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GIS-education: Where are the boundaries?

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Session 1: GI S&T Curriculum Design & Implementation

EduMapping the evolution of an academic GI curriculum – the case of Geomatics at Delft University

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ABSTRACT

This paper shows how EduMapping was used, in combination with Learning Outcomes, to describe the differences between versions of the Geomatics MSc programme at Delft University of Technology. With EduMapping labels, radar diagrams and centroid maps the changes in teaching content are visualized. The Learning Outcomes of each version were used experimentally to find out if the aimed for performance level of the students also changes. This experiment resulted in a change of level, but it is uncertain if it was caused by programme changes or by lack of conformity to the format rules.

INTRODUCTION

The MSc Geomatics programme[1] at Delft University of Technology is judged favourably by the students[2] and by its alumni. Also the staff-members involved in this MSc Geomatics programme are very motivated to educate the students at a very high level and to incorporate research activities into their teaching. So, it is not surprising that the latest visitations showed good marks for the programme, the facilities, and the quality of the education. The only thing is: throughout the last decades the number of registered students did not match the expectations and the potential. Despite a lot of marketing efforts, BSc students just didn't become aware of the existence of MSc Geomatics at Delft University of Technology.

To avoid threatening discontinuation of the programme, it was decided to shift Delft's MSc Geomatics programme from its current inter-faculty status to an independent programme, hosted by the Faculty of Architecture at Delft University of Technology. With regard to content, the MSc Geomatics programme will be of a more applied nature by a stronger focus on the built environment in order to make it more attractive for potential students. Besides, this update of the curriculum will increase the workability ("studiability") of the programme by a modular course setup. The new version of the programme (Verbree and Lemmens 2012) was developed during 2011 and early 2012. To help guard the quality of the curriculum during the update, EduMapping (Rip and Van Lammeren, 2010) was applied. This method includes a simple tool[3] to relate the components of the curriculum to a description of the GI domain: the Geographic Information Science & Technology Body of Knowledge (DiBiase *et al.* 2006), hereafter referred to as "GI-BoK".

EduMapping had been used in Delft to characterize the proposed (2011) and the final version (2012) of the programme. For this paper that was the opportunity to try answer the question: how does the EduMapping content characterization represent the three versions of the programme?

[1] http://home.tudelft.nl/en/study/master-of-science/master-programmes/geomatics/
[2] The Geomatics programme at Delft University of Technology came out 3rd in the 2011 edition of the "Keuzegids Hoger Onderwijs" (N.N., 2011), listing the student's appreciation for academic master programmes in the field of earth sciences, geography and environmental sciences in the Netherlands.
[3] The EduMapping Toolkit: http://www.geo-informatie.nl/rip001/EduMapping/EduMapping.html

Assessment summary	ECTS size	share
GI subjects in BoK	**45.0**	**38%**
AM. Analytical Methods	*6.2*	*5%*
CF. Conceptual Foundations	*4.9*	*4%*
CV. Cartography and Visualization	*2.8*	*2%*
DA. Design Aspects	*3.6*	*3%*
DM. Data Modeling	*4.5*	*4%*
DN. Data Manipulation	*3.4*	*3%*
GC. Geocomputation	*1.9*	*2%*
GD. Geospatial Data	*10.1*	*8%*
GS. GI S&T and Society	*4.3*	*4%*
OI. Organizational & Institutional Aspects	*3.4*	*3%*
New GI subjects wrt mapping in May 2011	**0.0**	**0%**
Application of GI subjects in generic compo	**75.0**	**63%**
Non-GI subjects	**0.0**	**0%**
sum	**120.0**	100%

Figure 1: EduMapping label for Geomatics for the Built Environment 2012

Changes in a teaching programme typically means: introduction of new subjects and / or expansion of the time spent to existing subjects and letting go of obsolete subjects, while the overall programme size remains unchanged. The values in the time/subject matrix, summarized in a label (Fig.1), make it easier to keep track of the consequences of the pruning and grafting process of programme change. In a compact way it shows how the study load of the programme is distributed across subject areas.

During preparation of this paper, a second question arose: how is the evolution of Geomatics reflected in the Learning Outcomes? That is important because they indicate the aimed-for capability level of the future graduates, so the impact of programme changes should be watched. The answers to the questions are relevant for GI curriculum managers and GI teaching programme directors.

