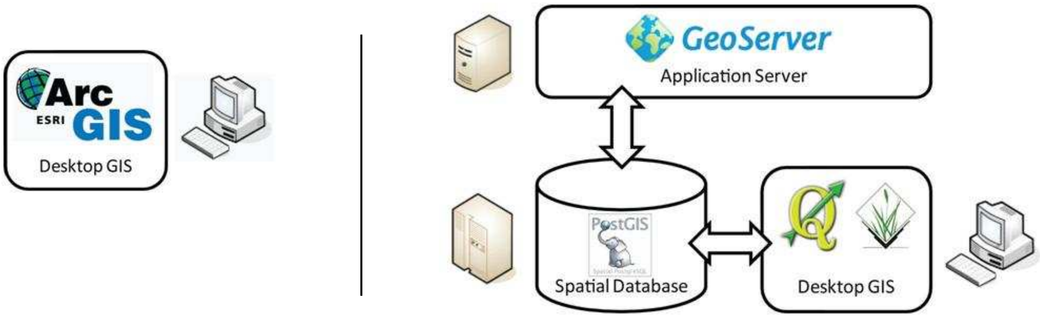


Figure 1a (left): Architecture of the old scenario containing a desktop GIS (ArcGIS) and Figure 1b (right): Architecture of the new scenario with a desktop GIS (QGIS / GRASS GIS), a spatial database (PostGIS) and an application server (GeoServer)

## Old scenario

Until recently, the GD used a classic system for handling data in exercises on a number of fields such as e.g. GIS and digital cartography. Both geographic and non-geographic data were stored on two separate file servers that were subject of a full mirror backup every 24 hours. One of those servers was intended for 'source data': staff members had full access and data was organized in a directory structure reflecting the academic year and names of the courses. Students could read all available data on this server regardless of their level or status. The second server held students 'home folders': every student got ample storage space and these folders were also accessible for staff members to monitor progress or grade assignments.

Ever since the start of GIS education in the GD, the ESRI line of desktop products has been the principal software used to introduce GIS to students. Ghent University had an agreement for 90 floating licenses available to the whole university (over 30000 students and over 7000 staff members) and the software was available through the central system for application virtualization Athena. This system was rather susceptible to errors and slow working speed and therefore some pc-rooms got local installations of the ESRI desktop products. Using the software from home was only possible through VPN on the error-prone Athena virtualization platform which lead to frequent complaints from students about the limited availability of the pc-rooms.

## New scenario

The GD opted for the implementation of a proper SDI. Central in the system is a PostGIS database which holds the geographic data. This PostGIS database is a PostGreSQL database enhanced with the extension PostGIS for dealing with spatial data in the framework of a SQL database. In this way, it not only enables the classic non-spatial queries and administration, but also certain basic spatial analysis to be computed directly by the database system. For example, calculating a buffer area around a spatial object no longer requires desktop GIS software to load the data, calculate the buffer and store the resulting feature, but can be directly handled by the PostGIS database.

In the spatial database, each layer of information is stored as a new table. These tables can be grouped in a schema which in turn can be combined in a database. One server can hold multiple PostGreSQL databases but since that configuration does not allow queries that use multiple databases, the central database of the SDI has been constructed as a single database in which each user was assigned a single schema. For this schema, the user has full access rights and can allow other users to access the data. This gives students the possibility to cooperate on certain projects without having to deal with exchanging data.

A second range of schemas is created for each course and is fully accessible for the selected staff members and offers read access to students enlisted for that course. A last set of schemas is dedicated to larger sets of base data that are available for all staff members. Students can get access through a procedure in which they state the purpose for which they intend to use the data, the approval of a staff member and the spatial extent of the information they would like to access. After this, they can either get read access to the entire table/schema or get a subset of the data added to their personal schema. To adequately administer this huge database, a web-based management system is being developed. It can be used by the administrator to create new schemas or tables and assign user rights to them. Staff members can use a well-organized webpage to add data for their courses or to grant rights to specific students for specific datasets. For students, a similar webpage allows to administer their own data or to apply for access rights for (subsets of) data and to monitor the amount of free disk space they have available.

Next to this PostGIS implementation, the SDI also includes a GeoServer which is mainly used for providing copyrighted data. Several web mapping services (WMS) were implemented that retrieve data from georeferenced raster imagery, the PostGIS database or a combination of both. Premium example here is the availability of high resolution orthophotos for the entire territory of Flanders.

The introduction of new technology does not stop with the data-providing side of the process. The major application for introducing students to GIS has changed too: QGIS has replaced ESRI's ArcGIS as the first tool students get to work with. Although QGIS lacks quite some of the advanced analysis tools that are available in ArcGIS, the partial switch to FOSS holds a few benefits. First of all, students can freely install and use the software on their own systems and are no longer subject to the limited availability or performance of the software provided by the university. Secondly, as a platform to introduce the basic concepts of GIS, the open source QGIS is very similar to ArcGIS in usability and performance. This does not mean that the position of ESRI as market leader and requirement of knowledge of their products in the industry is no longer acknowledged: after introducing the concepts, students are still required to use ArcGIS to complete certain assignments.

## Case study in the old and new scenario

The case study area of this paper is the Belgian Part of the North Sea (BPNS). In this area a fictive exercise of suitability analysis for the construction of a new windmill park is performed, comparable to a student exercise. The input datasets are real data of the BPNS (for references of the datasets cfr. Table 1): (i) occurrence of users: where a user is located, no new windmill park can be located, (ii) distance to 12 nautical miles: the park may not be too far from the coastline (because of economical costs) and not too close (because of the view), a distance of 12 nautical miles is for this exercise considered as a good compromise (iii) distance to Zeebrugge harbour: the closer to the harbour, the more suitable, because of a possible connection with the existing electricity network (iv) bathymetry: the deeper, the less suitable, (v) geology: clay is the most suitable substrate, followed by sandy clay, clayey sand and the co-occurrence of clay and sand, (vi) bedforms (dune structures): the higher the bedforms, the less suitable. Other datasets such as hydrodynamic conditions, grain size, or biological species are not taken into consideration.

A spatial analysis (consisting of merge, buffer, vector to raster, raster reclassification and distance calculation operations) results into different rasters with suitability classes ranging between 0 (not suitable) and 10 (very suitable). In the last analysis step, weights are assigned to the suitability rasters, which results into a final suitability map showing zones that are suitable or not for a future windmill park (Figure 2).

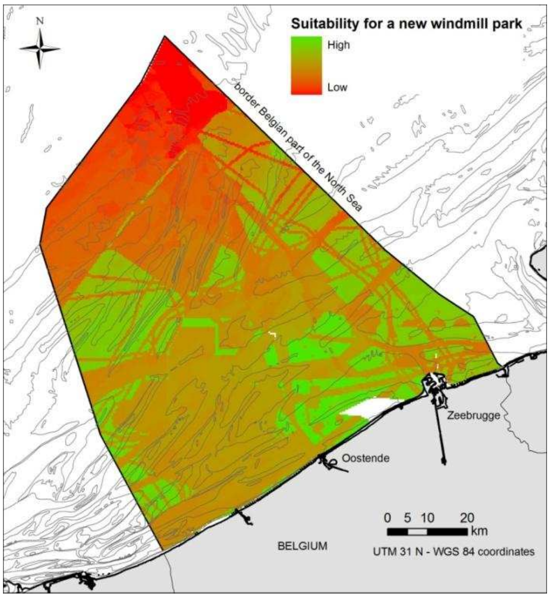


Figure 2: Suitability map for a fictive new windmill park on the Belgian part of the North Sea. The exercise shows that not a lot of suitable locations can be found for new windmill parks. The most suitable locations are situated close to the coast of Oostende and Zeebrugge, in between the user functions. As this is a fictive exercise, the interpretation of the map does not matter for this paper.

Table 1: Datasets that are used as input for the suitability analysis.

| DATASET | REFERENCE |
|---|---|
| **User functions** on the Belgian part of the North Sea (weather masts, radar mast, wrecks, pipelines, telephone cables, Zeebrugge harbour, military exercise zones anchorage area for vessels, dredge disposal areas, aggregate extraction zones, Ramsar and Habitat Directive nature areas, shipping lanes, shipping routes) | GAUFRE project: Maes et al., 2005 |
| **Bedforms** (dune structures) | MAREBASSE project: Van Lancker et al., 2007 |
| **Geology** | Le Bot et al., 2003 |
| Bathymetric data for **digital terrain model** | Flemish Authorities, Agency for Maritime and Coastal Services, Flemish Hydrography |

# RESULTS

## Impacts for staff, students and organization

So far, the introduction of the SDI has had major implications on the way both staff and students organize, prepare, experience and evaluate exercises.

As a starting point, all staff members using geographic data, GIS analysis or digital cartography in any form or to any extent in their courses had to be properly informed about the ins and outs of the new system. This was done in a two-day crash course on open source GIS software and SDI's. In a series of real-life scenarios, all aspects of handling the available geographic data were covered: from creating course specific data subsets, over combining locally stored data with publicly available data, to integration of web based services. Because the launch of the SDI was combined with a switch to open source QGIS as principal desktop GIS application, all of this was linked with an introduction to QGIS that closely resembles the introductory exercises on GIS that students get. In this way not only the new platform could be tested, but also the renewed educational approach was evaluated by some highly critical colleagues.

Although the need for staff members to adapt to the new system and bring the geomatics skills of people from other fields (social geography e.g.) to a ‘higher’ level was initially listed as a drawback for implementing the new system, most people in the GD agree that it has increased flexibility. In order to also increase ease of use for staff members, a number of scripts are being developed that will allow them to perform certain routine tasks through a web-based interface. Thus, they do not have to worry about specific database implementations and can make data available for certain (sub)groups of students as in the old system.

The second step was a complete overhaul of the way to give students hands-on experience in working with GIS software. With more and larger datasets easily available, preference was given to learning methods that ask more initiative from the individual student. Rather than providing students with data carefully prepared for a certain exercise, the new system allows tutors to point students in the right direction and let them build their own personal repository. The first advantage for students is the introduction to innovative technology. For example, already in series of basic GIS exercises they learn how to use an SDI which is fundamentally different from working with some files on a local hard drive. And in more advanced courses, they are introduced to the tasks of an SDI administrator and developer. A second major advantage is of course the access for all students: instead of working with outdated local copies of certain data layers, they can now at any time access the latest available data.

From a more organizational and technical point of view, the SDI has a clear impact on the IT organization of the department. First of all the system had to be installed, configured and thoroughly tested by someone who is familiar both with the technical aspects of servers and databases, and with the particularities of geographic data. This meant that although the IT section of the department provided hardware with operating system and reliable backup facilities, configuring all other aspects had to be done by a member of the teaching staff. This certainly had its influence on the availability of that person for other courses and activities. But it does not stop there, once the system is up and running, this person still has to dedicate a significant amount of time to administer it. These tasks involve e.g. user administration, adding and updating new geographic data, administer services (WMS, and web feature services (WFS), and provide advanced user support for staff members. Moreover, from the organizational point of view, the system allows more flexibility: the use of certain data can be restricted to certain groups and therefore data-suppliers are clearly persuaded to provide some more sensitive real-life data.

### Case study compared in two scenarios

As this exercise has been performed by one single person on a desktop, the difference between the two scenarios is not significant, but in the case of a large user group, e.g. different student groups from different GIS courses, working on this exercise, the advantages of the second scenario would tend to become more effective. In Table 2 pros and contras of the scenarios are listed. The more users and the more datasets, the more positive effect of the second scenario.

Table 2: Advantages and disadvantages of the old and new scenario

| | Old scenario | New scenario |
|---|---|---|
| Advantages | - number of ArcGIS functionalities is very extensive, both concerning raster and vector operations<br>- the overall performance of ArcGIS is still better than open source desktop GIS software<br>- most effective for simple exercises with a small number of datasets and a small user group | - number of QGIS / GRASS functionalities is continuously increasing and improving because of large and very vivid user and developer community<br>- very effective for a large number of datasets and users<br>- data are stored on a central server<br>- compatible with OGC services<br>- free and open source components |
| Disadvantages | - datasets are copied and saved countless times<br>- not compatible with all OGC services<br>- expensive | - the current version of PostGIS is not able to deal with raster datasets<br>- technical knowledge of teachers / assistants is necessary for the set-up / maintenance of a PostGIS database and a GeoServer application server |

## DISCUSSION

### Setting up an SDI in the context of GIS education

As the INSPIRE Directive aims for the set-up of a European SDI, the implementation of this Directive and the Flemish SDI Decree will happen based on a phased approach with an inventarisation of geographic datasets, an adaption of the ICT infrastructures, an adaption of the metadata, a harmonization of datasets, making the datasets available and an adaption of management processes. All of these steps will happen between 2011 and 2019 (AGIV, 2010). This planning will require a lot of effort, where all of the four professional aspects that were defined by De Bakker and Toppen (2009) play a crucial role. The user of GI information will have at the end of the process well-structured data and metadata conform to the INSPIRE standards. The data manager will have a very important role in the inventarisation, harmonization and delivery of datasets. The Geo-ICT expert will have the main responsibility in setting up the technical part of the SDI, that will be used by all stakeholders, data users, data managers and coordinators. The coordinator has to manage the whole process and needs a broad knowledge on all aspects, a high level education is necessary. Possibly not all graduated GIS students need a knowledge that covers all of these aspects at the same level, but at least they have to be familiar with terminologies and basic GIS and ICT skills. Using and managing data are basic skills for a GIS expert, while Geo-ICT and management is more specific and can be considered as optional specialization. A Geo-ICT expert will need more specific ICT skills such as programming, while a coordinator will need knowledge on management processes.

The relevance of implementing an SDI for the GD or Ghent University is twofold. The first point was already mentioned above: industry expects graduated students to have a certain level of knowledge on the components of an SDI and although there is no intention to make them all SDI-administrators, active use of a fully functional SDI will prepare them better for a range of jobs after graduation. Secondly, its relevance is demonstrated by the elements referred to in the results section of this paper: for students and staff and from an organizational point of view, the introduction has proved quite beneficial for all those involved. But of course, as with every new route that is taken, some unforeseen bumps on the road have to be dealt with.

## Technology

That FOSS is a hot topic in the GIS world, is proved by the success of the yearly FOSS4G (FOSS For Geospatial Conference) Conferences, that in September 2011 in Denver was attended by over 900 participants.

Although it is possible to set up an SDI based on ESRI or other non-FOSS components, the GD has made a very definite choice to build its SDI based on FOSS components. The reason for this choice is threefold: (i) no license costs have to be paid by the Department or the University, (ii) as stated before, students can freely install and use the software on their own pc's, (iii) an SDI with FOSS components supports open formats.

The two scenarios from the case study made use of different software packages (ArcGIS versus QGIS / GRASS / PostGIS / GeoServer). From own experience, it is still easier and more functional to use ArcGIS than QGIS to create a high quality map and lay-outs. Sillero and Tarroso (2010) compared the number of functionalities between different GIS software packages. At the moment of their publication, ArcGIS counted 114 functionalities, QGIS 94 and GRASS GIS 84. Still, the development and use of FOSS is boosting enormously over the past few years. This boost is proven by four indicators in Steiniger and Bocher (2009); (i) the number of recent started FOSS projects, (ii) the increasing financial support from governmental institutions, (iii) the increasing download rates of FOSS software and (iv) the increasing number of use cases. Students often have the perception that a GIS is only a desktop software to create beautiful maps. However, they should be aware of the magnitude and importance of a GIS and in particular an SDI with all its components.

## Future perspectives

Good GIS education results in highly qualified graduated students that are ready for the job market. As this job market is continuously evolving and as this market is becoming broader, it is our aim to organise in the near future a large scale inquiry in Flanders. Different GIS related job market stakeholders from private companies and governmental institutions will be questioned about particular needs and skills. Current education focuses a lot on data use and data management, while Geo-ICT and project coordination are important skills as well, as stated by De Bakker and Toppen (2009).

So far, there has been no evaluation of how the new system influences the learning process of students. Although it is not easy to quantify this influence, it is an essential element of improving and diversify the ways in which students can gather knowledge about GIS and SDI's. Moreover, at the end of this academic year, a questionnaire will be distributed in which students will be asked to evaluate several aspects of using the SDI and how the system and its integration in the study process can be improved. This should allow to not only focus on intended goals and results, but also to take into account some of the unforeseen issues students will probably encounter.

Regarding the understanding of students' cognitive processes from learning experiences with GIS, Baker and Bednarz (2003) stressed the need of more substantive research on this topic. This is indeed crucial for a better understanding on how certain adaptations in educational strategies and methodologies are perceived by students. DeMers (2009) cooperated at the UCGIS Body of Knowledge, a recommended baseline for the GIS and Technology undergraduate curriculum. He suggested that there is a need to increase the number of GIS learning objectives, requiring analysis, synthesis and evaluation. Moreover, higher cognitive level objectives should be included in existing learning objectives, as e.g. defined in ECTS (European Credit Transfer and Accumulation System) documents. It is clear that more research is needed in this domain. Part of the future work will focus on the perception and comprehension of students of study materials. Research questions that can be asked in this context are: how does the set-up of an SDI contribute to the knowledge and understanding of a GIS student? Which learning objectives reach higher levels making use of an SDI?

At the moment, the SDI of the GD is in a preliminary stage. Although it contains an application server (GeoServer), a spatial database (PostGIS) and a desktop GIS (QGIS / GRASS GIS), there are plans to expand the system once the first elements are fully functional and run smoothly. An important element in this extension will be to create a system to manage metadata: both for adding the metadata attached by data-providers as for adding metadata to newly created or changed layers of information. Second aspect is the integration of raster data in the system: the update to PostGIS 2.0 (expected Fall 2011) promises to encompass the storage of raster data. Another point of attention is the development of a virtual platform on which students can learn how to implement their own SDI and manage web services or administer geospatial databases.

Next to these technological steps, the educational method is also under development. A series of instruction videos is being developed and made available online to offer students a more flexible and efficient learning path.

Apart from the extension within the activities of the GD, a broader look to the whole of Ghent University and even cooperation with other institutions of the Association UGent is under consideration. Should the Department try to be the single point of contact for providers of geographic data or should it serve as a testbed for other departments that can build similar architectures and can learn from the experience at the Department?

## CONCLUSION

This paper showed the relevance of setting-up of SDI for the GD as an important step in the direction of an improved GIS-education that is conform to the evolving needs. Since the SDI is in a preliminary phase, it is too early to draw conclusions about the effects of the SDI on better positions for graduated students on the job market or about effects on the work load of the teaching staff. But as the SDI exceeds the level of a desktop GIS by adding a spatial database and an application server, it is foreseen that the effects will be positive for students and teaching staff for different reasons.

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# New challenges for the GIS-education in evolving spatial data and service-based infrastructures

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## INTRODUCTION

Sweden is implementing INSPIRE as an integrated part of the National Geodata Strategy. One of eight action areas within this strategy is research, development and education, focused areas recognized for the success of the implementation. This paper focuses, on one hand, on the need for better access to data within the Swedish education and research communities and, on the other hand, the need to integrate the concepts and theoretical considerations of Spatial Data Infrastructures (SDI) in the national GIS-education. The paper is based on two surveys. First, a survey where teachers at Swedish universities have described if and how they introduce SDI-concepts in higher GIS-education and what future development they want to see in relation to data access. Second, another survey focusing on the need and interest for a local SDI within the universities of Gothenburg is referred. Furthermore, the paper gives an overview of the current status and progress of the Swedish spatial data infrastructure. Also, the development of e-governance and its relation to SDI is described. Spatial data and geodata are used synonymously throughout the paper.

## BACKGROUND

Today, there are only a few universities that have SDI-concepts as an integrated part of their GIS curriculum, even at universities with a particular focus on GIS, such as Lund University and University of Gävle. There is no specific SDI-course, but several of the master courses offer an initial course on SDI-concepts. At for example, the University of Gävle a new study program with focus on IT and GIS has recently started. This program includes a course in SDI and service-oriented architectures.

Lund University hosts a GIS Centre that coordinates the use of geographic information within the university. Geographic information is used in most faculties today, e.g. engineering, science, medicine, economics and humanities), both in education and in research. This is believed to be true for most of the other major universities. Based on the results of a questionnaire distributed at Gothenburg University and Chalmers University of Technology during 2010 it is evident that a wide range of spatial data is used in various disciplines (Tornberg et al., 2010).