Profile of Geomatics for the Built Environment

The web pages of the 2-year 120 credits[4] programme describe it as follows (May 4, 2012):

- "In the first year, you will take the Common Core courses as well as courses from the various Application Domains. The Common Core provides a strong foundation to all students by teaching the fundamentals of data gathering, processing, analysing, and visualisation. Covered topics include 'Positioning and Location Awareness', 'Geographical Information Systems and Geovisualisation', '3D Modelling of the Built Environment', 'Geo Datasets and Quality', 'Geo Databases Management Systems', 'GeoWeb Technology, 'Spatial Decision Support', and 'Geo-information Organisation and Legislation'.
- The application domains are sets of interlinked courses meant to broaden and/or deepen the students' knowledge in one of the many Geomatics application fields: Urban Analysis, Asset/Facility Management, Water management, Hydrography, Remote Sensing and other geo-related fields. If you need to update your knowledge in Mathematics, Computer Science or basic geographical courses you can use a portion of the application domain credits to follow convergence courses."
- "In the second year, students can choose to undertake the Geomatics Synthesis Project or follow additional courses from one of the Application Domains. The Synthesis Project allows you to combine knowledge from the core programme and apply it to a real-world project while gaining hands-on experience in project management. The MSc in Geomatics is concluded with an individual graduation project that takes about 9 months to complete."

[4] In Europe, a 'credit' represents a study load between 26 and 28 hours. In full: ECTS, European Credit Transfer and Accumulation System

The courses in the Common Core part take up 45 credits. This is the part that can be mapped to GI-BoK. The GI-component in the various application field courses or supporting convergence courses varies. It has not been mapped. Together, their study loads are 30 credits. The individual graduation project represents another 45 credits. It is important to note that only the Common Core part of the programme could be mapped to GI-BoK. The non-mappable 75 credits are booked as ‘generic’ GI.

METHOD

Use of EduMapping implies acceptance of a limited set of concepts to describe the contents of a teaching programme: the GI Body of Knowledge with its hierarchical structure of hundreds of Topics organized in some 70 Units across 10 Knowledge Areas. Use of EduMapping results in a matrix, showing amounts of study load (in credits) against subject areas. In the present version of the tool, a GI programme could be mapped to GI-BoK on the Units-level of detail. Edumappings of all three versions of the programme were made by Edward Verbree, programme manager of the present version of the Geomatics curriculum. The sets of Learning Outcomes of the 2010 version of the programme and the 2012 version were written by the teaching staff. For the proposal-version of 2011 no Learning Outcomes were formulated.

Edumappings comparison

The primary outcome of applying EduMapping is the label. It shows the distribution of study load in credits per content category. The four categories show: which share of the programme can be linked with GI-BoK Knowledge Areas, which share is clearly GI but not present in GI-BoK, which share is GI but cannot be linked to specific GI-subjects (hence: “generic”), and finally the share of the programme which is clearly not GI.

The first category, GI in BoK, provides most details. This invites further comparison. The quantitative nature of the edumappings allows a straightforward tabular comparison of the study load values per GI-BoK subject for the three versions. The 2011 version and the 2012 version of the programme were assessed on the level of GI-BoK-Units, but the 2010 version was assessed on the less detailed Knowledge Area level. This makes Knowledge Areas the preferred level of detail for comparing the three versions of the curriculum.

Please note that the assessment activity, required to produce the figures, is less straightforward. There clearly is an element of subjectivity involved, as was indicated in (Rip and Van Lammeren 2010). Sensitive parts of the process are the assignment of GI-BoK items to parts of the programme description, and also the quantification of their share of the whole.

The figures resulting from the assessments allow arithmetical processing and enable graphical presentation. Two types of visualization were created with Microsoft Excel: a Radar diagram and Scatter diagrams. For this purpose, the GI-in-BoK category in each label was taken to represent 100% of the programme. For that purpose the scores per Knowledge Area were recalculated to their part of 100%. This gives normalised shares for the dedication of study load to each of the Knowledge Areas.

The Radar diagram shows the 10 GI-in-BoK values by a polyline. Comparing different versions of the programme then means: check in which of the ten directions which polygon has higher or lower values. However, doing this for more than a few polylines soon becomes too complex.

To reduce the complexity of comparing more than a few polylines, their centroids can be calculated. The Scatter diagram was used to show the positions of the centroids of the three Geomatics versions in a two coordinate reference system. For this spatialization purpose, a little data processing was required: grouping, value addition per group and centroid calculation. This process was explained in (Rip and Van Lammeren 2010), and it is included in the EduMapping Toolkit.

Scatter diagrams were also made of the centroid coordinates for the individual modules of each version of the programme, altogether about 40 of them.

Comparison by means of Learning Outcomes

Nowadays, in the European Higher Education Area, Learning Outcomes (LO) are essential to describe qualifications to be obtained at third level institutions. LO's are defined as a statement of what a learner is expected to know, understand, and/or be able to demonstrate after completion of a process of learning. The standardized format of a set of LO's starts with the phrase "On successful completion of this module, students should be able to:", followed by descriptive triplets of the form: active verb – object – context for each LO (Kennedy 2007). It is recommended to formulate four to six LO's for a teaching module. In each LO, only one action verb should be used. A guide to help which verb to choose can be the non-exhaustive lists of verbs for each of the six stages of Bloom's taxonomy (fig. 2). These 6 stages represent performance levels, for which learners could acquire the ability. Bloom also defined performance levels for the affective domain and the psychomotor domain, but here only the cognitive domain is relevant.

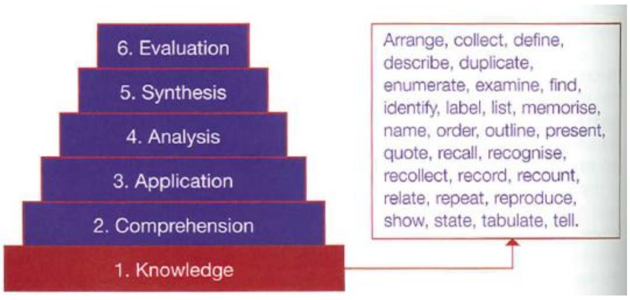

Figure 2: The first stage of Bloom's Taxonomy, with suitable active verbs (Kennedy, 2007)

For the Delft Geomatics MSc programme, LO's were available for the 2010 and the 2012 version of the programme. They were experimentally processed as follows. For each LO it was determined to which performance level the action verb belonged. In a number of cases, the LO contained more than one action verb, in which case the one belonging to the highest performance level was chosen to represent the LO. The other two components of the LO, the object and the context, were not taken into consideration. The performance level for a group of LO's (ideally 5 LO's per module) was calculated by simply averaging the set of values. This approach produced performance values for the individual modules. For the programmes, the values for their individual modules were also averaged.

It appeared, that the LO format rules have not been followed very closely when making LO's for the Geomatics 2010 version. For some 2010-modules, this required a more than average amount of interpretation by the authors to decide which active verb(s) might give a fair representation of the teaching intention of those modules. Then the number of the appropriate Bloom-stage was taken to represent the performance level for that LO.

RESULTS

EduMapping products

Three types of results were available from the collected EduMapping excel sheets.

1. Labels. The values in the labels of the three versions are shown in Table 1.
2. Radar diagrams. The visualisations of the In-BoK categories (columns 'c' in Table 1) are in Figure 3.
3. Centroid coordinates. They were also calculated for the c-columns in Table 1.Their values are shown in scatter plots in Figures 4 and 5.

Figure 4 shows the centroids of the Knowledge Area scores for the EduMappings of the three programme versions in a two-dimensional space (explained in Rip & Van Lammeren 2010). The horizontal axis (x) reaches from all time spent on Society & Organisation subjects (left) to all time spent on Concept/Methods/Tools subjects. The vertical axis (y) reaches from all time spent on Physical Reality (top) to all time spent on Presentation (bottom). The resulting centroid coordinates were: x:6.03, y:8.87 for 2010; x:0.65, y:11.76 for 2011; 7.93,10.33 for 2012.

Figure 5 combines the centroid representing a version of the whole programme with the centroids representing the individual modules of the programme. It shows the centroid clouds for the three Geomatics editions.

Table 1: Values in the labels resulting from EduMappings made by E.Verbree. The values in the columns marked 'c' were used for visualisation in radar diagrams and for calculation of the centroid coordinates.