Currently the access to spatial data for universities is under great changes. Some of the authorities that deliver data for the INSPIRE themes do this for free to universities, whereas other charge, a reduced or full fee for the data deliverance. The current direction of improvement is towards the inclusion of the Swedish universities in the Swedish national spatial data infrastructure by 2013.

## WHAT ARE SPATIAL DATA INFRASTRUCTURES?

There are different definitions of what SDI’s are, but some common elements often appear. In the Spatial data infrastructure cookbook (2009) published by the Global Spatial Data Infrastructure (GSDI) Association the term “Spatial Data Infrastructure” (SDI) is defined as  the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general. The official definition used for the Swedish SDI (in Sweden denoted Infrastructure for geodata) is that it provides geodata together with regulations, services for searching, finding and using the information and systems for cooperation between different parts (www.geodata.se, 2011-08-10).

## THE SWEDISH SPATIAL DATA INFRASTRUCTURE – CURRENT STATUS AND PROGRESS

Today Swedish national and local authorities can sign either a collaboration or a contribution agreement. The Geodata Cooperation Agreement regulates a sustainable cooperation within the spatial data infrastructure. It presents how to handle organization, steering, coordination and responsibilities as well as technical prerequisites, forms of supply and terms of use of spatial data. The parties in the Geodata Cooperation Agreement offer each other their spatial data for official use to an annual fee. The Geodata Contribution Agreement offers all actors that fulfil basic requirements the right to publish metadata and make their spatial data products available via the Swedish national Geodata Portal. A condition for contribution is that metadata should be described according to the national metadata profile. Metadata should also be of public interest and well adapted to its purpose. To join as a contributing part is free of charge.

At present the Swedish Geodata Portal (Figure 1) presents available spatial data from a number of Swedish national authorities (17 national authorities). The Portal also comprises a national metadata catalogue which describes available spatial data, their quality and conditions for use. To some extent the Portal also provides the entry to web services, which are hosted at each producers' own server and accessed through the producers' web sites. At this stage the Geodata Portal is mainly aimed for professional users, although it is accessible to everyone.

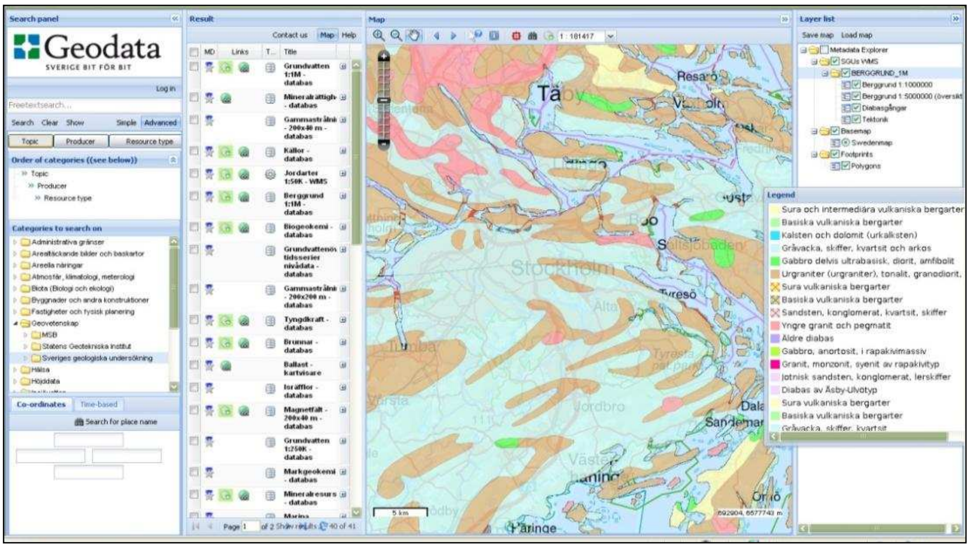


Figure 1: The Swedish national Geodata Portal. In this example a view-service of the geology in the Stockholm area is shown. To the left a list of producers and different search options are shown.

## E-GOVERNANCE AND A WEBSERVICE BASED GIS-INFRASTRUCTURE

E-governance will potentially have a large impact on society as a whole and SDI's are an important part of e-governance. Through clear and standardized conditions of access to public information different actors in society can develop services that provide additional value to society by re-use of the public information. Today there is no common or coordinated handling of semantic solutions or information structures between authorities. This means that authorities have different definitions for the same facts and information is organized in different ways. These differences in semantics and information structure are two of the larger general problems when developing shared solutions or services with independent partners (Swedish Government Inquiries, 2009). An important focus in e-governance is to develop and provide services for enterprises and citizens making it easier for them to utilize their rights, fulfil their obligations and benefit from services from the public administration. Another important driving force is to develop more efficient handling within the public administration, including reducing costs and the office turnaround time The Swedish SDI is part of this reform and will improve the supply and access of standardized spatial data from Sweden and from the member's states of the European Union.

Both the INSPIRE directive and the European Interoperability Strategy aim to enhance interoperability at legal, organisational, semantic and technical levels. This should progressively provide requirements for delivery of public services, built on cross-border interactions between public administrations and businesses. Such services may be the result of aggregating 'basic public services' provided at various levels of government. The key to success will be development and broad adoption of commonly agreed data specifications as a base for a broad selection of national and European public services (Elg, 2011). This should have an important impact on how to work with spatial information in education and provides new pedagogical possibilities. It will for example be easier to adopt a problem-orientated perspectives as well as solving real life problems using real life practices, where access of data will not hinder to learning process.

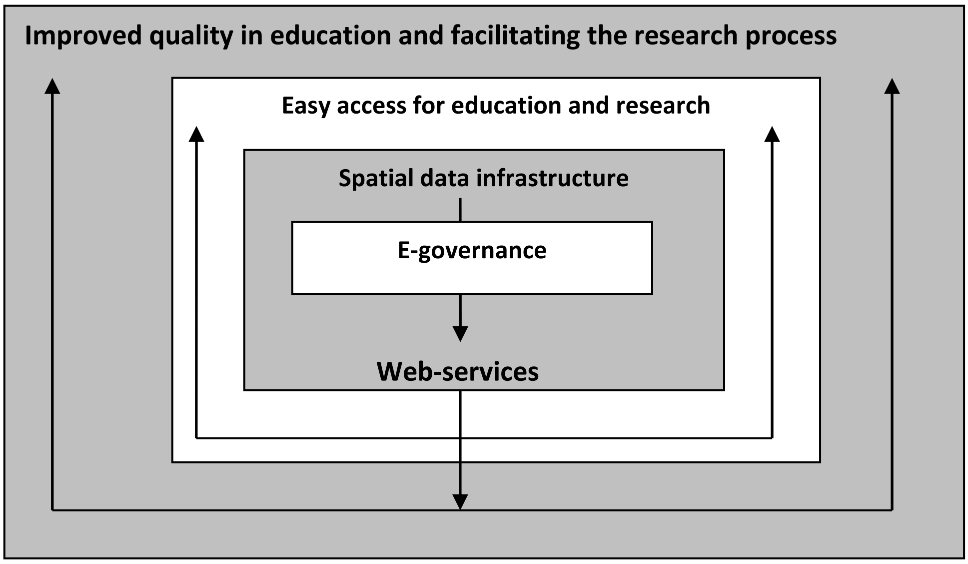


Figure 2: The connection between e-governance, SDI and a web-service based architecture and how these potentially will have an important positive influence on both education and research.

## THE USE AND NEED OF SPATIAL DATA AT SWEDISCH UNIVERSITIES

A questionnaire focusing on the use of geographic information and the potential needs for a common infrastructure for spatial data for the universities within the municipality of Gothenburg (Chalmers university technology and Gothenburg University) was distributed in 2010 (Tornberg et al., 2010). The questions were answered by 61 respondents. About half of these thought it would be of interest to have a common platform for the distribution of spatial data within the universities, both for research and education purposes. The wide range of use revealed solely from the different departments at these two universities points at the wide use and the potential for an even wider use if access was easier and some additional knowledge in how to use the spatial data could be acquired (Table 1). The need for easy access to data from several authorities, e.g. Statistics Sweden, Lantmäteriet, The Swedish Maritime Administration, The Geological Survey of Sweden, Swedish Armed Forces), was revealed in the comments.

Examples of spatial data themes mentioned by the respondents as useful are: revenues, demographic data, prices, environmental data, land use, population, infrastructure, geology, sea bottom topography, shorelines, hydrography, vegetation and climate zones, settlements, ancients remains, laser scanned data, satellite imagery and aerial photographs. Many different authorities produce these data sets (Table 1). Thus, easy access to spatial data is a crucial issue. A similar questionnaire as the one distributed by Gothenburg and Chalmers universities will be distributed to all Swedish universities during autumn 2011 to better understand the use and the need for spatial data at a national level.

Table 1: Examples of spatial data themes as referred to by the respondents of a questionnaire distributed at Chalmers University of Technology and Gothenburg University. In the right column the corresponding authorities producing the data.

| **Data theme** | **Responsible authority/authorities** |
|---|---|
| Demographic data | Statistics Sweden |
| Environmental data | Lantmäteriet/ Swedish Environmental Protection Agency/ SMHI/ The Geological Survey of Sweden/ Swedish University of Agricultural Sciences |
| Land use | The Forest Agency/ The Forest Agency/local municipalities/Lantmäteriet |
| Population | Statistics Sweden |
| Infrastructure | The Swedish Transport Administration/The Swedish Maritime Administration/Air navigation services of Sweden |
| Geology | The Geological Survey of Sweden |
| Vegetation | Lantmäteriet/ Swedish Environmental Protection Agency/ Swedish University of Agricultural Sciences |
| Ancient remains | Swedish National Heritage Board |
| Settlements | Statistics Sweden/ Lantmäteriet |
| Shorelines | The Swedish Maritime Administration/ Lantmäteriet |
| Sea bottom topography | The Swedish Maritime Administration/ The Geological Survey of Sweden |
| Hydrography | SMHI/Lantmäteriet |
| Laser scanned data | Lantmäteriet |
| Aerial photographs | Lantmäteriet |
| Satellite imagery | Lantmäteriet |

Lantmäteriet = the Swedish mapping, cadastral and land registration authority
SMHI = Swedish Meteorological and Hydrological Institute

## HOW ARE SDI-CONCEPTS INTEGRATED IN THE SWEDISCH HIGHER GIS-EDUCATION?

To get an understanding of how the SDI-concepts are handled in the higher education a questionnaire was prepared and distributed to teachers and course coordinators at all Swedish universities giving GIS-courses. A commonly used textbook in Sweden is Geografisk informationsbehandling – teori, metoder och tillämpningar (Geographic information processing – theory, methods and applications) (Harrie, 2008), which includes a chapter on SDI-concepts. The questionnaire specifically referred to this chapter. The questionnaire aimed to answer if this chapter is used in education and if not used – to understand why, e.g. lack of priority or of competence or not corresponding to the course curriculum. It was also asked if other literature than the above mentioned textbook is being used and if it introduces SDI-concepts. If so, it was asked if these parts of the content was introduced during the course. Further, the respondents were asked if they are familiar with the Swedish SDI and if they introduce their students to the Swedish Geodata Portal. Finally, we also asked the respondents if they would like to be able to access data through the Geodata Portal in the future for educational purposes.

The questionnaire was sent to contact persons and teachers at all universities giving a basic GIS-course (38 individuals at 19 different universities). Seventeen individuals answered the questionnaire, representing 13 universities.

The results show that the Swedish textbook is used by a majority of the respondents (13 of 17 use it, while only 4 do not use it). Few of the respondents introduce the whole SDI-chapter (5). Five respondents introduce parts of the chapter, of these two mention that they give an overview of the chapter, but do not go into any details. One respondent answered that the chapter is ignored because it is irrelevant to the course curriculum, but also point out that this is in relation to a course mainly focusing on remote sensing. Among other literature that is used different editions of Heywood et al. "An introduction to Geographical information systems" and Longley et al., "Geographical *information systems and science"* (Heywood et al 2011,2006; Longley et al., 2010; 2005) is dominating. Nine respondents report using additional literature as the main literature or as a complement. It is worth to notice that in two cases very specialised literature is mentioned Conolly and Lake, 2006, "Geographical information sys*tems in Archaeology"* (Conolly and Lake, 2006) and Worboys and Duckham, 2005 "GIS - *a computing perspective"* (Worboys and Duckham, 2005). When SDI-related questions are included in the additional literature, parts of it are most often mentioned during the course (6).

Ten of the respondents report that they know the Swedish SDI very well, while seven say that they have heard about it. None have never heard about it. Most of the teachers do not introduce the Swedish Geodataportal during the course (11), while six of them do so.

The last open question of the survey was What need do you anticipate of being able to use the Swedish Geodata Portal in education in the future?

Two broad categories can be distinguished. First, three respondents refer to the cost of accessing data. The second group (6 respondents) sees new opportunities with the SDI and the Geodata Portal and that it can be very useful for both research and education.

One comment bring specifically up the access to data as a problematic issues today: The bottleneck is still the access to data, without easy access to data, the GI-education is most often just exercises with no link to reality. The real applications will be taught later in working life, dampening both knowledge and interest for this area during the study period.

## DISCUSSION AND CONCLUSION

### SDI-concepts in education – different perspectives

The results of the questionnaire show that in general SDI-concepts are not given any greater priority, but parts of the SDI-related concepts are still brought up at most courses. There are few teachers who do not include SDI-concepts at all in their courses. But, part of the answers together with the comments of the respondents, show that there is an increasing awareness around SDI. The issue here is two-folded; an increase in awareness is accompanied by better access to spatial data. If SDI-concepts are not implemented in reality by the national authorities, including easier access to spatial data for universities and education bodies), it is difficult to see the incentive to understand and teach SDI-concepts in higher education.

At the same time, as the process of making easier access to spatial data has started at a national level in Sweden, it is important that teachers at universities understand the implications of this, both from theoretical and technical points of views. This is crucial since most of the students will work with or use the national SDI, and in a longer perspective some might even be users of the European SDI. The development of all SDI's depends on cooperation and relevant competence of the partners and participants in the cooperation. The development of a web-service based architecture also means that most users will work differently in practice with spatial data – depending on the nature of the work, this means retrieving data in real time through links integrated in the software used.

Hopefully, the development will also enable web-services being connected to each other, which will make the workflow easier and more efficient. One example is data themes with common elements but produced by different authorities. Today, the users have to retrieve data from the different producers, instead of being delivered the whole relevant data theme, e.g. land use or hydrography.

Other important aspects of SDI, relevant to GIS-education, are the importance of standards and metadata, as well as quality issues related to data. We see today that there is a need among professionals of better knowledge in these areas. This is also relevant for those who will collect and produce their own data, either in the private sector or as researchers. Many of the students will be later on in their profession part of the implementation of INSPIRE and therefore it is important to bring up the basic principles of. Lack of knowledge hinders the development of a broad access to spatial data at a national and European level, because all actors need to be involved in the progress of a fully established and evolving SDI.

### New pedagogical possibility with better access to data

With easy access to any spatial data the GIS-education could be formed differently than today. Today GIS-exercises are often based on already downloaded datasets located at the university server in a specific folders and the work flow is described step by step. What is the best way to learn how to handle the structure and possibilities of complex GIS-software is not the focus here, but most often a frequent use of a program promotes the understanding of the software. Software may also vary between different courses and between different employers. In working life it is often needed to find and retrieve relevant data for a specific project or you work regularly with the same data set, but need well updated data. The web-service based architecture will provide new possible to retrieve updated data and to get easy access to spatial data from different sources. Hopefully, less focus will be on the control of the software, but instead on the actual analyses that can be performed using spatial data and how this can be used to plan, analyse and make accurate decisions in various sectors and applications, as well as visualising the results.

As a conclusion SDI has implications for improved quality in education by maker the access to a various and large number of datasets much easier, thus enabling a clear focus on defining relevant case studies and how to perform analysis on the data and presenting the results. From a pedagogical point of view this is important since it both will teach how to obtain data in a similar manner as in professional life, improving access to all relevant data and as a consequence minimizing the time used for accessing data.

The web-service based architecture will also provide a more dynamic and efficient work-flow and for the more technically focused students give opportunities to develop new spatial data based web-services. To achieve this, it is important that educators recognize the advantage of and follow the development of national SDI's. At the same time, it is equally important that national authorities create financial models and agreements enabling universities and educational bodies to be included in the SDI's. Thus, promoting a wide use of spatial data in the GIS-education.

## ACKNOWLEDGEMENTS

Jonas Tornberg, lecturer at Chalmers University of Technology, Bo Magnusson, lecturer Gothenburg University, Lars Harrie, lecturer Lund University and Ulf Sandgren, senior adviser at the Swedish National Mapping, Cadastre and Land Registration Authority are acknowledged for providing results and giving input to this paper.

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# GIS and SDI in the department Provinciale Hogeschool Limburg-Bio: essential for preparing young potentials in Green management

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## ABSTRACT

Department Provinciale Hogeschool Limburg (dpt. PHL)-Bio is part of PHL University College ("the University College with the laptop") in Hasselt. About 230 students are enrolled in two principal fields of study: Green management and Biotechnology, both located at the campus in Diepenbeek.

The professional bachelor Green management offers a GIS-course in the first year. Each student has his or her own laptop on which the ArcGIS10 Desktop software is installed. Using the wireless network at dpt. PHL-Bio they have access to a license. Students can also borrow the software to study at home.

We have worked out a good solution for our software and as always, the challenge has moved to how to manage the data. Today we use Blackboard, a file based environment, to save the spatial data needed for the GIS-course or other activities. However, this leads to typical problems concerning the multiplication, actualisation and authenticity of data.

Our future challenge will be, the construction of a Spatial Data Infrastructure (SDI) for dpt. PHL-Bio. This is necessary when we look at what is expected from the professionals in Green management. For example, we need to prepare our students for field inventorizations and GIS-analysis using regional SDI-solutions such as the SDI-Flanders of the Flemish Government.

This presentation will present our experiences in GIS-education in the environmental sector and will give our ideas for the future development.

## INTRODUCTION

This paper focuses on our experiences in GIS-education in the professional bachelor Green management at the PHL University College (Provinciale Hogeschool Limburg) and focuses on our GIS-ideas for the future.

Building a Spatial Data Infrastructure (SDI) and further integrating GIS in the curriculum are our main goals. We believe this is essential for preparing young potentials in Green management.

In the following pages a short introduction of the PHL University College and the professional bachelor Green Management will be given. Moreover, an overview and challenges of GIS within the curriculum of Green Management will be given. As an answer to these challenges we give an insight into our plans for the future. The paper concludes with the need to elaborate a mission statement on how to organise our GIS-education in the future.

## PHL UNIVERSITY COLLEGE

The PHL University College (PHL) was founded in 1995 and is the product of a merge of six colleges of higher education. PHL provides programmes of non-academic higher education (three years of study) and academic higher education (four to five years of study). PHL has about 5,000 students and 372 teaching staff members at two locations: Hasselt and Diepenbeek (PHL, 2011a).

The PHL is better known as "the University College with the laptop", that is to say each student is expected to have his or her own laptop. This makes integration of ICT in the colleges easier, creating new opportunities and challenges for the students and teachers.

PHL has seven departments offering education in very diverse domains going from economics over pop and rock to architecture.

## THE PROFESSIONAL BACHELOR GREEN MANAGEMENT

About 230 students are enrolled in the two main fields of study of the department PHL-Bio (Dpt. PHL-Bio): Green management and Biotechnology, both located at the campus in Diepenbeek.

In Green management, students can specialize in three fields, namely, Green space and tree nursery, Garden landscaping or Nature- & Forest conservation. Biotechnology students take their degree in the field of Molecular Biology, Environmental Technology or Food Technology (PHL, 2011b).

## GIS AND GREEN MANAGEMENT

### Importance of GIS

Between 1996 and 2006 the use of GIS worldwide has enormously increased from thousands to millions of users; the GIS-community includes a broader group of users working with GIS on different levels, besides the classical specialists in survey and mapping (Masser, 2007).

This trend is certainly visible in Green management. A green manager is always dealing with the environment, be it a private garden or a national park. Many of his actions have an impact on these locations and, consequently, influence the spatial information. At the same time a green manager needs spatial information of his location in order to adequately perform his job. This combination of location and information in the daily work of a green manager makes GIS as a useful instrument.

Two cases can briefly illustrate the application GIS in Green Management. In the field of Nature- & Forest conservation, the study of exotic species is a hot topic in Flanders. One of these species is the American bullfrog, one of the more invasive exotic species that is currently being investigated by the Bio-Research team from dpt. PHL-Bio (Bio-Research, 2011). GIS turns out to be a very useful instrument for mapping the frogs and following their movements, so as to get a better knowledge of their habitats. The same can be mentioned for the field of Green space and tree nursery where making an inventory of trees and other plants becomes easier by the use of GIS, resulting in a good location based database.

The contacts made with former students and companies also confirm the importance of GIS on the work floor. On a regular basis the dpt. PHL-Bio organises meetings with its stakeholders in order to guarantee a constant close connection between the course program and the expectations of a professional green manager.

The previous examples illustrate why the dpt. PHL-Bio thinks it is important for the students to learn to work with GIS.

### Topics and spatial data

Each student has the ArcGIS10 Desktop software installed which they access using the wireless network at dpt. PHL-Bio. Students can also borrow the software to study at home.

The main goal of the GIS-course in the first bachelor Green management is to teach the students a set of basic GIS-skills: for instance, they learn how to use symbology, they conduct basic analyses of attributes and objects and are taught how to present their work on a good map. At the same time they learn how the SDI-Flanders is organised, for instance, where to consult metadata or how to get the spatial data. The acquirement of these skills and of this knowledge enables them in the first year to conduct in team a landscape study of a certain area, analysing different spatial data. In the second year GIS appears as a working instrument in different courses, where it is mainly used for the creation of situation maps for a specific area or for thematic maps. Finally, in the last year of study GIS often comes in handy for the elaboration of the student's graduation project.

The spatial data offered to the students is geographically limited to the region of Flanders. The PHL-Bio data catalogue contains many types of data that can be useful for the students. For instance, in the group of REFERENCE DATA topographical maps, orthophotos and the Large Scale Reference Base ('Grootschalig Referentiebestand' (GRB 1 are used. The thematic data used, can be divided over different INSPIRE2-themes ranging from hydrography, protected sites, soil, land use and habitats, and biotopes (INSPIRE, 2007 and INSPIRE, 2011a).

## CHALLENGES

In essence, the use of GIS confronts the dpt. PHL-Bio with on the one hand a technological and organisational challenge and on the other hand with an educational challenge.

### Managing the data: a technological and organisational challenge

Today we use Blackboard[3], a file-based environment, to save the spatial data needed for the GIS-course and other related activities. This leads to typical problems concerning the multiplication, actualisation and authenticity of data.

Students of the first year are offered a set of spatial data needed for the GIS-course and their landscape project. In principle, these data are up-to-date and ordered from the Agency for Geographical Information Flanders (AGIV)[4]. However, once offered through Blackboard, students often keep on using these data in the following years without checking the version date or looking for the most recent metadata; the information also often gets mixed with new data from other sources (even without the metadata). Obviously, this 'bad practice' leads to problems of update and

[1] GRB: http://www.agiv.be/gis/ganaar.aspx?gtid=1
[2] INSPIRE = Infrastructure for Spatial Information in the European Community
[3] More information on Blackboard (in Dutch): http://icto.phl.be/node/112
[4] Agentschap voor Geografische Informatie Vlaanderen (www.agiv.be)

authenticity, even though, in fact, students easily have access to the metadata catalogue (website application) of AGIV[5], in order to check the metadata.

This poor data management confronts us with a technological and organisational challenge. We need to adapt our electronic data platform where we offer our students the GIS-information, so that we can counter the disadvantages of Blackboard. In the Blackboard students are enrolled to a course and hence they belong to a certain student group, they only have access to the information made available on this course platform. Once they download this information into their own computers, it remains there and can be used by them even after completing the course year, and so the information can get out-of-date. A possible solution so as to counteract the use of outdated information could be to create a separate access or course on Blackboard, available for all students (over the three years), that is managed by a single tutor, guaranteeing in this way a constant access to recent and authentic spatial information. Needless to say, the way the data are currently offered and managed needs to be redesigned. Yet, other solutions should also be explored in more detail.

### Further integration in the curriculum: an educational challenge

Another challenge lies in looking for a more solid and gradual implementation of GIS in the curriculum, spread over the three years of study.

Today, the study of GIS as a methodological tool is mainly situated in the first year. In the second and third year GIS does not constitute a course topic as such; it is merely implemented as course ‘material’ when needed to perform certain analyses or actions. For instance, for the creation of situation or thematic maps, during an internship as part of the graduation project, etc.; cf. supra. In other words, GIS attempts to disappear into the background in the second and third year, since it is not included as part of the final qualifications, defined for each course.

Given the (growing) importance of GIS on the work floor, this lack of prominence of GIS in the course material of our second and third year students needs to be tackled. GIS needs to be further implemented in the curriculum; it needs to be given a more prominent place, to assure a continuous learning path from first to third year, realising specific GIS-goals.

## FUTURE APPROACH

### Building an SDI for the dpt. PHL-Bio

As above mentioned the distribution and management of the digital spatial data needs to be redesigned. As a first step in finding a solution we should follow the principles of an SDI. An SDI consists in general of four components: institutional arrangements, creation and maintenance of spatial data, procedures for making spatial data accessible and the ways of facilitating the development of strategic technology and applications (Masser, 2007). Building an SDI for the dpt. PHL-Bio in fact implicates looking at the solutions that are offered by the SDI-Flanders collaboration framework (SDI-decree, 2009).

Within the Flemish region there is a 15 year old tradition of sharing spatial data without (or with very low) charges. A co-financing mechanism is used to buy data from third parties to reduce costs. This is the result of the close cooperation between the regional, provincial levels of government and the

[5] http://metadata.agiv.be/

municipalities. A legal framework for this cooperation to deploy and maintain an SDI - called GIS-Flanders - was put in to place in 1994 (GIS-decree, 2000).

Transposing the INSPIRE-directive (INSPIRE, 2007), the Flemish Parliament voted a decree (the SDI-decree) in 2009 in which GIS-Flanders was transformed in SDI-Flanders. SDI-Flanders represents a partnership between Flemish public authorities -local and regional- with the goal of optimizing the production, management, exchange, use and re-use of spatial information and services within and between these public bodies. Due to this new decree (higher) educational institutes have become a partner of SDI-Flanders and enjoy the advantages of full partnership.

Dealing with aspects of metadata, spatial data, authentic spatial data and services, the SDI-decree also defines the accessibility of these data and services. To facilitate accessibility of spatial data and services for the execution of public tasks, public authorities in Flanders have free access to them. This applies to data and services owned by those public authorities, as well as to data and services purchased from third parties (SDI-decree, 2009). In accordance with the SDI-decree, the Flemish governmental order of 10/9/2010, concerning the access and use constraints for the partners of SDI-Flanders, implies an administrative simplification because no contracts will have to be signed nor licenses to be clicked (Flemish governmental order, 2011).

The SDI-decree creates new opportunities for educational institutes in Flanders. Not only it facilitates the accessibility of spatial data available in the SDI-Flanders, free of charge, but it also offers the possibility to access data directly from the source by using services.

In search of a good technical solution for managing and distributing spatial data, the SDI-Flanders framework offers a good starting position: the availability of data and services is or will be guaranteed. The key milestones are defined by the European commission (INSPIRE, 2011b) and translated to the Flemish situation by the SDI-manual (AGIV, 2010) and SDI-plan (Flemish government, 2010). The Dpt. PHL-Bio will connect to the SDI Flanders. Yet, today only a few view services are available. So, in fact the data will still need to be downloaded (ftp) or delivered on a digital medium like a dvd.

We therefore need a short term solution. We plan to arrange our data in different themes on a specific server that will be available for students and other users in the dpt. PHL-Bio. Adding the metadata to the files as an xml-file will lead to an integration of the data and the metadata. An option to be explored is to separate the shapefiles from the layer files offering the latter to the users. This offers the flexibility to arrange the data thematically on the layer level and to organize it source- or data-based on the shape level, which makes updating data and searching for data easier. Adding an open source catalogue application like GeoNetwork (Geonetwork, 2011) makes it possible to offer a powerful search engine as well as a web map viewer and functionality for downloading data.

The long term solution could be implementing ArcGIS Server (Esri, 2011). This in fact is a very expensive solution. Other possibilities are open source solutions like PostGIS (Refractions Research, 2011) for building a spatial database for GIS. These options need to be explored further.

## Integrating GIS from start to finish

The existence of SDI-Flanders and the SDI-decree will help us to overcome in the near future the technological and organisational challenges we are confronted with. Moreover, they will lay the foundation of our mission statement for the future, on how we want to develop our GIS-education.

Assuring a continuous learning path from the first to the third year, realising specific GIS-goals, is essential in this development.

Whereas the GIS-course in the first year is focused on the acquisition of basic skills, the second year students can be taught how to integrate services in their GIS, by using the regional SDI-solutions. As such, students will be better prepared for future challenges on the work floor. The final and third year course could then be oriented towards a more thematic GIS-approach. This is also the year where the students do their internship and are confronted with real GIS-projects. For instance, we could set up an assignment where students can learn how to make an inventory of trees using a handheld GNSS[6] receiver or tablet pc.

This approach is necessary and justified when we look at what is expected of professionals in Green management. In fact a Green manager needs geospatial education focussing on the data mining expertise and the insight into what Geographic Information knowledge and skills are needed in their domain (De Bakker and Toppen, 2010).

## CONCLUSION - A MISSION STATEMENT FOR GIS-EDUCATION

Our main challenges lie in two aspects of GIS-education dealing with the content of the GIS-course and its integration in the curriculum on the one hand, and creating a good technological and organisational data solution for students as well as for the dpt. PHL-Bio on the other hand.

For this process we will need to elaborate a mission statement on how we want to overcome these challenges, offering concrete solutions for, on the one hand, multiplication, actualisation and authenticity of data and on the other hand, the distribution of GIS in the second and third year of the bachelor training.

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# Papers session 4:

# Formats of GI-education

# In-class or self-study of GI S&T? Five years of experience with FOSS4G in teaching GI S&T

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## ABSTRACT

In this paper we summarise the experiences which participants reported between 2007 and 2011 with respect to three short in-class training initiatives and two academic courses of the Supervised Self-Study (SSS) type, all dealing with Free and Open Source Software for Geomatics (FOSS4G) in the context of land evaluation and land use planning. The general findings are that (i) FOSS4G is equally appreciated as Commercial and Closed Source Software (CCSS4G), (ii) mature, graduate students prefer to be exposed with FOSS4G in a supervised self-study framework rather than with CCSS4G in a traditional class setting, (iii) the open source nature of FOSS4G is less important than its free character and that (iv) the transition from in-class study to supervised self-study is more important and will be more sustainable than the shift between CCSS4G and FOSS4G. To further elaborate the SSS, software independent tutorials for Geographic Information Science and Technology (GI S&T) may be a way forward. Software-specific materials will however be necessary to enhance education in GIS-software programming and geo-application development.

## INTRODUCTION

Over the last decades, both in the public and private sectors of society, Geographic Information Systems (GIS) have become major suppliers of information to support the preparation, justification, implementation, monitoring and adjustment of territorial policies, the management of property and infrastructure and related spatial decisions (Van Orshoven et al., 2011). Not surprisingly courses dealing with the science and technologies (GI S&T) underpinning the GISs are now firmly integrated in many higher education and vocational training programmes dealing with e.g., physical and socio-economic resources management, urban and regional planning or cadastral management. Such courses typically encompass theoretical and practical parts. In the latter students have the opportunity to put the theoretical concepts into practice and to acquire skills in using one or a number of GIS-software toolboxes and database management systems.

Until approximately 2005, almost all GIS-software used in education and training worldwide was of the commercial and closed source type. With the advent of the web 2.0, not-for-profit software development communities could develop, maintain and disseminate free and open source GIS-software (FOSS4G) of which the usability, user-friendliness and scope were and are continuously strengthened. Today many FOSS4G are available and are increasingly challenging the Commercial and Closed Source Software for Geomatics (CCSS4G), not only in education but also in other types of professional practice (Steiniger and Bocher, 2009).

The fact that most FOSS4G is not only licensed 'with freedom' but is also distributed as 'freeware' is of course an interesting feature for use in education, both for the educational institution and for the students as well. Institutions do no longer have to pay for CCSS4G-licences to equip computer class rooms. In this case students have the disposition of sufficiently powerful desktop or laptop computers and of sufficiently broad internet connectivity, institutions can even abandon the class rooms since students can work at home on their own computers using the free software. The latter approach requires that instructions, data, advice and feedback are made available by the instructors via an internet-based educational platform allowing for two-way communication. Moreover the open source nature of FOSS4G allows for advanced education and training in software analysis, evaluation and development.

Whereas literature is not so clear about the magnitude of the spread of the distance learning and self-study approaches, it is a fact that FOSS4G is increasingly used in formal and less formal education about GI S&T. Several papers do indeed report, mostly in positive terms, about such initiatives (e.g., Chen et al., 2010; Scholz et al., 2011). What is mostly missing however is data about the student's appreciation of the shift from CCSS4G to FOSS4G.

In this paper we summarise the experiences reported by regular and occasional students at K.U.Leuven over the five year period during which we have used FOSS4G in teaching GI S&T both in-class (TA, Traditional Approach) and through supervised self-study (SSS). Moreover we try to summarise these experiences in a number of statements which we present for further discussion and amendment.

The first experiences were reported in 2007 when we conducted a first short training initiative (STI) dealing with desktop FOSS4G, accommodating participants coming mainly from developing countries. This two week summer school was repeated in 2008 and 2009 with more focus on the training of trainers and addressing increasingly the concepts and components of spatial data infrastructures, in addition to the desktop GIS-functionalities. The training materials initially developed for these STI were later extended and fine-tuned for use in introductory and advanced academic GI S&T courses (AC) in the academic years 2009-2010 and 2010-2011. Whereas the STI were conducted according to a more or less traditional in-class approach, the academic courses were set up in a supervised self-study spirit.

## MATERIALS AND METHODS

### Courses

Short training initiatives

The characteristics of the STI conducted in 2007, 2008 and 2009 are summarised in Table 1. As a reference, the table also includes the description of an STI conducted in 2005, focusing desktop GIS-functionalities of CCSS4G for land evaluation and land use planning.

Academic courses

In the 1st semester of the academic years 2009-2010 and 2010-2011, FOSS4G was used in the practical part of both an introductory and an advanced course on GI S&T. Both practices were organised in a supervised self-study approach (SSS). Moreover in 2010-2011, a CCSS4G-based variant of the introductory practical was simultaneously organised in a traditional class setting.

Table 1: Characteristics of the Short Training Initiatives

| | 2005 | 2007 | 2008 | 2009 |
|---|---|---|---|---|
| Title | GIS and Earth Remote Sensing for physical land evaluation | Land evaluation with Free and OpenSource geomatics tools | Free and Open Source geomatics tools for land evaluation and land use planning | Free and Open Source geomatics tools for sharing and processing of spatial data for land evaluation and land use planning |
| Period | 20-jun-05 to 2-jul-05 (12 class days) | 27-aug-07 to 7-sep-07 (10 class days) | 18-aug-08 to 29-aug-08 (10 class days) | 27-jul-09 to 7-aug-09 (10 class days) |
| Type | Train-the-User | Train-the-Trainer | Train-the-Trainer | Train-the-Trainer |
| Total n° of participants | 15 | 20 | 23 | 21 |
| N° of scholars | 12 | 11 | 12 | 12 |
| Structure | Module 1 (6 days): Basics of GIS and its application in physical land evaluation<br><br>Module 2 (6 days): Basics of remote sensing for GIS and its application in physical land evaluation | Module 1 (5 days): Concepts and functions of GIS for land evaluation; Using FOSS4G QGIS and its GRASS-plugin<br><br>Module 2 (5 days): Concepts and functionalities of remote sensing and image processing; Using FOSS4G GRASS | Module 1 (4 days): QGIS and its GRASS-plugin as a FOSS4G-tool for land evaluation and land use planning: Module 2 (3 days): GRASS as a FOSS4G-tool to integrate remotely sensed data in GIS for land evaluation and land use planning<br><br>Module 3 (2 days): Customising QGIS-software<br><br>Module 4 (1 day): Evaluation of FOSS4G-solutions | Module 1 (7 days): FOSS4G-tool for processing geospatial data in the context of land evaluation and land use planning<br><br>Module 2 (3 days): FOSS4G-tools for sharing geospatial data |
| Software | ArcGIS 8.3<br>ERDAS-Imagine 8.6 | Quantum GIS 0.8.1 'Titan'<br>GRASS 6.2.2 | Quantum GIS 0.11.0 'Metis'<br>GRASS 6.3.0.4<br>MS4W 2.2<br>Python 2.5 | Quantum GIS 1.0.2 'Kore'<br>GRASS 6.4.0svn<br>PostgreSQL 8.3.7-1<br>PostGIS 1.3.6 |
| Geodatasets covering | Various sub-regions in Belgium | Tabacay river basin in the southern Andes of Ecuador | Tabacay river basin in the southern Andes of Ecuador | Tabacay river basin in the southern Andes of Ecuador |

Table 2: Characteristics of the academic courses: (A) points to the introductory course in which FOSS4G is used in a supervised self-study approach, (B) is the in-class introductory course with CCSS4G and (C) is the advanced supervised self-study course with FOSS4G

| Academic year | 2009-2010 and 2010-2011 (A) | 2010-2011 (B) | 2009-2010 and 2010-2011 (C) |
|---|---|---|---|
| Type of course | Introductory – FOSS4G/SSS | Introductory – CCSS4G/TA | Advanced – FOSS4G/SSS |
| Number of ECTS | 4 of which 1 for the practical learning activity | Idem as (A) | 3 of which 2 for the practical learning activity |
| Overall objectives of the practical learning activity | - Acquire skills with one GIS-software package<br>- Acquire a capability to apply these skills in a number of case studies related to physical geography and land management | Idem as (A) | - Acquire profound understanding of database concepts for modeling geographic reality and for analysis of geodata<br>- Acquire a capability to apply these techniques independently |
| Target audience | Bachelor students in Land and Forest Management and Biology | Bachelor students in Geography, Geology, Archeology | Master and post-Master students in Earth Observation, Geography, Land and Forest Management |
| Time available for practical learning activity | 7 weeks | Idem as (A) | Idem as (A) and (B) |
| Evaluation | 4 assignments<br>- 2 related to spatial multi-criteria analysis<br>- 1 related to geodata quality assessment<br>- 1 about geodata editing | 2 assignments + 'practical question' included in theoretical exam | 2 assignments<br>- Conversion of file-based geodatasets into an object-relational database<br>- Exploitation of this database by means of SQL and geoSQL |
| Advice and Feedback | - Weekly possibility for meeting with tutor + e-mail support during first 4 weeks.<br>- Collective feedback after 7 weeks; Individual feedback on demand | - 6 in-class sessions, organised and supervised by teaching assistant<br>- No work outside class expected | - Weekly possibility for meeting with tutor + e-mail support during first 4 weeks<br>- Collective feedback after 7 weeks; Individual feedback on demand |
| Software used | Quantum GIS, GRASS, R | IDRISI | PostgreSQL/PostGIS, Quantum GIS |

## Questionnaire surveys and data processing

### Short Training Initiatives

At the end of each module of each STI, participants were given the opportunity to express appreciation, evaluate utility and usability and formulate points of attention. They were asked explicitly whether they envisaged to re-use the course materials in their professional educational, research or business practice. At this stage no distinction was made between the re-use of software, data or documents.

Early 2009 all participants of the first three STI were sent by e-mail a follow-on questionnaire, enquiring about the effective use made of the materials since the end of the training. In January-2010, a similar but internet-based questionnaire was offered to all participants of all four STI. In these follow-on questionnaires, separate questions were asked by module about software, data and documents and a distinction was made between scholars and other participants.

The particular timing of these questionnaires leads to the set-up, displayed in Table 3 (Van Orshoven and Wawer, 2010):

Table 3: Number of months between end-of-STI and survey (a) and year of survey at 0, 5, 17 and 29 months after the end of the STI (b)

(a) EoT = At end of STI

| Survey → | EoT | 2009 | 2010 |
|---|---|---|---|
| STI ↓ | | | |
| 2007 | 0 | 17 | 29 |
| 2008 | 0 | 5 | 17 |
| 2009 | 0 | NA | 5 |

(b) EoT = At end of STI

| Survey → | 0 | 5 | 17 | 29 |
|---|---|---|---|---|
| STI ↓ | | | | |
| 2007 | EoT_2007 | NA | 2009 | 2010 |
| 2008 | EoT_2008 | 2009 | 2010 | NA |
| 2009 | EoT_2009 | 2010 | NA | NA |

The data resulting from the questionnaire surveys were processed by means of frequency analysis and other descriptive statistics. No hypotheses were statistically tested.

Academic courses

A web-based questionnaire addressing all students participating in the introductory and advanced courses of 2009-2010 was conducted in January 2010. A similar questionnaire was offered to the IC and AC-students of 2010-2011 in January 2011. Toledo, the K.U.Leuven educational e-learning platform, hosted the questionnaire. This platform allows tutors to create an active learning environment by providing learning materials, assignments and feedback to students. Moreover, students can submit assignments, communicate with the tutor or with peer students, and share documents through the platform. Both surveys contained a wide variety of question types. The surveys were anonymous but participation of students was tracked.

The particular set up of the IC and AC (Figure 1) as organised in 2010-2011 allowed for four comparisons to be made and analysed based on data provided by the survey (Hubeau et al., 2011a):

- Analysis 1: The comparison of the IC-students' appreciation of the TA-teaching method on the one hand and the SSS-method on the other hand;
- Analysis 2: The comparison of the appreciation of SSS by undergraduate students on the one hand and graduate students on the other hand;
- Analysis 3: The comparison of the appreciation of SSS by students with previous SSS-experience on the one hand and those without such experience on the other hand;
- Analysis 4: The comparison of the students' appreciation of CCSS4G on the one hand and FOSS4G on the other hand.

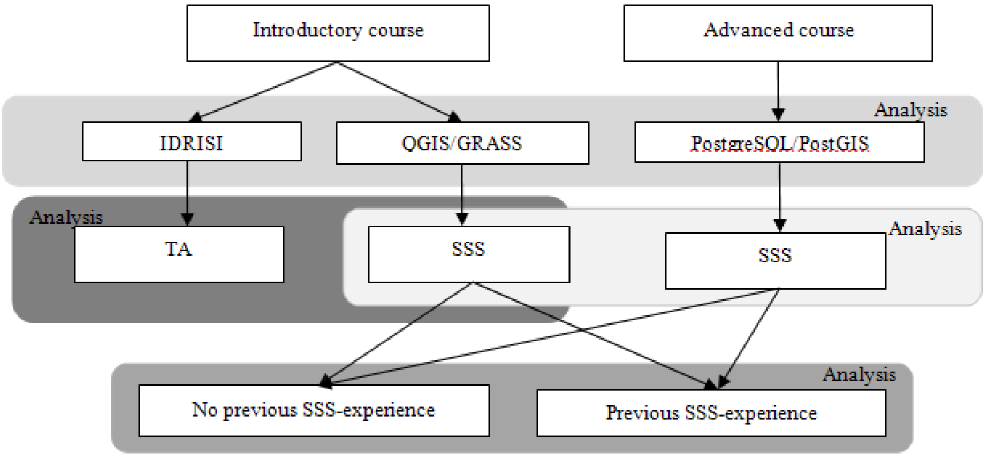


Figure 1: Set up of the introductory and advanced courses in 2010-2011 with overview of analyses made

Since the data are ordinal of nature, the non-parametric Mann-Whitney test was used to assess the difference of scores between groups.

## Publications and synthesis

More details about the set-up of the various training initiatives and academic courses, about the student characteristics and the questionnaire surveys, the responses and the results extracted from them, have been presented and discussed in the conference papers listed in Table 4. In these papers we reported our findings about the student's appreciation of the STI/TA-combination and the academic courses/SSS-combination without taking an integrated view. In this paper we first repeat the major partial findings and then try to integrate them in what could be called an intuitive meta-analysis.

Table 4: Publications related to the conducted questionnaires

| # | Subject | Reference to publication |
|---|---|---|
| (1) | STI 2007 & 2005 | Abu el Nasr, A. and J. Van Orshoven, 2008. CSS or FSS for education in GIS? Proceedings of the 11th AGILE International Conference on Geographic Information Science 2008, held at the University of Girona, Spain, 5-8-may-2008. CD-ROM: 73_DOC.pdf and http://plone.itc.nl/agile_old/Conference/2008-Girona/PDF/73_DOC.pdf : 9 p. |
| (2) | STI 2005, 2007 & 2008 | Van Orshoven, J., R. Wawer and K. Duytschaever, 2009. Effectiveness of a train-the-trainer initiative dealing with free and open source software for geomatics. CD-ROM-proceedings (J.-H. Haunert, B. Kieler, and J. Milde, eds. (2009)) of the 12th AGILE International Conference on Geographic Information Science (2009), Hannover, Germany, 2-5-june-2009, IKG, Leibnitz Universität, ISBN 2073-8013. |
| (3) | STI 2007, 2008, 2009 | Van Orshoven, J. and R. Wawer, 2010. Effectiveness Over Time of a Short Training Initiative Related to Free and Open Source Software for Earth Image Processing. Book of abstracts of the 30th Symposium of the European Association of Remote SEnsing Laboratories in Europe on Remote Sensing for Science, Education and Culture, held in Paris, France, 31-may – 3-jun-2010: p. 245. Available at http://www.earsel.org/symposia/2010-symposium-Paris/Abstract-Book.pdf . |

| | | |
|---|---|---|
| (4) | Academic courses 2009-2010 | Van Orshoven, J., K. Verbeeck and S. Heremans, 2010. Attitude of undergraduate and graduate students to free and open source software for geomatics in a supervised self-study context. Proceedings of the 13th AGILE International Conference on Geographic Information Science - Geospatial Thinking. ISBN: 978-989-20-1953-6 (Marco Painho, Maribel Yasmina Santos and Hardy Pundt (eds.)). Available at http://plone.itc.nl/agile_old/Conference/2010-guimaraes/PosterAbstracts_PDF/90_DOC.pdf |
| (5) | Academic courses 2010-2011 | Hubeau, M., K. Verbeeck, S. Heremans, A. De Meyer and J. Van Orshoven, 2011a. Self-study or in-class study of geographic information science and technology: the student's perspective. Proceedings of the EDULEARN11 International Conference on Education and New Learning Technologies, Barcelona, Spain, 4-6-July-2011. http://library.iated.org/view/HUBEAU2011SEL. 2872-2881. |

## Summary of partial results

(1) The comparison of experiences with FOSS4G on the one hand and CCSS4G on the other hand in the STI offered to participants from developing countries in 2007 resp. 2005 showed a better overall participant satisfaction with the former. But since the design of the FOSS4G-training was more oriented towards self-learning and self-helping than its CCSS4G-counterpart, it could not be concluded that the observed difference in satisfaction was related to the inherent generic characteristics of FOSS4G as compared to those of CCSS4G. Back in 2008 we believed however that FOSS4G-technology had already reached a level of maturity which enabled the -at least-partial substitution of CCSS4G in geo-awareness raising, general purpose GIS-training and also in basic academic GIS-education. We stated that for more advanced education, CCSS4G kept the advantage of meeting more closely the direct requirements of the labour market while FOSS4G might offer more incentives for students to explore and develop creative solutions beyond the algorithms found in CCSS4G.

(2) Although almost every participant confirmed at the end of the STI of 2007 and 2008 the intention and readiness to re-use the distributed documents, data and software in his or her educational, research or other professional practice, the effective re-use of these materials was much more limited 40, 17 resp. 5 months after the end of STI. CCSS4G had almost not been used mainly due to the lack of access to this type of software. The re-use of FOSS4G was more pertinent though. A majority of the responding scholars was using the FOSS for self-study but some also had incorporated them in teaching and training programmes. No projects were reported in which additional software code was developed. Documents accompanying the softwares and explaining and illustrating concepts had been re-used more than the software sensu stricto, especially where it regarded FOSS4G. Hence, joint availability of software and documentation seemed to foster re-use more than when the software was not easily available (CCSS4G). Documents had been used mainly for personal reference. Only a limited number of attempts were made to adapt and re-use them in local teaching and training. Logically, the geodatasets used during the training were re-used only for enhancement of the software skills. We concluded (in 2009) from these experiences that the effectiveness of a train-the-trainer or train-the-user initiative geared towards the developing world was modest but that the availability of both (FOSS4G) software and accompanying materials after a course had clearly lead to more intensive re-use than when only documents supporting the use of otherwise not distributed CCSS4G would have been available.

(3) For all of the STI of 2007, 2008 and 2009, the survey results of 2010 showed that at the end of the courses, a majority of the participants intended to take the step to FOSS4G in their professional practice including teaching, but that a relatively small fraction of the responding participants had effectively done so. This fraction had increased with time though, from 15% for the 2009-participants, 40% for those of 2008 to 50% for the participants of the 2007-edition. Adoption and –in most cases- adaptation of the distributed documents and presentations had been much higher and more immediate (86% for 2009, 100% for 2008 and 62.5% for 2007). This was explained by the fact that documents and presentations were and remained useful also in combination with other software, not necessarily FOSS, and even without concurrent use of software. The distributed geodata were re-used less than the documents but considerably more than the software (57% for 2009, 80% for 2008 and 62.5% for 2007). The interpretation (in 2010) of these figures was that the data (covering a watershed in the Andes region in Ecuador) are re-used with other software than the ones used in the STI and that re-use was high even though the datasets do not cover the participants' territories of interest. Overall, the effectiveness of the train-the-trainer initiatives was judged to be considerable but it was found surprising that the further use of the FOSS was weak compared to documents and data. On the other hand, effectiveness was stable as far in time as the surveys could reveal and was even increasing with time. It was clear though that participant's initial intentions were far too optimistic regarding further use of FOSS and training materials and that there was a time lag of several months before those who stuck to their intentions, eventually put them into practice. It was concluded that effectiveness of such courses should be measured at appropriate times after the initiative. Other encouraging findings were that 36% (2009), 50% (2008) and 75% (2007) of the responding adopters of the FOSS4G had become active members of one or more internet-based FOSS-user communities. In addition 50% (2009), 50% (2008) and 75% (2007) of the responding participants stated that they had become more aware of the spatial data infrastructure initiatives in their countries and regions.

(4) From the survey among graduate and undergraduate students of 2009-2010, it was inferred that the availability of FOSS4G clearly facilitated the introduction of the supervised self-study approach in academic education related to GI S&T. Mature, graduate students such as Master and post-Master-students did indeed express clear appreciation for this combination of SSS and FOSS4G in an advanced course. Undergraduate students were more reluctant though. They seemed to prefer a more traditional in-class format with the presence of an experienced teaching assistant. As a possible explanation, the undergraduate students' lack of experience to autonomously handle less-than-perfect software in an efficient way and their lack of experience and self-confidence to tackle assignments independently were put forward. These results were encouraging to continue exposing graduate students to FOSS4G in the SSS-spirit. For undergraduate students, the question was asked whether a return to the traditional in-class format was necessary or whether the provision of even more strict tutorials, software installation instructions and answers to frequently asked questions could result in higher student's appreciation.

(5) The survey among students in the academic courses of 2010-2011 enabled to compare traditional in-class-study and supervised self-study. The overall students' attitude was positive towards both approaches. The students reported strengths and weaknesses about the two teaching approaches. Students who followed the SSS-approach agreed that human support, advice and feedback were sufficiently available indicating that it had been possible to overcome the possible drawback of insufficient support by organising non-compulsory feedback sessions, managing a discussion board and giving feedback through e-mail. The availability of FOS-software clearly facilitated the introduction of SSS. Although, graduate students like master and post-master

students appreciated the SSS-approach more than bachelor students (undergraduate), undergraduate students certainly did not dislike learning and working in an SSS-environment. Another factor that facilitated the introduction of the SSS-approach was the increased reliability and standardisation of the used FOS-software. The undergraduate and graduate students had a very positive attitude towards the used FOSS4G (QGIS, GRASS and R). Also the students using FOSS4G had more intention to reuse the software than those having worked with CCSS4G. Although these results indicated the increased reliability and availability of FOS-software, they were obviously case specific and it would have been inappropriate to make strong conclusions. Nevertheless, these results were interpreted as a stimulus to recommend the implementation of the SSS-approach using FOSS in other software-based courses thereby facilitating the achievement of secondary objectives like the acquisition of problem-solving skills related to software installation, management of hardware and operating system and coping with lack of system and data interoperability.

## INTEGRATED DISCUSSION AND PERSPECTIVES

By integrating the partial observations, conclusions and recommendations listed in the previous section and by considering recent evolutions in the FOSS4G-domain, we come to the following statements which we present for further discussion and amendment:

(1) SSS combined with FOSS4G is a strong option for educational programmes of GI S&T, especially when geared towards more mature students. The factor determining the success is the transition from TA to SSS rather than the shift from CCSS4G to FOSS4G. Advanced students have a very positive attitude towards SSS while FOSS4G and CCSS4G are equally appreciated;

(2) It is envisageable that in the near future SSS will be combined not only with FOSS4G but also with CCSS4G. Commercial GIS-software vendors are indeed adapting their pricing policies towards educational institutions as a result of the increasing competition with FOSS4G. CCSS4G for use in education is becoming cheaper through the promotion of free, short duration trial versions and campus-wide, server-based licenses;

(3) Today it is the freeware dimension of FOSS4G rather than its open source character which is the major contributor to its popularity. The open source character of FOSS4G is underexploited in GIS-education. No educational initiatives have been reported in which FOSS-code is studied and edited;

(4) Already today, CCSS4G contains, integrates or connects to FOSS-components. For example, ESRI's ArcGIS (CCSS4G) is capable of processing data held in PostGreSQL/PostGIS-(FOSS4G) databases. We expect that the scope and extent of such hybrid software packages and combinations will but increase which will lead to a continuous transition field between CCSS4G and FOSS4G and to a wide variety of applicable license types and conditions for use;

(5) Measuring the effectiveness of education and training is not an easy issue. In addition to the level of acquisition of knowledge and skills, also the attitude of the students towards the educational approach must be assessed. Moreover it must be taken into account that incorporation in professional activities of knowledge, skills and attitudes gained in a training, may lag months to years behind.

To further address the first statement we are now in the process of adapting our SSS/FOSS4G-course materials for true distance learning where no physical interaction at all is possible between student and tutor and among students. In the same rationale we are also developing software-independent versions of the course materials (Hubeau et al., 2011b). During the running academic year 2011-2012, all these materials are being tested in a introductory academic GI S&T course. They will also be used in a new STI which will be held in the summer 2012. Whereas few data are available yet about the student's appreciation of these more pronounced SSS-developments, we already anticipate stating that it must be possible to offer high quality practical GI S&T-education which is not only independent of time and location but also of software. The latter means that students could select themselves one or more GIS-softwares (CCSS or FOSS) of which the functionalities are in line with the guidelines and conceptual, software-independent requirements set out in the tutorials. We believe that in this way the learning experience of students will be brought to a higher and more generic level. We will test this hypothesis by comparing the performance of two groups of students, one having taken the software-independent tutorial and assignments and the other one having worked through the Quantum-GIS-tutorial and assignments, when faced with a third GIS-software not used at all for the tutorials. A question we have not addressed so far is to what extent the content of the software-based or software-independent training packages must be adapted to the type of programme it is intended to fit in, e.g. academic, higher non-academic, secondary school, vocational, ….

## ACKNOWLEDGEMENTS

The authors sincerely thank all other contributors to the FOSS4G-self-study materials, in particular Rafal Wawer, Ludo Engelen, Ahmed Abu El Nasr, Donna Tabangin, Bert Meeus, Klara Duytschaever, Ben Savelkoul, Klaartje Verbeeck and Stien Heremans. They are all current or former collaborators, scholars or students at either the Spatial Applications Division, the Division Forest, Nature Landscape or the Raymond Lemaire International Center for Conservation of K.U.Leuven. The University Development Cooperation section of the Flemish Interuniversity Council (VLIR-UOS) is gratefully acknowledged for supporting the five short training initiatives. Finally, we thank sincerely the educational policy service of K.U.Leuven for funding the educational project LeGIO (Leuven Geografisch Informatie Onderwijs) in the context of which this paper was elaborated. Koenraad Van Balen is acknowledged for the inspiring co-promotorship of the LeGIO-project.

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# EuroSDR e-learning courses for European Mapping Agencies

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## ABSTRACT

EduServ is the Education Service of EuroSDR - a European spatial data research organisation addressing the needs of Geospatial Information (GI) provision in Europe through its national mapping agencies (NMAs).

In order to transfer the outcomes of research activities to users, e.g. to key personnel in GI production organisations and industry, EuroSDR commenced EduServ, a series of e-learning courses based on its research activities. The Internet courses, which are preceded by a two-day seminar, are designed to include practical assignments - manipulating data or processes, evaluating the consequences and drawing reasoned conclusions. NMA participants come from diverse educational and cultural backgrounds and are not required to possess any formal academic or personal qualification to avoid imposing barriers to accessing this type of educational resource. Although NMA staff represents one key target group, participants from the academic and private sectors are also frequently enrolled.

Bringing course participants together from many European countries and from a variety of working backgrounds generates a synergy which results in fruitful exchange of experience and, in itself, begins a forum for the inter-state exchange of ideas on the practical implementation of technologies and methodologies covered by the courses.

Addressing the issue of capacity building and skills updating in those European states without a comprehensive GI education resource (but where considerable training in GI fields is still required) is seen by EuroSDR as a major challenge. Other challenges include (i) achieving a practical 'learning by doing' element to Internet-based courses in technical areas; (ii) providing timely and effective learner/learner and learner/teacher communication; (iii) evaluating the performance of the participants in a reliable manner and providing effective feedback; and (iv) enhancing the learning experience. This is particularly so in light of a series of recent EC Directives that impact on spatial data and GI.

## INTRODUCTION

EuroSDR (European Spatial Data Research) is an organization, established as OEEPE (Organisation Européenne d'Etudes Photogrammétriques Expérimentales) in 1953 by signature to an International Treaty ratified by the governments of five European countries. It is a spatial data research organisation that brings national GI production organisations from European countries together with research institutes and industry (Heipke et al., 2009).

EuroSDR currently has seventeen member states represented by delegates from a GI production organization and a Research Institute or University (Figure 1).

Figure 1. Member States of EuroSDR

Staff of NMCAs (National Mapping and Cadastral Agencies) are faced with the need to become proficient in the use of new technologies, particularly at the spatial data acquisition side of the GI production process, new requirements in the area of data structures, management and delivery, and new user demands in relation to currency and fitness for purpose. This is particularly the case nowadays with the need to offer services compliant with the emerging spatial data infrastructures.

There is a constant need for the updating of skills of NMCA staff and many have identified CPD as an area of priority and spend significant percentages of annual salary budgets on training and development (Martin et al., 2003). Traditional sources of CPD are not always appropriate. Such sources include

- in-house short courses or seminars directed at small groups of key staff,
- distance-learning modules from ‘Open’ Universities, and/or
- limited study leave for individual courses.

However, it is often found that these traditional CPD methods of training are not practical in a busy working environment due to

- disruption to the organization when short courses are held for large numbers of personnel,
- inadequate dissemination of information provided by in-house seminars,
- difficulties in accessing various courses due to location, as travelling often impinges on work time, and
- difficulties experienced in sourcing relevant CPD courses.

E-Learning may, therefore, be seen as a more flexible training model, particularly in the technical area of GI provision. Of course E-Learning courses are available from the traditional university sources. However, university courses may require significant time to update and validate and may, therefore, not be responsive to delivering CPD in a timely manner in a topic area that may have a very short shelf life, such as research outcomes in specialist areas.

The ultimate aim of EuroSDR is to address the research needs of GI provision, management, delivery and utilisation across Europe. Extensive applied research projects and focussed workshops are undertaken and the results published in the official EuroSDR publications series, of which the 60th publication will be distributed this year.

Publication of research and workshop reports is, in itself, not sufficient to attain the necessary goal of transferring the outcomes of EuroSDR research activities from the research to the user domain, in other words to key personnel in the GI production organisations and the user community. The impact of EuroSDR research is lessened if the results and outcomes are not translated into the GI production process.

To address these concerns EuroSDR commenced its education service (EduServ) in October 2002, an annual series of short distance E-Learning courses based on specific research projects or on the recommendations of workshops (Mooney et al., 2007).
The results of these research projects are learnt in depth with the goal that new technologies and methods are ultimately used by the national mapping agencies, private firms and universities of the member states. A EuroSDR task force organizes the educational service for each year. It selects the topics and the teachers of the courses. The teachers are recruited from the group of EuroSDR project leaders or from universities who have experience of the selected topic and E-Learning.

EduServ-9, the most recent module consisted of four two-week courses that ran consecutively from April to June 2011. Hosted by Ecole Nationale des Sciences Géographiques (ENSG), France, the courses attracted twenty-three participants from fifteen organisations in twelve countries.

## THE EDUSERV-CONCEPT

Annual EduServ programmes consist of short (usually two-week) consecutive Internet-delivered E-Learning courses, which are linked to the research activities of EuroSDR. They require approximately thirty hours of work (both online and offline) from the participants per course. Participants follow the courses remotely via the Internet either from their place of work or from home. On successful completion of all assignments and the submission of a detailed course evaluation feedback questionnaire, participants receive a signed 'Certificate of Completion' from EuroSDR.

### Pre-Course Seminar

Participants frequently have very different technical backgrounds. In most cases, they are professionals of European national mapping agencies, but some come from private firms as well as university students. E-Learning is unknown to many of the participants and cultural differences in the relationship between teacher and participant may exist. Therefore, the courses are preceded by a two-day seminar at which the participants meet with the course teachers and receive all necessary instruction and guidance to allow them follow the courses from their own organisations.

### Learning by Doing

Courses are designed to follow the principle of 'Learning by Doing' and therefore include practical assignments which require, for example, the participant to manipulate data or processes, evaluate the consequences and draw reasoned conclusions. It is generally accepted that active learning produces better results than purely passive learning (Arrow, 1962).

This represents a significant challenge to the course designers. In the course 'Co-ordinate Reference Systems and Transformations for Spatial Data Position' (Table 2), for example, use was made of Microsoft Excel worksheets where participants could experiment with four-, six- and seven-parameter transformations to investigate the characteristics of the transformation, the effect of redundancy and the influence of gross errors. In the course 'Positional Accuracy Improvement in GI Databases' interactive Flash exercises were developed where participants could move vectors into 'improved' positions and evaluate and report the knock-on consequences. Further examples include the issuing of temporary licenses to participants allowing them to apply relevant software to process data sets for camera calibration or to manipulate laser scanned data.

## Enhancing the Learning Experience

Participants come from diverse educational and cultural backgrounds and are not required to possess any formal academic qualification because it is important not to impose barriers to accessing this type of educational resource. However, participants must possess a working competence in IT. The pre-course seminar helps to identify and remedy weaknesses in this area.

In order to gain knowledge from E-Learning courses the learner must find them stimulating and enjoyable. The two-day pre-course seminar is carefully designed to include a social element to give participants time to relax and get to know course tutors and fellow participants. Background presentations on each course topic are presented in a semi-formal manner. In other words, whereas the presenter will use standard conference-typical delivery methods, frequent interruptions with questions and clarifications are encouraged. In this way the participant is helped to feel part of the EduServ process.

During the course, the participant has access to a range of material, some online and some offline. Frequent use of the internal conferencing facilities of the E-Learning platform helps to inform the learner of progress and give encouragement where necessary. The correct balance of content and assignments is essential in enhancing the learning experience. The degree of difficulty of the assignments should increase gradually from the first to the last and be of such complexity that extends the learner without requiring too onerous a commitment within an already busy work schedule. Since 2009, all EduServ courses are served from the Open Source platform, Moodle, hosted by the Dublin Institute of Technology, Ireland. In this way, participants following more than one course have only to become familiar with one learning platform.

## Sharing Experiences

Bringing course participants together from over ten European countries and from a variety of working backgrounds generates a synergy which results in fruitful exchange of experience. Organizers have noticed a significant unanticipated benefit of the pre-course seminar, that of providing a forum for the inter-state exchange of ideas on the practical implementation of methods covered by the courses. This, in turn, informs the course tutors of the practical realization of theory in busy GI production environments, which can only improve the effectiveness of current and future course development.

### Accessing Experts

EuroSDR, by its nature, brings delegates from GI production and user organizations together with GI researchers and experts. It is a natural philosophy of EduServ, therefore, that course participants should enjoy effective access to course tutors. All course tutors are invited to participate in the pre-course seminar including the social events. For mid-career staff following CPD courses, there is often a perceived barrier between them and the so-called experts in the field. This barrier is intended to be removed in EduServ. Participants are encouraged to ask as many questions as they need of tutors throughout the course in order to maximize their understanding and gain maximum benefit from participation. Course tutors, generally invite participants, where practical, to maintain this contact long after the EduServ courses have finished.

### Establishing Contacts

Course participants are encouraged to exchange contact details, thereby becoming part of a network, which they can utilize in the future as appropriate. The effectiveness of this has not yet been monitored by EuroSDR and represents an interesting exercise to be undertaken by the taskforce in its regular reviews of EduServ. Anecdotal evidence suggests that such contacts are difficult to maintain in the context of busy and changing working environments.

## STRUCTURE OF EDUSERV

### The EduServ programmes

The tenth annual EduServ programme will commence in March 2012 with a pre-course seminar at the Dublin Institute of Technology in Ireland. At that stage, pre-course seminars and overall programme management will have been hosted by nine different organisations (Table 1) and twenty courses delivered (Table 2).

Table 1: EduServ Host Organisations

| Year | Host Organisation | Country |
|---|---|---|
| 2002 | Aalborg University, Aalborg | Denmark |
| 2004 | Budapest University for Technology and Economics, Budapest | Hungary |
| 2005 | Dublin Institute of Technology, Dublin | Ireland |
| 2006 | ITC, Enschede | The Netherlands |
| 2007 | Charles University, Prague | Czech Republic |
| 2008 | University of Applied Sciences, Stuttgart | Germany |
| 2009 | Norwegian University of Life Sciences, Ås | Norway |
| 2010 | KU-Leuven, Leuven | Belgium |
| 2011 | ENSG, Paris | France |
| 2012 | Dublin Institute of Technology, Dublin | Ireland |

Details of the designers and teachers of these courses, together with the years in which they were included in EduServ programmes and the number of participants, are given in Table 2.

Table 2: EduServ Courses, Centres, Years Delivered and Student Numbers

| Course Title | Centre | Years | No.s |
|---|---|---|---|
| Integrated Sensor Orientation | University of Hannover | 2002, 2004 | 14, 16 |
| Automatic Orientation of Aerial Images on Databases | Aalborg University | 2002, 2004 | 14, 18 |
| Laserscanning & Airborne Interferometric SAR | ITC, Enschede | 2002, 2004 | 14, 14 |
| Digital Cameras/Sensors | Ohio State University | 2004, 2005 | 16, 15 |
| Co-ordinate Reference Systems and Transformations for Spatial Data Position | Dublin Institute of Technology (DIT) | 2005, 2006 | 12, 11 |
| Positional Accuracy Improvement in GI Databases | Ordnance Survey GB; TU-Berlin; DIT | 2005, 2006 | 13, 12 |
| Quality of Geospatial Data and Related Statistical Concepts | ITC, Enschede | 2006, 2007 | 15, 13 |
| Quality Control of DTMs | Aalborg University | 2006, 2007 | 10, 21 |
| Mapping with SAR | TU-Berlin | 2007, 2008 | 14, 18 |
| Laserscanning for 3D city models | Finnish Geodetic Institute | 2007, 2008 | 18, 24 |
| CityGML | TU-Berlin and University of Gävle | 2008, 2009 | 20, 11 |
| Geometric performance of digital airborne cameras | Institute for Photogrammetry (ifp), Stuttgart University | 2008, 2009 | 25, 15 |
| Schema matching, mapping and transformation for INSPIRE | University of Gävle | 2009, 2010 | 9, 34 |
| Laserscanning for Tree Extraction | Finnish Geodetic Institute | 2009, 2010 | 9, 9 |
| Assessment of the quality of Digital Terrain Models | Aalborg University and Charles University | 2010, 2011 | 12, 10 |
| The INSPIRE Directive and its Implementing Rules | K.U.Leuven | 2010, 2011 | 22, 12 |
| Geodetic Reference Systems | IGN France / LAREG | 2011, 2012 | 6 |
| 3D Urban Modelling | IGN France / MATIS | 2011, 2012 | 10 |
| Radiometric performance of Digital Photogrammetric Cameras and Laser Scanners | Finnish Geodetic Institute and Vienna University of Technology | 2012 | |
| Open Standards & Open Source WebMapping | ITC – University of Twente | 2012 | |

The courses, while targeted at European countries (in particular NMCAs), are advertised and followed widely, which is evident in the countries of origin of participants: Austria, Belgium, Cyprus, Denmark, Greece, Hungary, Ireland, Italy, Latvia, (The) Netherlands, Norway, Oman, South Korea, Sudan, Switzerland, Turkey and United Kingdom.

An evaluation of the effectiveness of EduServ courses is possible due to the requirement that participants must submit completed quality-assurance (QA) questionnaires prior to receiving their certificates. In general terms, participants have felt that the courses are useful, and most respondents indicate that the goals of the courses are achieved. Course material is appreciated and additional hardcopy material is found to be useful. The combination of the introductory seminar and E-Learning was regarded as positive by about 70% of respondents and a similar percentage indicated that they would participate in further courses.

**EduServ-9**

The most recent EduServ programme – EduServ-9 – took place during the spring of 2011. Four consecutive courses, of two-week duration, were preceded by a two-day seminar, which took place from 8th to 9th March 2011 at Ecole Nationale des Sciences Géographiques, Paris. There was a one week separation between consecutive courses to allow for the possibility of a small extension. Background material was presented by the tutors during the seminar, participants met the tutors and fellow participants and the learning platform - Moodle - was demonstrated.

Twenty-three participants followed the courses, coming from twelve countries, representing National Mapping Agencies (61%), Universities (22%), Private companies (4%) and Other (13%).

Many students attended more than one course. EduServ-9 had a fee structure that included participation in the seminar, and participation in the courses. It was slightly more expensive to attend three or four courses than to attend one or two courses.

On completion of the courses, participants were asked to give their feedback. Comments were varied but included the following as an example: most were very satisfied with, and appreciated, the courses; some had difficulties in keeping the time schedule and felt the work load was somewhat too heavy (more than 40 hours) and a small number considered the courses as difficult.

## CONCLUDING REMARKS

The experience of hosting nine EduServ modules so far suggests that such educational resources are of particular interest to the smaller states, both within and beyond Europe. This may be due in some part to the existence of adequate CPD resources in the larger states, which are not generally available in smaller ones. On the other hand, key staff members of GI organisations in several countries do not have high levels of proficiency in the English language and feel that such courses are beyond them.

This of course raises the issue of capacity building in general and in skills updating in particular in those European states where a comprehensive GI education resource does not exist but where the implications of European directives such as INSPIRE will require considerable training.

The EuroSDR EduServ model of distance E-Learning for CPD is an example of the use of appropriate technologies to assist states to build capacity but it must address the challenges of language and better marketing.

EuroSDR is also aware of the need to ‘future proof’ research capacity in all European states so that emerging GI research and education issues (in an increasingly ‘joined-up’ Europe) may be addressed effectively and economically.

It is the firm intention of EuroSDR that its education service, EduServ, continues to address the issue of transferring the outcomes of its research activities to the GI production and user domain.

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# Software-independent tutorials for supervised self-study of Geographic Information Science and Technology

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## ABSTRACT

Today, commercial and closed source desktop GIS-software and their free and open source counterparts have reached a significant level of de facto standardisation regarding interfaces, content of their toolboxes and supported data formats. This stimulates the development of Geographic Information Science and Technology (GI S&T) tutorials which are not software specific. Such tutorials fit extremely well in the "Supervised Self Study" (SSS)-concept. SSS's main objective is to stimulate students to more actively engage in their learning process while tutors pick up the role of advisors.

The LeGIO project is developing such software-independent tutorials related to two fundamental GI-themes, i.e. (i) geospatial data modelling for and functionality of GI-Systems, and (ii) viewing and mapping of geospatial data, and three GI-application fields, i.e. (iii) land resources assessment, (iv) solving network problems and (v) cultural heritage conservation. At this stage we are evaluating these learning materials from both the instructor's and the student's perspectives. The first results are positive which motivates to continue to develop and implement such software-independent tutorials.

## INTRODUCTION

Various study programmes at the Katholieke Universiteit Leuven (K.U.Leuven) have a long history in teaching the science behind and the technology and applications of Geographic Information Systems (GIS). From the late 1980's until today, students in those courses were exposed to the GI-Technology through software packages like ArcInfo, MapInfo, IDRISI and ArcView GIS. The Commercial and Closed Source nature of these Software systems (CCSS) prevented the implementation of a true self-study approach, even with the advent of broad intra- and internet connectivity. Thanks to the availability of increasingly reliable Free and Open Source Software for Geomatics (FOSS4G), it became recently possible to introduce the "Supervised Self-Study" (SSS)-teaching approach in the practical parts of the GIS&T-courses. In line with the principles of SSS, students nowadays work independently with Free and Open Source Software systems (FOSS) like Quantum GIS (QGIS), GRASS, R and PostGIS. The students solve and report about a set of exercises with FOSS while having the possibility to receive supervision and feedback. It can be stated that the combination of SSS with FOSS has been well accepted by K.U.Leuven students and that the level of knowledge and skills acquired is similar to what is achieved in more traditional GIS-courses (Van Orshoven et al., 2010; Hubeau et al., 2011).

Students must have easy and flexible access to hardware, software and data to implement SSS in software based courses. Today, these conditions can be considered to be fulfilled at K.U.Leuven since almost the full K.U.Leuven student community has a personal desktop or laptop with broadband internet connection, since reliable free (and open source e.g. FOSS) GIS-software packages are available for use online or for download and since geospatial data repositories are increasingly opened up through spatial data infrastructures. The major purpose of the SSS-teaching approach is to stimulate students more actively in their learning process while the tutor picks up the role of advisor.

A major advantage of SSS is that the students also acquire technical skills like solving problems related to software installation, hardware and operating system compatibility and data interoperability. Another potential advantage is that the use of FOSS4G enables direct access to the implementation of the concepts, i.e. the source code for data encoding and for algorithms for transformation, and analysis.

Also outside K.U.Leuven, several GIS-courses have been and are being organised where specific FOSS-software is used, such as QGIS and/or GRASS (Schweik et al., 2009), gvSIG (Dorner et al., 2011), ILWIS (Rossiter, 2011). These examples show that the FOSS4G, along with the Closed and Commercial Source Software for Geomatics (CCSS4G) has reached a significant level of de facto standardisation.

With the rapid evolution of software systems, even more rapid for FOSS4G than for CCSS4G, software-specific tutorials are rapidly out-of-date and important efforts are required in keeping them up-to-date. Table 1 illustrates the rapid development of versions of QGIS (http://www.qgis.org/) and OpenJUMP (http://www.openjump.org/) over a two and a half year period (January 2009-September 2011). 8 versions of QGIS and 7 versions of OpenJUMP are released over a period of 2.5 year.

Table 1: Evolution of QGIS- and OpenJUMP-versions (January 2009-September 2011)

| **QGIS version** | **Release date** | **OpenJUMP version** | **Release date** |
|---|---|---|---|
| 1.0.0 Kore | January 5, 2009 | OpenJUMP 1.3 | April 19, 2009 |
| 1.1.0 Pan | May 12, 2009 | OpenJUMP 1.3.1 | December 6, 2009 |
| 1.2.0 Daphins | September 1, 2009 | OpenJUMP 1.4 | October 24, 2010 |
| 1.3.0 Mimas | September 20, 2009 | OpenJUMP 1.4.0.2 | November 8, 2010 |
| 1.4.0 Enceladus | January 10, 2010 | OpenJUMP 1.4.0.3 | December 1, 2010 |
| 1.5.0 Tethys | July 29, 2010 | OpenJUMP 1.4.1 | July 2, 2011 |
| 1.6.0 Capiapo | November 27, 2010 | OpenJUMP 1.4.2 | September 1, 2011 |
| 1.7.0 Wroclaw | June 19, 2011 | | |

The consequence of the rapid development of FOSS4G is that all the screenshots and the description of the workflow of the exercises need to be renewed and replaced every time when a new version is released with as consequence the short-term validity of the learning material. Another drawback is the risk that the students follow the description of the exercises step by step without gathering the in-depth knowledge of the concepts behind the GIS-functionalities.

The increasing standardisation of GIS-software opens opportunities to develop tutorials which are software-independent, so that students can complete the tutorial using a CCSS4G or FOSS4G of their choice while the need for tutorial maintenance becomes much more limited.

This paper describes the development and implementation of and the first experiences with software-independent tutorials related to GIS&T meant for use in SSS. The first section describes the objectives and design of the tutorial exercises. The second section presents the investigation of the implementation of the tutorial within an introductory GIS-course. Finally, a dedicated distance education initiative that used the learning materials is highlighted and the results of this experience are discussed.

## CONCEPTUAL EXERCISES

The software-independent tutorials are composed of what we call "conceptual exercises". Conceptual exercises are software-independent exercises which can be solved with every GIS-software that contains the necessary functionalities. The first objective is to teach in-depth knowledge about GIS-concepts by stimulating the student to explore the GIS-functionalities without fully explained exercises, e.g. screenshots, illustrations of buttons etc. Our second objective is to give the students the opportunity to choose and select a GIS-software (FOSS4G or CCSS4G) so that the students learn to differentiate between different desktop GIS-software and to work with internet-based GIS-communities. Our last objective is to develop long-living tutorials, i.e. tutorials with limited maintenance that can be used for more than one version of a certain GIS-software.

The structure of every conceptual exercise is similar and standardised. An example of an exercise is represented in Table 2. The entire exercise description is not referenced to a specific GIS-software. First, all the GIS-functionalities required to solve the exercise are described in a checklist. In that way, the student can verify whether the selected GIS-software offers all the necessary functions to complete the exercise. Afterwards, the exercise is explained and the students need to solve it according to the solution scheme. Of every exercise, a demo-movie is available, i.e. the exercise is solved by an arbitrarily selected GIS-software to illustrate and visualise the different GIS-concepts and functionalities so that the students can correct or improve their solution. Optionally, the students can also send a non-compulsory assignment to the tutor to receive personalised feedback.

Table 2: Illustration of the standardised structure of a conceptual exercise

**Exercise: Spatial data analysis using a GIS-software**

***Checklist GIS-functionalities***

Checklist GIS-Functionality:

- Import vector-layers → Shapefiles
- Execute spatial queries/data analysis and more specific:
  - Buffer analysis
  - Overlay analysis
  - Intersect operation
  - Dissolve
- Create a new column in the attribute table
- Calculate the area as a value to be displayed in the new column of the attribute table

***Assignment***

Most GIS-softwares have some analytical capabilities, i.e. it is possible to process geodata from one or more geodatasets to ask questions of which the answers can be stored in the geodatabase.

The purpose of the first assignment is to determine which land cover or land use classes occur in 100m wide zones along the river system of the Tabacay watershed. You also need to calculate the area of the present land cover. The geodatasets we need for this analysis need to describe the river system on the one hand and the land cover/land use distribution within the watershed on the other hand.

The necessary geodatasets are:

- *Rios.shp*
- *Coberturas.shp*

***Solution scheme***

- Create a new GIS-project.
- Load the shapefiles *rios.shp* and *coberturas.shp.*
- Make sure the map units are *meters*.
- Change the Coordinate Reference System to *WGS84/UTMzone17S.*

***STEP 1: Buffer analysis***

The first operation is a **buffer** operation. A buffer analysis is a specific vector data analysis that is used to identify areas surrounding geographic objects. The process involves generating a buffer round an existing geographic object and then identifying or selecting objects based on whether they fall inside or outside the boundary of the buffer.

- The input vector is *rios.shp.*
- The buffer distance is 100 meters.
- The new layer *rios_buffer.shp* needs to be displayed in the data view.
- Examine whether the expectations are met. How many polygons are in this geodataset? (TIP: Check the attribute table)

***STEP 2: Overlay analysis***

The second operation is to create an overlay (intersection) between the *coberturas* geodataset and the new buffered river geodataset. Overlay analysis is one of the spatial GIS-operations which integrates spatial data with attribute data, it combines information from one GIS-layer with another GIS-layer.

- The operation is a spatial query: *rios.shp intersects with coberturas.shp.*
- The input vector is *coberturas.shp.*
- The intersect layer is *rios_buffer.shp.*
- Name the output file as *rios_intersects.shp.*
- Load the new geodataset as a layer into the GIS-project.
- …

Five conceptual tutorials are being developed. Two are related to basic GIS-themes: (i) Spatial data modelling for and functionality of GIS and (ii) Viewing and mapping, while three deal with GIS-applications fields: (iii) Cultural heritage conservation; (iv) Land resources assessment and (v) Solving network problems. The first two tutorials can be considered introductory modules without any prerequisite other than familiarity with computers. Theme (iii), (iv) and (v) assume that the students have prior knowledge about the basic functionalities and concepts of GIS. They are meant to be used as a follow-up tutorial to the basic tutorials.

At this moment, the conceptual exercises are already developed for the first three tutorials. Moreover, all the learning material, instructions and datasets are made available online through an e-learning platform. All these tutorials are now in a testing phase. A first test of the tutorials was carried out in a distance education setting in which no credits were earned. Participating students had the opportunity to access all the teaching materials, databases and tutorials for free. The first results of this test are discussed below.

## CASE STUDY

### Course design

The first set-up to test the conceptual exercises was through an online-based course. The course provided all the learning materials for students to learn the basic GIS-concepts. Students of the Master of Conservation of Monuments and Sites at the Raymond Lemaire International Centre for Conservation (RLICC) who were interested, could follow the online tutorial 'spatial data modelling for and functionality of GIS'. The course was not for credits; however, the tutorial was useful for the students to implement GIS in their practical field work or master thesis.

The course is hosted by Toledo (http://toledo.kuleuven.be/), the K.U.Leuven educational e-learning platform which is a blackboard software application. This platform allows tutors to create an active learning environment by providing learning materials, assignments and feedback to the students. Moreover, students can submit assignments, communicate with the tutor or peer students and share documents through the platform. The theoretical concepts are represented in small manageable units called modules. The introductory course comprises seven modules. Every module has the same design and the modules are organised hierarchically. A consequence of the hierarchical structure is that every consecutive module is more difficult than the previous one. The most interactive components within the tutorial are the hands-on conceptual exercises, where the students search, select and download a

GIS-software and data packages and solve practical exercises using a GIS-software. The course design of a module is represented in Figure 1.

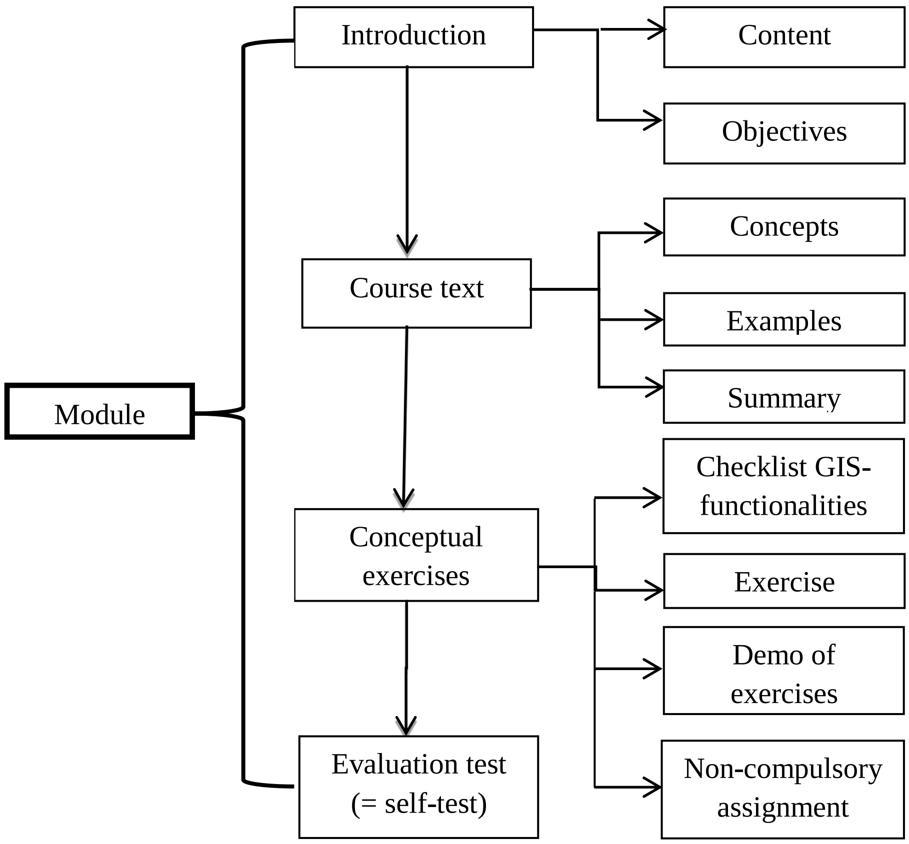


Figure 1: Course design and description

As represented in Figure 1, every module starts with a short introduction to describe the theme and the specific objectives of the module. The second part contains the course text where the theoretic concepts are explained and illustrated with real-world examples. These components are followed by the hands-on conceptual exercises and at the end of every module; the students complete an evaluation test. The evaluation test consists of different kind of questions such as multiple choice, multiple answers, linking, or true/false. These tests are based on the theoretical content of the module to motivate the students to recall all the important concepts and include immediate feedback to the students. The evaluation test is compulsory; the next module appears only when the students have a score of more than 60%. The students have three attempts to pass this evaluation test. When the students complete the whole module and finish all the modules hierarchically, the objectives of the introductory course are reached.

## Test results

The conceptual exercises were tested with Master students of Conservation of Monuments and Sites at the RLICC. In the master-after-master program the students have a background (first master degree) ranging from archaeology, art-history, architecture to engineering. All students who were interested could participate to learn spatial data modelling for and functionality of GIS in distance education. 23 students registered to the introductory course. 16 of these students (70%) effectively started the module and 14 students reached half way of the course (60%). 10 of the 23 students who showed interest (43%) finished all the modules, so 63% of the students who effectively started the online course also finished it. This rate of completion can be considered to be quite high, especially since it was a non-credit, voluntary course.

The experience of the students with the conceptual exercises and their attitude toward SSS were assessed through a web-based questionnaire. Two questionnaires were held, one after the second module of the tutorial (response rate = 14 students, 61%); and one at the end of the course (response rate = 9 students, 39%). The web-based survey contained a variety of question types such as the likert-scale or true/false. Because the number of respondents was limited, the six-fold scale was reduced to a fourth-fold scale (agree, rather agree, rather disagree, or disagree).

The results revealed that only one student had some basic knowledge of GIS while the other students had no prior knowledge. The results of the questions of the likert-scale of the two web-based questionnaires concerning the SSS-approach and the conceptual exercises are represented in Table . The web-based questionnaire after module 2 is considered as the students' attitude at the beginning of the tutorial. In advance, QGIS was advised to be utilized as GIS-software as QGIS contains all the necessary GIS-functionalities, is user-friendly and is without multiple technical bugs. As the course was fully given in distance education and on voluntary basis, the risk existed that students would easily drop out when facing technical problems. However, the objective was to test the conceptual exercises, i.e. exercise description without any reference to a predefined GIS-software, therefore the choice of GIS-software was optional. This is illustrated through the demo-movies, which were made using different GIS-software so the conceptual character of the course was preserved.

The results in Table 3 show that all students were satisfied or rather satisfied with the SSS-teaching approach at the beginning and at the end of the tutorial. However, the satisfaction slightly decreased at the end of the tutorial (71% agreed to be satisfied at the beginning and 56% at the end). The reasons to explain the satisfaction can be the time-efficient way of learning and the availability of sufficient support, advice and feedback. The time-efficiency was highly appreciated by the students, all students agreed (71%) or rather agreed (29%) that the SSS-teaching approach is time-efficient after module 2 and at the end still 67% agreed and 11% rather agreed. Concerning the support, advice and feedback, a large majority of the students, 86% of the students after module 2 and 78% of the students after module 7, agreed that it was sufficiently available.

However, less than 50% of the respondents both at the beginning and end of the tutorial agreed that the SSS-teaching approach stimulated to deal actively with the learning materials. Concerning the overall SSS-spirit, 78% of the students who finished the tutorial concluded that they would recommend the SSS-approach. The students stated that the main advantages were that they could work on their own pace to discover a certain GIS-software and had the independence to organise their work.

At the beginning of the tutorial, one student rather disagreed and one student disagreed that the theoretical concepts were explained clearly by the conceptual exercises. However, at the end of the module all students agreed (56%) or rather agreed (44%) that the conceptual exercises explained the theoretical concepts clearly.

Table 3: Results of the two web-based questionnaires concerning the SSS-approach

| **Students attitude towards SSS-approach:** | | | |
|---|---|---|---|
| **Question:** | **Likert-scale** | **After module 2<br>14 students** | **After module 7<br>9 students** |
| 1. I am satisfied with the SSS-approach: | Agree<br>Rather Agree | 71%, 10 students<br>29%, 4 students, | 56%, 5 students<br>44%, 4 students |
| 2. The SSS-approach stimulates to deal actively with the course material and the learning process: | Agree<br>Rather Agree<br>Rather Disagree<br>Disagree | 43%, 6 students<br>43%, 6 students,<br><br>7%, 1 student | 44%, 4 students<br>22%, 2 students<br>22%, 2 students<br>11%, 1 student |
| 3. The SSS-approach is time efficient: | Agree<br>Rather Agree<br>Rather Disagree<br>Disagree | 71%, 10 students<br>29%, 4 students | 67%, 6 students<br>11%, 1 student<br>11%, 1 student<br>11%, 1 student |
| 4. Human support, advice and feedback were sufficiently available and clear: | Agree<br>Rather Agree<br>Rather Disagree<br>Unanswered | 86%, 12 students<br>7%, 1 student<br>7%, 1 student | 78%, 7 students<br><br>11%, 1 student<br>11%, 1 student |
| **Students attitude towards conceptual exercises:** | | | |
| **Question:** | **Likert-scale** | **After module 2<br>14 students** | **After module 7<br>9 students** |
| 5. The conceptual exercises were sufficiently clear and explain the theoretical concepts clearly: | Agree<br>Rather Agree<br>Rather Disagree<br>Disagree | 50%, 7 students<br>36%, 5 students<br>7%, 1 student<br>7%, 1 student | 56%, 5 students<br>44%, 4 students |
| 6. The online software-manuals and help-forums were sufficiently available and clear: | Agree<br>Rather Agree<br>Rather Disagree<br>Disagree<br>Unanswered | 57%, 8 students<br>29%, 4 students<br>14%, 2 students | 44%, 4 students<br>33%, 3 students<br><br>11%, 1 student<br>11%, 1 student |
| 7. Experience with the GIS-software prepares for professional life: | Agree<br>Rather Agree<br>Unanswered | 79%, 11 students<br>21%, 3 students | 78%, 7 students<br>11%, 1 student<br>11%, 1 student |
| 8. Sufficient possibilities exist to solve problems (though internet, sending an e-mail, discussion board,…): | Agree<br>Rather Agree<br>Rather Disagree<br>Unanswered | 93%, 13 students<br>7%, 1 student | 67%, 6 students<br>11%, 1 student<br>11%, 1 student<br>11%, 1 student |

Since no learning material for a specific GIS-software was provided, all specific GIS-software information was gathered by the students. Moreover, installation and other technical problems concerning the specific GIS-software also had to be solved by the students. The consequence is that the students learned to solve problems through exploring other channels, such as internet. 93% students after module 2 and still 67% of students after module 7 stated that sufficient possibilities exist to solve problems. More than 60% solutions were found on the internet to solve specific problems while 50% contacted peer students. Only 14% used e-mail or the discussion board to ask questions to the tutor. After completing module 2, 57% agreed and 29 rather agreed that the online software-manuals and help-forums were sufficiently available and clear, at the end 44% agreed and 33% disagreed.

All students agreed or rather agreed both at the beginning and the end of the module that the experience with GIS-software prepared them for professional life. Also, the intention to reuse the GIS-software is large, 67% of the students have the clear intention and 33% sees possibilities to reuse the GIS-software. Moreover, the preparation for professional life is highly important, namely 78% of the students have the intention to use the GIS-software in professional activities, 44% in presentation and demonstration purposes, 22% as a personal reference and 11% for further self-study (11%).

### Discussion of the results

On one hand, previous studies (Van Orshoven et al., 2009, Hubeau et al., 2011) revealed that the main advantages of the SSS-teaching approach are the time-efficiency and the stimulus to deal actively with the learning materials. These advantages were confirmed by our results. On the other hand, these studies revealed that the insufficient human support, advice and feedback available could be a risk that could limit the interest of the students. However, in this study, this challenge was not seen as a drawback, only one student pointed it out as an issue. On the contrary, less than 50% agreed that the SSS-approach stimulated them to deal actively with the learning materials. One hypothesis to explain this result is that no deadlines were set and no credits were granted. All the motivation to complete a module was inherent to the student.

It can be stated that all students agreed or rather agreed to be satisfied with the SSS-approach. This result is similar to previous research that stated that mature students are very positive to work in the SSS-spirit using a FOSS4G.

The students answered positive to work with the conceptual tutorial. The students who finished the module at least rather agreed that the exercises were sufficiently clear and explained the theoretical concepts well. Two students disagreed or rather disagreed with this statement after module 2. Although the web-based questionnaire was anonymous, one hypothesis is that these two students dropped out in the middle of the online course. It would be useful to ask to the students the main reason why they did not continue the course. A possible explanation is the lack of motivation and time, but another explanation could be the difficulty of the later modules due to the hierarchical structure of the course.

Most problems were solved though internet resources such as forums of developer/user communities, Google, blogs, or wikis. Only 14% asked questions to the tutor or posted questions on the discussion board. Internet-based problem solving is positive because the students learn to work with internet-based communities of peers and therefore are likely to develop a critical perspective on GIS. Another remarkable result is that all students (100%) agreed or rather agreed that experience with the GIS-software prepared them for professional life. In a previous study that investigated the attitude of students towards SSS-teaching approach and towards a specific FOSS, only 81% agreed or rather agreed that their experience prepared them for professional life (Hubeau et al., 2011). This could indicate that the objective that students learn the in-depth concepts of a GIS-software by exploring all the GIS-functionalities by themselves was reached. Moreover, these results indicate that the students were more confident by their own competences. However, a comparative test should be taken to draw conclusions.

Although all these results are preliminary, they definitely encourage further development and investigation of the applicability and appreciation of conceptual exercises. Therefore, a second test set-up of the conceptual tutorials will be performed within a number of regular Bachelor study programmes. The students enrolled in a regular introductory course on GIS&T will be divided into two groups. A first group will follow the SSS-approach in combination with specific FOSS GIS-software (QGIS, GRASS and R) and a second group will follow the SSS-teaching approach in combination with the conceptual exercises and a GIS-software selected by the student. After the two groups complete the tutorials and assignments, they will both take a test. The goal of the test is that the students solve a specific assignment in a computer classroom with a specific CCSS4G (ArcGIS10). The assignment tests the in-depth knowledge of software-independent GIS-concepts. The students will need to find the correct GIS-functionalities concerning different GIS-concepts with a GIS-software that they did not use before. This 2nd test started in October 2011 and the first results are expected to be available in January 2012.

## CONCLUSION

The rapidly increasing availability and improving quality of free and open source software, including FOSS4G, is a benefit of the web 2.0. Today, it can be stated that FOSS4G together with CCSS4G have reached an important level of standardisation. Therefore, conceptual, software-independent tutorials for GIS&T-courses can be developed. Conceptual exercises fit extremely well in the Supervised Self-study approach. The conceptual exercises could overcome the main drawbacks of the SSS-teaching approach in combination with a specific FOSS4G, such as the workload for tutors according to the short-term validity of exercises and the rather shallow knowledge of students about GIS-concepts.

Conceptual tutorials were developed and tested. The construction of the tutorials was described and their appreciation by a group of Master students discussed. The first results were positive and therefore, after structured feedback of the students was received, the tutorials could be adjusted and implemented. In the fall semester of 2011, the conceptual exercises will be further tested by undergraduate students.

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# Posters

# Geographic Information Systems (GIS) as a tool for heritage conservation education

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## ABSTRACT

Since 2002 education of Geographic Information Systems (GIS) is part of the curricula in the Architecture Faculty at the University of Cuenca-Ecuador. Initially, a GIS module was assigned to the last year students of the graduation program of "urban planning" thanks to the efforts of few educators; however, since the beginning its usefulness and its dissemination was questioned by the Faculty. The module was therefore oriented to become a more practical and participative tool. Now, a few years later, the poster aims to show the successful diffusion and application in other academic fields of the GIS module within the Architecture Faculty.

A concrete example describes how GIS became a tool that complements heritage conservation education. In October 2010, a pilot program was set up in the option "Heritage Conservation" as part of the framework of the VLIR project "World Heritage City Preservation Management" between the K.U. Leuven, Raymond Lemaire International Centre for Conservation and the Architecture Faculty at University of Cuenca. The project aspires at contributing to the conservation of the cultural heritage of the city by: i) developing tools, which supports an adequate management of heritage data, especially for decision-making and ii) capacity building, through lectures and/or field work for students and young professionals.

The students were involved in lectures that were structured through three components that feedback each other in a continuous cycle: i) Methodological and conceptual approach ii) Theory and practice with information systems and iii) Integrated project work. The interaction between tutors and students resulted in a fundamental and real improvement of the heritage GIS module. Different analysis and user requirements at different scales: city, building, building elements; have introduced new contributions and future challenges. Nowadays, the heritage GIS module is still open for further improvements and adjustments depending mainly on its use.

**KEYWORDS**: Heritage, Conservation, GIS, Management, Capacity building.

## 1. INTRODUCTION

Since 1981, the Architecture Faculty at the University of Cuenca offers to the last year students three specialization options: Architectural Design, Urban Planning and Heritage Conservation. Geographic Information Systems (GIS) is part of the curricula in the Faculty since 2002. The GIS module started at the Urban Planning option with successful results. The students used this technical tool for the analysis and phenomena interpretation in topics relative to: the territory, landscape, social aspects, economic activities, etc. In consequence, the students had a better and a clear idea of the studied territory, which will support the formulation of urban projects.

The main objective that has been guiding the GIS module in the option of "Urban Planning" is to train the students from a comprehensive theoretical, technical and practical perspective. It gives to the students: 1) conceptual approach through planning theory, 2) methodological approach through the study of Information Systems applied to landscapes and territories and 3) practical approach through an urban project in a human settlement no bigger than 10.000 habitants. From these experience, and conscious that conservation of cultural heritage implies an adequate management of huge amounts of data, of good decision-making and of trained people in management topics[1]. In October 2010, the specialized option of Heritage Conservation set up a pilot program following the existing GIS module structure.

## 2. THE PROPOSAL MODEL

Heritage Conservation is not a simple practical issue and in order to know why a building or site is important or valuable it is also essential to understand it. This necessarily involves a close approach to the heritage site in order to record and gather all forms of relevant information pertaining to it. But the conservation of a heritage monument implies more a than full data collection, it requires an adequate data management which could guide the decision-making. To reach this objective it is necessary a structure monument data set articulated with other components that could provide potential, effective and trustful information of a heritage monument (See figure 1) [2].

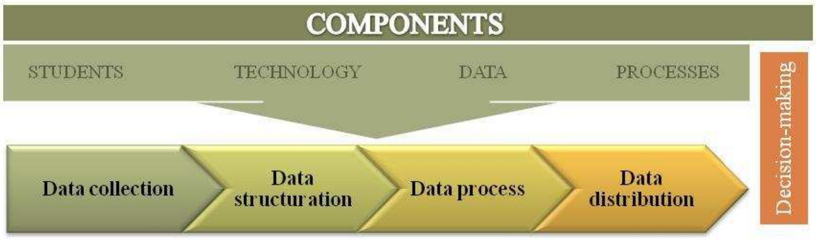



Figure 1: Components for a Heritage Information System. Source: Ximena Salazar.

All the efforts to comply with recording and documentation requirements are wasted, if these data are not properly archived or it is not accessible. Heritage information systems were designed as electronic repositories. They constitute powerful management tools with the potential to expedite conservation processes[3]. For this reason the specialized option in Heritage Conservation issues intended to incorporate on its curricula "information systems", which entails data collection, data management and data presentation through thematic maps. The main objective with the implementation of this GIS module is settle on the creation of a Heritage Information System (HIS), that allow to the student the access and visualization, in simple way, different types of documentation related to the cultural heritage (cards, images, drawings, 2D and 2.5D models).

In the specialization option of Heritage Conservation, the GIS module has been structured through three components that feed-back each other in a continuous cycle:

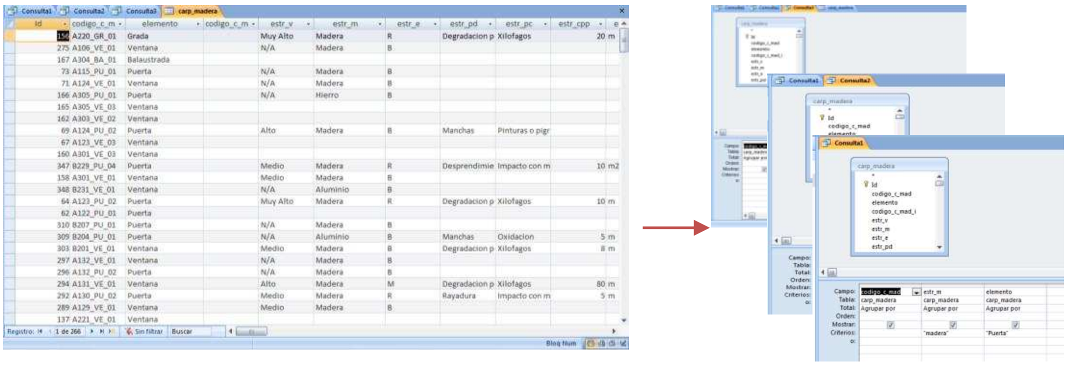
i. Methodological and conceptual approach: theoretical basis for the future work.
ii. Theory and practice with information systems: data management, analysis and to get the upmost data profit.
iii. Integrated project work: the proposed Conservation Project.

The successful GIS module application, in this experiment, entailed the interaction between one tutor and ten students with the objective of a complete training on information systems, identification of system components and a subsequent system conformation. The central part of the module is the student's preparation on the use of Access-databases and common GIS-applications (ArcGIS 9.3), in which tutors and students can create and share information. Thereby the students started to become familiar with tools that will provide and settle management possibilities in monitoring and preventive conservation plans of a heritage place.

## 3. RESULTS

The GIS module was tested by the last year students of the specialized option of Heritage Conservation. From April to July 2010, the students were collecting data of the "Seminario San Luis" (Study case, which constitutes an important nineteenth century building in the city. Nowadays the future of the building is under discussion). The GIS module started in October 2010, and after one month of lectures the students were capable to: 1) structure an Access Data Base and 2) continue with practical exercises in ArcGIS 9.3; both applied in their building. In the course, heritage phenomena's were analyzed at different levels (city level, building block, building elements)[2]. Therefore the students were able to execute diverse analysis from small (building element) to larger scopes (building block).

a)



The final results of this technical application are different thematic maps as shown in figure 2. The results are the outcome of an important effort from the tutors and the students, who have to define proper modelling conditions (Geometry data structures), in function of required analysis or preliminary assessments.

b)


Figure 2: a) Seminario San Luis Access Data Base b) Different thematic maps at different levels of approach. Source: Last year students, specialized option of Heritage Conservation, July 2011.

# 4. CONCLUSION

The conservation process of historic building requires the management of collected and evaluated data. It constitutes the major component in a decision-making process. Hence information systems appear as efficient tools for storing, organizing, analyzing, evaluating and monitoring this data. But the integration of Geographic Information Systems as a complement in heritage conservation education is a new issue. Regarding the topic, the Faculty of Architecture at the University of Cuenca has successful experience with their last-year students in the specialized option of Heritage Conservation. A GIS module has been introduced as part of their curricula.

The students are capable to manage large amounts of heritage information through the implementation of databases related to GIS software. It gives them a better understanding of different phenomena influencing directly or indirectly a heritage monument or site. Nowadays, the heritage GIS module is still open for further improvements and adjustments depending mainly on the practical use that tutors and students could provide.

## 5. FUTURE RESEARCH

Nowadays the use of open-source packages is widely spread. Different discussions around the topic have taken place since several years ago. The final aim of the Architecture Faculty is the benefit of the society through its students. Therefore in a near future, the Heritage GIS module will incorporate open-source software packages, allowing to the students to use these systems in their professional live.

## 6. ACKNOWLEDGEMENTS

The authors wish to acknowledge the collaboration of the Architecture Faculty at the University of Cuenca as well as the participation of the last year students of specialized option Heritage Conservation. Gratefulness for all the guidance and support during the elaboration of this module to the VLIR Project: "World Heritage City Preservation Management".

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# Would Google Earth be a proper GIS?

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## ABSTRACT

The teaching of GIS has become a vital part of the academic offer for the Faculties of Agriculture in Italy. Several constraints (i.e. policies, expenditure limitations, etc.) do not allow a sufficient predisposition of students, often prompted to start courses where GIS is a main tool without having had a proper propedeutic literacy.

In this context, for the course of Principles of Geomatic at the Università Politecnica delle Marche a test has been devised to encourage students, from the early stage, to focus on platforms deemed more intuitive and user-friendly (i.e. Google Earth®) rather than on classical GIS software. Would Google Earth ever be a proper GIS? May be not or not completely, anyway in our experimental test students have shown an improved production of elaborates and self-initiative to integrate background material with other information.

## INTRODUCTION

Despite Italy had been among the first countries where Aerial Photographs was acquired in 1909[1] over an area near Rome (Centocelle), releasing five years later in 1913 the first Italian photogrammetric map, either in current times the basic paradigms: geodesy, cartography, photogrammetry, are not taught and investigated under the coherent umbrella of a National Scientific Subject. Thus, according to Rinaudo: "Italy never had a Geomatics School". This situation has remained unchanged over the time. As a result it is not possible to find a bachelor or Master or even a PhD school curriculum based on Geomatics in Italy today (Rinaudo, 2011).

The teaching of Geomatics in Italy has been sprawled into various other scientific curricula such as (Spatial Planning, Urban and Rural survey, Engineering, Cultural Heritage, Agriculture, …). There is an actual underrating of culture of survey and of the relentless growth of available geo-information across the world. All that makes up a situation in which the Faculties of Agriculture play a second fiddle to the whole offer of courses of Geographical Information Systems (GIS). Because of their relative high multi-disciplinary, if compared to other related profiles such as: Civil Engineering, Architecture, Planning, etc. Agriculture Faculties are particularly affected by the above mentioned lack of national structure. Nevertheless the importance of being skilled of GIS techniques is paramount to all the profiles issued by the faculty of Agriculture (i.e. Agronomists, Agriculture Engineers, etc.) since the ability to manage spatial information by means of GIS is one of the main requirement to obtain a qualified job, especially by Governmental and Public bodies dedicated to agriculture services and rural land management. As a reference in Figure 1 the relative ubiquity of regional GIS services is shown. Note how the specific regional context in which the Università Politecnica delle Marche (Univpm) operates scores for a significant 45%.

Synthesising, GIS is an essential item of the Agriculture Engineer's toolbox, despite this its teaching is not soundly structured in the Italian context where during the training, students are often prompted to start courses devoted to: GIS, planning and management, without any specific literacy of the paradigms and of software basic. In the next few pages our first attempt to try to mitigate the impact on students by pushing them to use friendly interfaces (i.e. Google Earth) is briefly depicted. The scope is to reduce the considerable waste of time that have to be invested to teach the specifics of GIS software's interfaces at the expense of what would be rather better dedicated to communicate sound paradigmatic approaches that should form the backbone of courses.

[1] On April 24th 1909 the first use of a motion picture camera was used in Wilbur Wright und seine Flugmaschine the 3:28 silent short film.

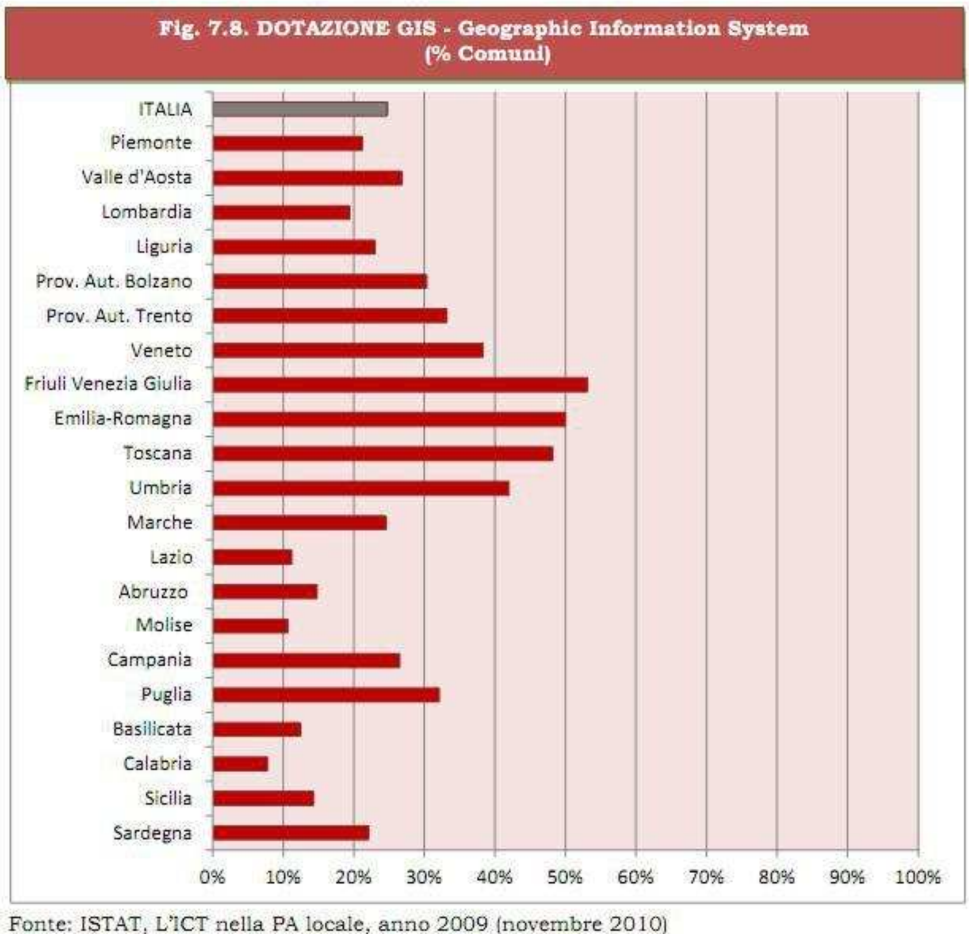


Figure 1: the relative importance of GIS for Public bodies in Italy. The plot shows, per Region, the percentage of Municipalities attaining to the region where a GIS has been put in force.

## WHY DO 'GOOGLING-EARTH'?

In the above context, for the course of Principles of Geomatics held during the academic year 2010 at the Univpm, an alternative approach has been devised to encourage students to focus, from the early stage, on platforms deemed more intuitive and user-friendly.

To do so, instead of branded software (e.g. MapInfo, ArcGIS, Idrisi) or open-source solutions (e.g. QGIS, Grass) students have been introduced to the use of Google Earth to annotate and manage information and to perform the surveys and the final cases appraisal. In particular, GE allows, in an intuitive-fashion environment, to identify spatial features and land covers by drawing polylines and polygons as well as managing landmarks and raster imageries. Moreover it allows the overlay of a wide a range of volunteered information. Furthermore, the possibility of swapping the spatial information throughout e-mails has made the class-work more appealing by encouraging open communication among groups. Once the digitizing and the collection of needed information has been concluded, limitations in terms of relational database management have been overcome by converting GE's format Keyhole Markup Language (Kml) to Shape-file format (see Fig. 2). This allowed students to finalise course-work in a "classical way" making the students familiar with ArcGis Desktop release 9.3®.

In particular, once gathered in groups students have immediately started to interact with GE interfaces scrolling over each assigned case study areas to analyse the context. The relative good quality of available false colours images textured on the 3D globe model has attracted students to zoom in and out to annotate facts and to detect items they have seen on the reality during the previous surveys on the field. All the detected elements chosen according to the analytical approach devised by each group have been digitised: points, lines and polygons, and finally exported in shape-file format to cope with the final task to release a set of proper geographic information and related thematic maps (Fig. 3).

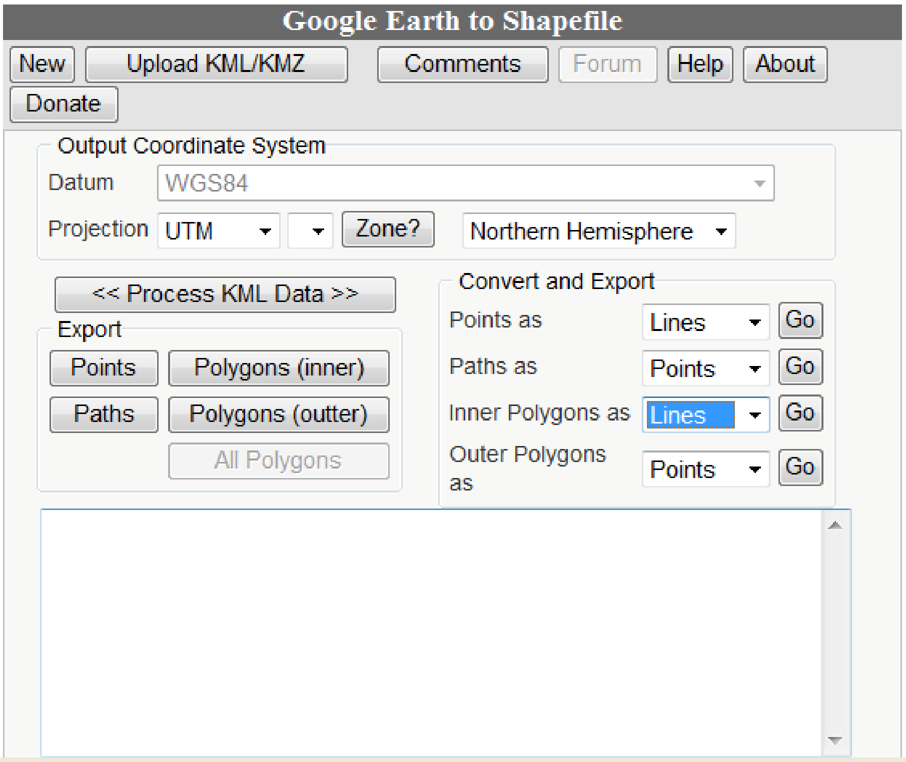


Figure 2: the online pop-up (http://www.zonums.com/online/kml2shp.php) to translate Google Earth native files in Keyhole Markup Language (KML) to Shape file format.

Unlike during previous courses where most of the available time was consumed to explain GIS interfaces' functionality, this time as soon as the cases have been assigned and the groups defined students have started to focus on the assignments, on the analyses and on the potential alternative solutions. Surprisingly students have found more intuitive to rush on the "wild-wide-web" looking for solutions to, as an example, convert files in GE format to shape files (see Fig. 2) format rather than to use the help-online of ArcGIS Desktop® release 9.3 to make the conversion.

When teaching, it is important to explain the theoretical elements, but it is also necessary to illustrate the basic functions with examples. To help students it is advisable to separate the teaching of fundamentals from the practical application of complex GIS software by shifting towards interfaces students consider more intuitive and user friendly to create opportunities for acquiring knowledge in an easy way.

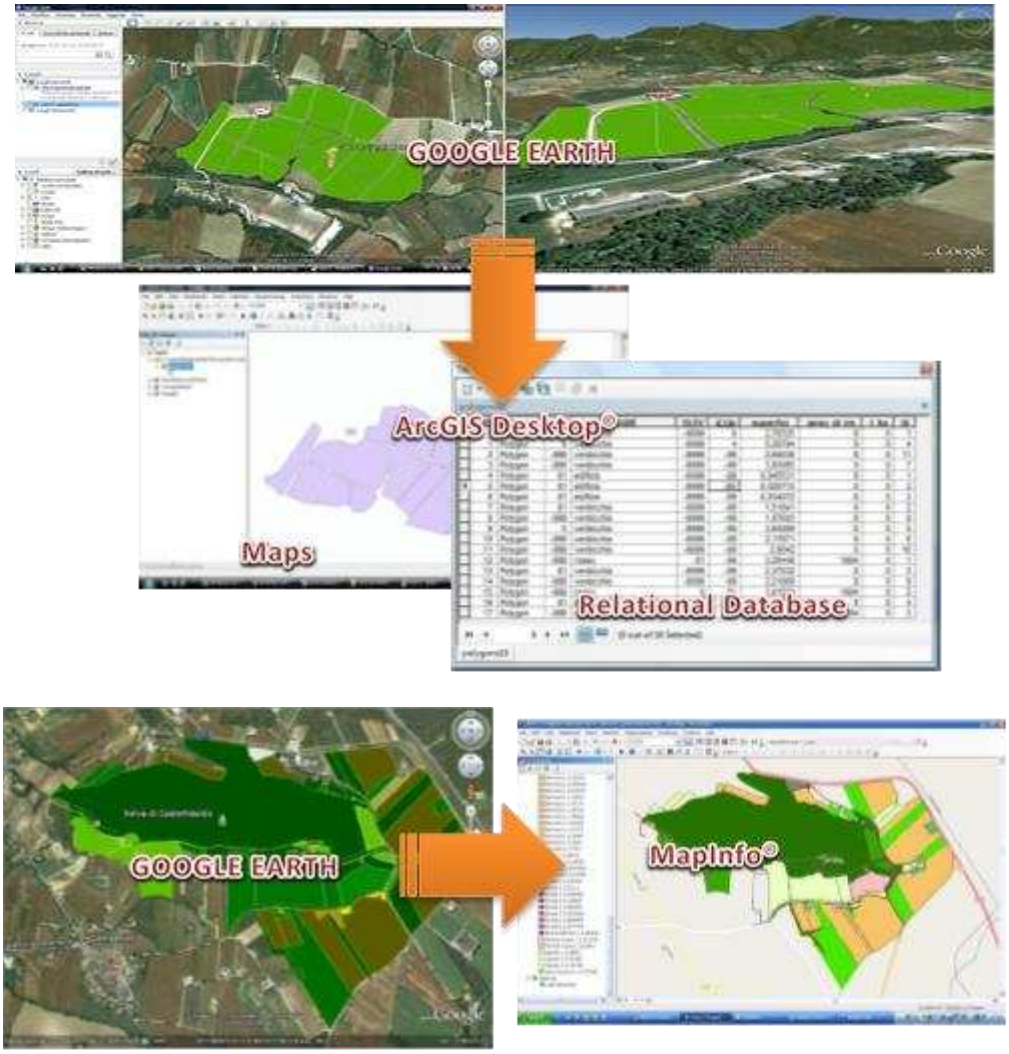

Figure 3: the analysis of context and the digitising of detected items can be operated on GE with ease. The information stored in KML can be shifted to classical GIS software with ease.

## CONCLUSIONS

Would Google Earth be a proper GIS? May be not or not completely. Our experiment is indicating that, unlike the past experiences, the burden of mere technical issues due to software's specificities has declined of 30-40%, saving a considerable amount of time available to better debate on the proposed study cases. Students have showed a more efficient production, in terms of elaborates, and their self-initiative to integrate background material with other information has been much higher.

Before concluding few words deserve to be spent highlighting the growing importance of what we call volunteered information. Important meanings interweaving with such a neologism, on the whole, according to Abd-Elrahmana et al. (2010), citizens have become more aware of the relationships between human society, geography and natural resources. This desire of involvement in the planning and decision making processes is clear. Now raises the question whether or not participants with minimal background on landscape and land use, spatial information, and GIS and with amateur equipment, such as a handy camera and Google Earth, are useful sources for terrain information. Amichai-Hamburger (2008) has recently defined these volunteers of information as "field workers" using their computers to help, communicate and share gathered information with others many thousands of miles away.

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Rinaudo, F. Teaching Geomatics in Italy. GTC 2011 Geomatics Technologies in the City First International Geomatics Symposium in Saudi Arabia Jeddah - 10-13 May 2011

http://www.zonums.com/online/kml2shp.php

# Cultivating Participatory Environmental Accounting with Distributed GIS: The Role of the Academe

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## ABSTRACT

We live in an era epitomised by technical progress so dynamic that we are confronted with the consequences of progress (i.e. depletion of land resources and environmental degradation) which we did not foresee and hence, we are not prepared for. The role of Philippine higher education institutions (HEIs) as *"center of inquiry and research, of effective and responsible leadership, education of high* level profes*sionals, and enriching the historical and cultural heritage"* is now all the more emphasized as HEIs not only actively contribute to the growing body of literature on environmental conservation and management but can further become an "environmental conscience" by engaging the community to which they are part of, to increased awareness and committed involvement on pressing environmental issues.HEI support in studies and researches in the realm of Open Source Geographic Information Systems (OSGIS) as a relevant ubiquitous technology coupled with the Internet has made possible the building of a geo-portal maintained in Saint Louis University for Baguio City. The geo-portal shall serve as a cutting-edge environmental accounting gateway to a growing inventory of geographically integrated land and environmental resources data with the aim of sharing them to the community thus providing for transparency and a platform where decision-makers and stakeholders are encouraged to participate in the responsibility of conserving and managing the City's common heritage. Academia can be the catalyst to raising the consciousness among stakeholders the relationship between technical progress and environmental problems. With geographic information technology and the Internet, the community IS the classroom.

**KEYWORDS**: GIS, distributed GIS, open source, community participation, geo-portal

## INTRODUCTION

Since the late 1990s, the geographic industry has seen increasing interest and activity in the deployment of web sites that provide access to geographic content (Tait, 2005). Longley and Batty (2003) confirm that the GIS community had since then recognised the new medium of participation that the web provides and that software technologies were developed to provide the capability of implementing GIS in a distributed environment, thus the birth of geo-portals. A geo-portal is a type of web site used to find and access geographic information via the Internet (http://en.wikipedia.org/wiki/Geoportal). Websites like MapQuest (http://www.mapquest.com) and MapBlast (http://www.mapblast.com) are examples of portals that capitalized on the advent of the Internet and the interest of the public to locate places and map them (Tait, 2005).

Choosing the open source path provides benefits to the community as they enable ready accessibility and interoperability thus exploiting the participation of all stakeholders (local and regional planners, officials, politicians, and the public) in the environmental planning and management process.

The urban challenge of today is tackling the economic, social and environmental dimensions of sustainable development. A geo-portal where spatial information could be integrated and made accessible to all stakeholders may provide significant benefits to the environment and consequently, to urban economy and society as it would improve the information supply to environmental policy. Web services, service-oriented architectures and distributed GIS are the foundation technologies through which society will realise the benefits of GIS, and geographic portals play a key role, guiding the way to the emergence of societal GIS (Tait, 2005).

This paper/poster discusses the development and amalgamation of geo-spatial information and the Internet as a tool to open a platform where active dialogue and participation of stakeholders in environmental planning and management may be made possible. It also puts emphasis on the possible role of the academe as an "environmental conscience" on top of its primary role in knowledge creation. That by supporting studies and researches in the realm of Open Source Geographic Information Systems (OSGIS), geographically integrated land and environmental resources data may be shared to the community.

## THE STUDY AREA

Baguio City, Philippines is located in the highlands of the Luzon Island with geographic coordinates: latitude=16.416 and longitude=120.593 (Figure 1). The city measures about 7.9 km. from east to west and 7.4 km from north to south. It was established in 1904 to serve as an American Hill Station and was planned by Daniel H. Burnham. The Americans saw in Baguio a surrogate to their home country in the northern latitudes because in the midst of humid tropical Philippines was Baguio with its "invigorating cool climate, spectacular pine-clad mountain landscapes, occasional frosts, fields bursting with brilliant flowers and ferns, and other varied fauna" (Reed, 1976).

Architect Burnham stressed that the maximum population for the city should be at 25,000 only in order not to compromise its unique natural environment. Baguio now has 301,926 residents in a limited land area of 54.65 sq km. The 25,000 limit was breached in 1948, fifty-six (56) years ago. Figure 2 shows two (2) periods of development in the city and is a testament to the reality of rapid urbanization.

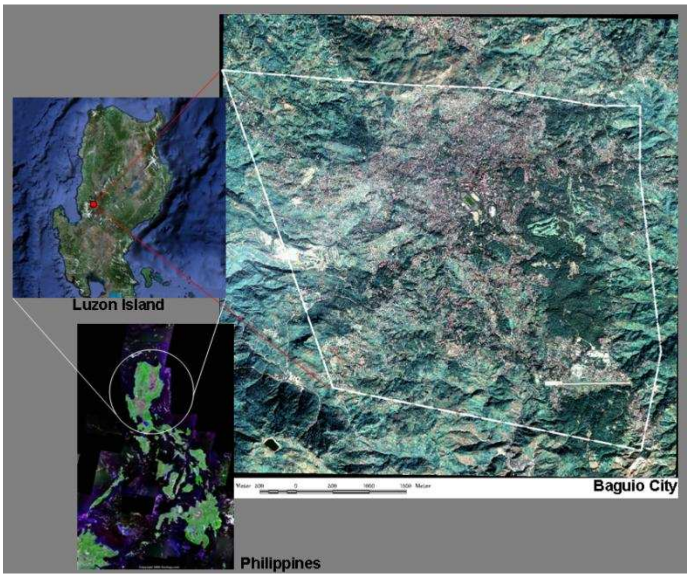


Figure 1: The study area in true color composite (B=2, G=3, and R=5).

Figure 2: Two periods of development in Baguio City.

## BUILDING THE GEO-PORTAL

The geo-portal (http://webgis.slu.edu.ph:8000) was developed using free and open source software. The software used in the creation of the geoportal include the following: Ubuntu Linux for the operating system, Apache for web server management, UMN MapServer for web mapping applications, PHP for web application development, and Quantum GIS (QGIS) for GIS project/application development. The geodatabase includes the satellite imagery covering the city of Baguio, whose usage is bounded by licensing agreement, and various layers created on top of the satellite image using QGIS.

The geo-portal incorporated features that allow users to navigate and query maps through Internet browser or access data in standardized formats thru Web Map Service (WMS) or Web Feature Service (WFS). These capabilities offered by the system were made possible through the use of the UMN MapServer. UMN MapServer is an open source development environment for building spatially-enabled web mapping applications and services. It is fast, flexible, reliable and can be integrated into just about any GIS environment. MapServer supports popular Open Geospatial Consortium (OGC) standards including WMS and WFS.

There are three aspects of the Geoportal: the WebGIS, the WMS server and the WFS server. The developed system was tested thru the website of the Engineering and Urban Planning Research Laboratory. The system allows users to pan, zoom and query maps using a web browser. Figure 3 shows the snapshot of the result of the testing.

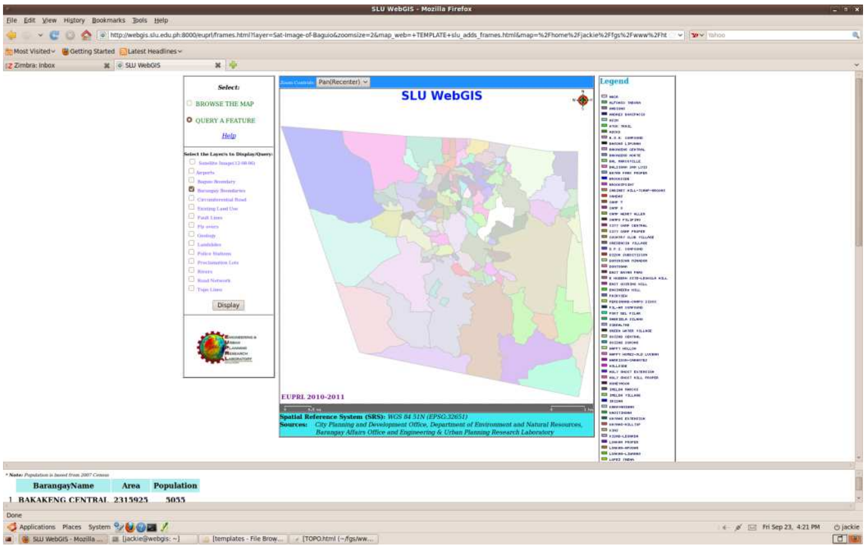

Figure 3: Test Result of the SLU WebGIS

The developed project is both a WMS-compliant server and a WFS-compliant server. A WMS (or Web Map Server) allows for use of data from several different servers, and enables for the creation of a network of Map Servers from which clients can build customized maps. WMS servers interact with their clients via the HTTP protocol. In most cases, a WMS server is a CGI program just like MapServer. The WMS server was tested using QGIS as a real client and a snapshot of the result of the testing is shown in Figure 4.

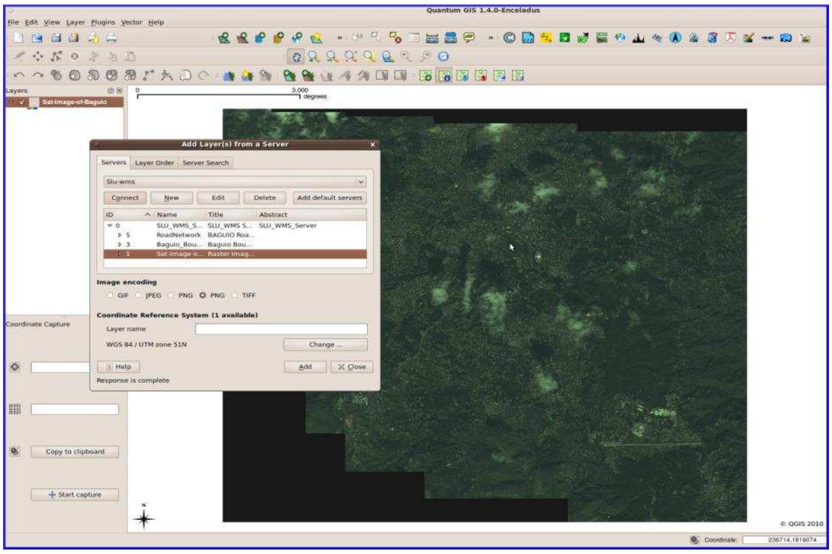

Figure 4: Test result of WMS server using QGIS as a WMS client

A WFS (Web Feature Service) publishes feature-level geospatial data to the web. This means that instead of returning an image, as MapServer has traditionally done, the clients now obtains fine-grained information about specific geospatial features of the underlying data, at both the geometry AND attribute levels. As with other OGC specifications, this interface uses XML over HTTP as its delivery mechanism, and, more precisely, GML (Geography Markup Language), which is a subset of XML. Much as in the WMS support, WFS publishing is enabled by adding certain magic METADATA keyword/value pairs to a MapFile. The WFS server was also tested using QGIS as a real client and a snapshot of the result of the testing is shown in Figure 5.

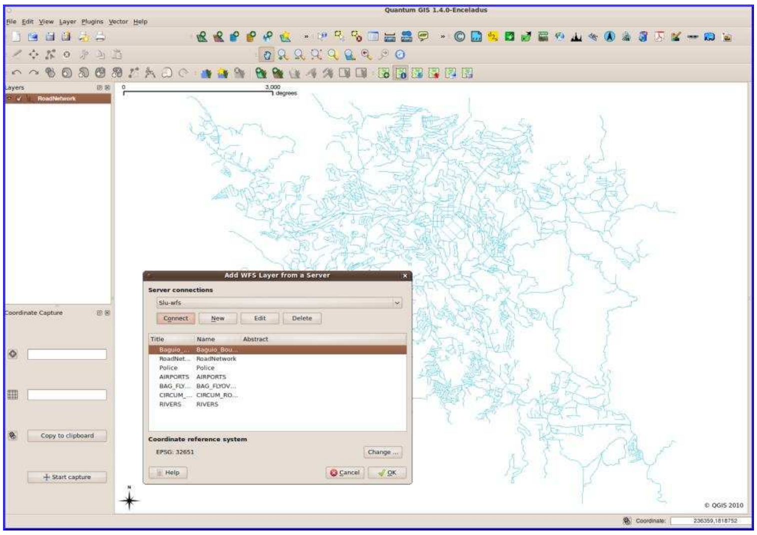


Figure 5: Test result of the WFS server using QGIS as a WFS client

## PROMOTING COMMUNITY PARTICIPATION

Saint Louis University is actively partnering with the community by fostering information exchange through research output dissemination, technical trainings, networking and outreach activities. It is steadily building the awareness among decision-makers in the local government and stakeholders, especially in the professional sector, the value of geo-data as an information source and that the Internet allows for its fastest and largest diffusion. Also, emphasis is given on the availability of open source technologies that are accessible and cost-effective given limited resources. The geo-portal is becoming an important part of all information exchange activities since it makes geo-data available and ready for use whether inside or outside the campus. As of today, trainings designed to serve practical applications had been conducted for the Baguio City Police Department, the Mines and Geosciences Bureau of the Department of Environment and Natural Resources – Cordillera Administrative Region, and the Philippine Institute of Civil Engineers – Baguio Chapter. A number of trainings for other government agencies and professional organizations are now being prepared.

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# A case study: GIS-education applied in the study field of cultural heritage conservation

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## INTRODUCTION

This poster shows an application of the LeGIO (Leuven Geographic Information Distance Education) platform in the field of conservation of cultural heritage. The Master of Conservation of Monuments and Sites (MCMS) taught at the Raymond Lemaire International Centre for Conservation (RLICC), K.U.Leuven offers an advanced international and interdisciplinary study programme in conservation and preservation of historic monuments and sites. However, until today no GI S &T (GIS Science and Technology) course is contained in the MCMS's curriculum. Therefore, the RLICC together with two members of the Leuven Sustainable Earth Research Center (LSUE), the Spatial Applications Division Leuven (SADL) and Forest Nature and Landscape (BNL) are developing a tutorial on cultural heritage as part of the LeGIO educational project. This tutorial consists of a package of practical exercises based on a database of the World Heritage Property of Cuenca, Republic of Ecuador and heritage applications. The basic LeGIO e-learning platform applied in cultural heritage during the last academic year showed positive results and the application of the new specific heritage tutorial will be tested in the academic year.

## GIS IN HERITAGE CONSERVATION

Geographic Information Systems (GIS) are a powerful tool for cultural heritage. A GIS is a software that allows analysis and management of spatial and temporal data, can support data collection and help in many decision-making processes. Different thematic layers of a site e.g. regarding risks, typologies and data repository of heritage places can be combined and data analysis can inform stake holders where additional conservation-based investigations are necessary.

An important benefit of a GIS is the possibility to display spatial information in various ways rapidly enough to perform complex analyses that allow for customized maps, charts and statistics. Digital data and maps require less physical storage capacity and can be updated more easily than paper maps. GIS can be used as an efficient storage medium for spatial data. Because of these advantages, GIS is widely used in such fields as urban planning, utilities management, cartography, natural resource management, commercial site selection, and some areas of academic research like archaeology (Easa et al. 2000).

Furthermore, Geographic Information Systems, e.g. data + databases + GIS, appear as a technological tool to support different cultural heritage applications, such as: surveying and inventory towards preventive conservation, analyzing and investigating, assessing and evaluating, developing strategies, implementing, monitoring, and reviewing, and risk mapping (Box 1999). Other applications are used in both, site management, by including e.g. spatial distribution of survey data or aerial photography to visualize site development in the past or in tourism management, to carry out e.g. tour route analysis, interpretative studies and determine the carrying capacity of a site.

In Archaeological conservation the application of Information Systems is not a new issue, but without question there is an important possibility to continue with a practical use of this tool in other important research fields. Thereby the introduction of GI S & T courses in heritage conservation master curricula potentiates this development.

## THE PLATFORM

The LeGIO educational platform is linked to the e-learning blackboard of the K.U.Leuven, Toledo. Therefore, students have the opportunity to access this supervised self-study long distance course. This system is already developed but still under revision. Toledo gives the opportunity to exchange information between tutors and students by means of different tools such as a discussion board, e-mail and personalized feedback through assignments. Moreover, tutors are able to follow up the progress of the students and evaluate them. Because the module is designated as supervised self-study, it allows students to complete the course trajectory on their own pace during the first or second year. It also gives students the opportunity to apply the learned concepts in their own project work and/or thesis in the field of cultural heritage. Moreover, the students of MCMS are multidisciplinary and therefore this GI S&T course potentiates the use of the tool in different research fields with different perspectives, requirements and user needs.

The course contains a specific module on cultural heritage conservation. This module aims to link the use of GIS with the cultural heritage activities of the MCMS. Figure 1 shows one of the exercises based on the geographic database of Cuenca. Seven exercises and two assignments have been created and illustrated with the geographic datasets of the city of Cuenca. For example, after collecting cultural heritage data, such as data about historical buildings, and heritage elements, the students are able to structure the data and explore its content. Often these data come from the official sector, thus, the exploration of meta data, data structure and content will be necessary.

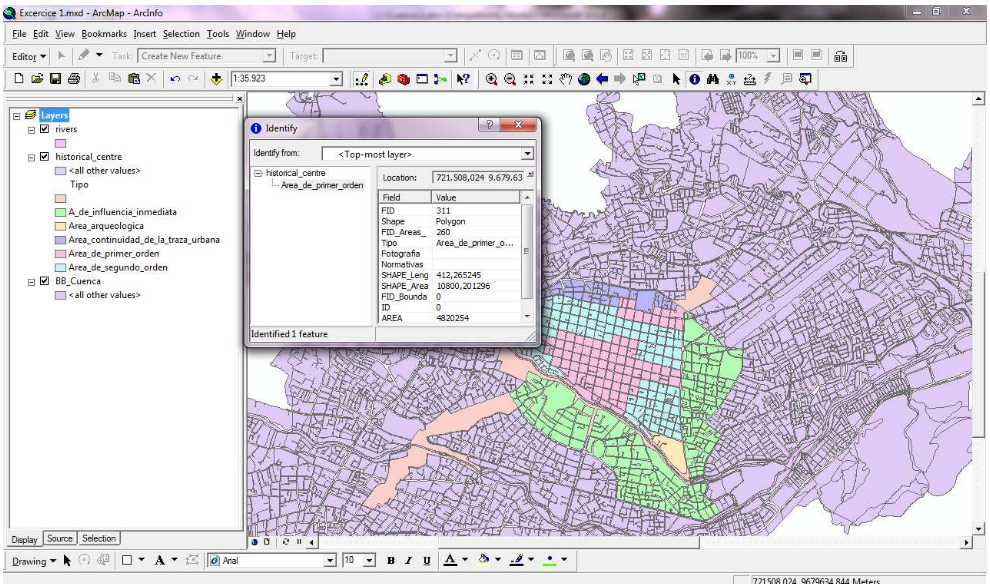

Figure 1: LeGIO - gDB of Cuenca

In the case study of Cuenca, students can easily define the range of significant places within the World Heritage Property and could take informed decisions about future developments or interventions.

## TEST RESULTS

The e-learning GI S&T course was tested last academic year by first and second year MCMS students achieving good results. Course registration was voluntary but recommended as preparation for the work carried out during the study trip and Risk Mapping project in Petra, Jordan. 22 students registered to the online course and 40% finished it completely, which is a positive equivalent to the average of students that normally finish an online course. After finishing the GIS & T course in less than one month on their own pace, the students were able to both have a basic understanding of and be able to work with the GIS tools for management strategies and risk mapping of the Petra World Heritage Property. (1) For data collection: As a preliminary assessment the tracks or points of significant heritage places and visitor facilities were recorded together with panoramic photos. These points were taken by GPS and later inserted into the GIS system. (2) Planning: Knowing the places and their location could help on the establishment of new services or detect areas at risk. This will lead later to specified protection areas and management zones.

## CONCLUSION

Our case study shows that including GIS training and a special cultural heritage module into the curriculum can be beneficial to the understanding of conservation management processes. Students learn about different techniques to gather and analyze spatial data. This data can improve their knowledge on aspects like risk management and tourism planning. It also enables them to visualize conservation management issues more clearly and more easily manage and analyze large data sets. The next step will be to incorporate the cultural heritage GIS module in the curriculum of the RLICC in the near future.

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# LeGIO 2011

## GIS-education in a changing academic environment

The objective of the LeGIO-workshop was to exchange ideas and experiences about academic GIS-education, to debate about different teaching and learning methods and to increase and facilitate the networking between GIS-educators. The workshop aimed to stimulate the reflection about innovative ways to address GIS-education in diverse and changing environments.

The framework of the 1-day workshop was provided by the educational innovation project LeGIO supported by the K.U.Leuven office for educational affairs and performed by RLICC and two LSUE-members, i.e. SADL and BNL.

These workshop proceedings encompass all the papers presented at the workshop, which was held on the 18th of November 2011, Leuven.

Marianne Hubeau

Editor-in-chief

ISBN 978-90-8826-217-3