	Geomatics 2010			Geomatics 2011 (concept for 2012)			Geomatics 2012 – for the built environment		
	a. ECTS	b. share	c. In-BoK =100	a. ECTS	b. share	c. In-BoK =100	a. ECTS	b. share	c. In-BoK =100
GI in BoK	47.0	39%		51.0	43%		45.0	37.5%	
AM	*7.0*	*6%*	14.9%	*5.5*	*5%*	10.8%	*6.2*	*5%*	13.7%
CF	*3.0*	*3%*	6.4%	*2.0*	*2%*	3.9%	*4.9*	*4%*	10.9%
CV	*3.0*	*3%*	6.4%	*5.0*	*4%*	9.8%	*2.8*	*2%*	6.3%
DA	*2.5*	*2%*	5.3%	*2.0*	*2%*	3.9%	*3.6*	*3%*	8.0%
DM	*4.5*	*4%*	9.6%	*11.0*	*9%*	21.6%	*4.5*	*4%*	10.0%
DN	*3.0*	*3%*	6.4%	*0.0*	*0%*	0.0%	*3.4*	*3%*	7.5%
GC	*3.0*	*3%*	6.4%	*2.5*	*2%*	4.9%	*1.9*	*2%*	4.2%
GD	*11.0*	*9%*	23.4%	*12.0*	*10%*	23.5%	*10.1*	*8%*	22.3%
GS	*6.0*	*5%*	12.8%	*3.0*	*3%*	5.9%	*4.3*	*4%*	9.5%
OI	*4.0*	*3%*	8.5%	*8.0*	*7%*	15.7%	*3.4*	*3%*	7.6%
GI Not in BoK	10.0	8%		6.0	5%		0.0	0%	
Generic	56.0	47%		60.0	50%		75.0	62.5%	
Not GI	7.0	6%		3.0	3%		0.0	0%	
sum	120	100%	100%	120	100%	100%	120	100%	100%

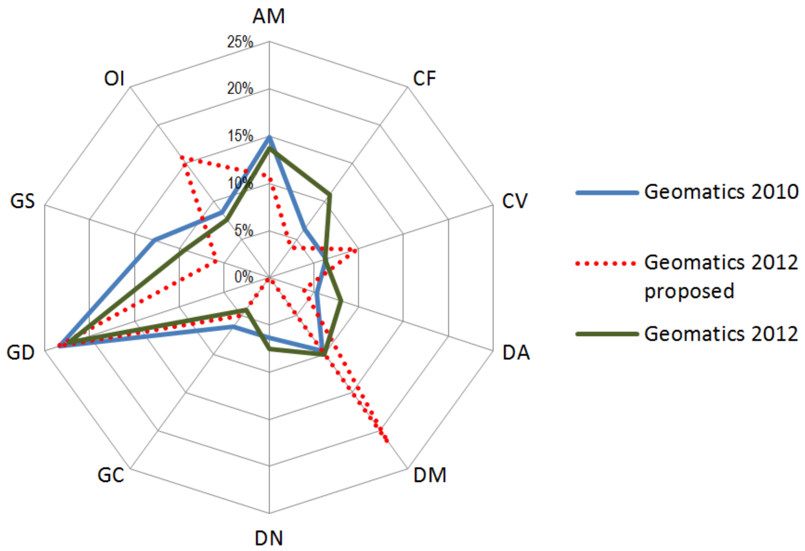

Figure 3: Three overlaid Radar diagram polylines representing the three versions of the Geomatics programme, as mapped on 10 GI-BoK Knowledge Areas by E.Verbree.

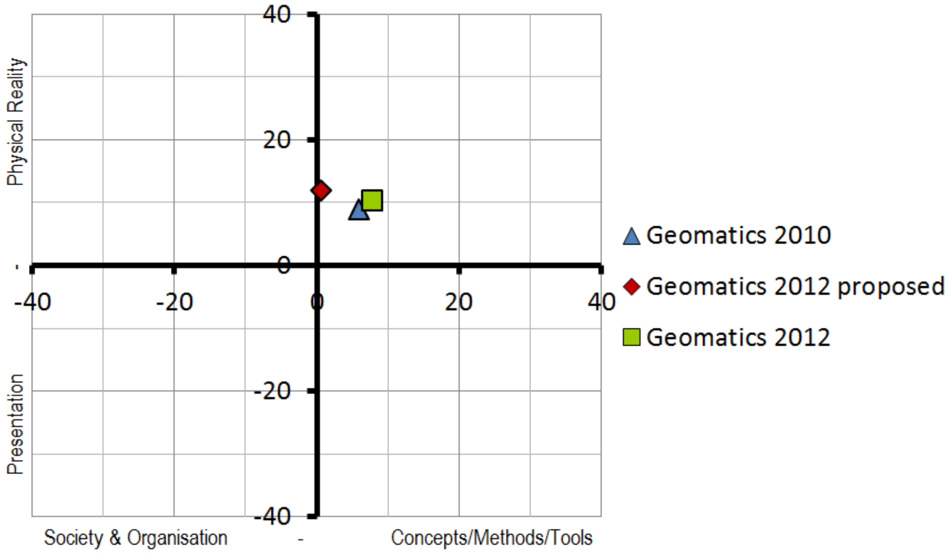

Figure 4: The centroids of the Knowledge Area scores for the three EduMappings in a two-dimensional space.

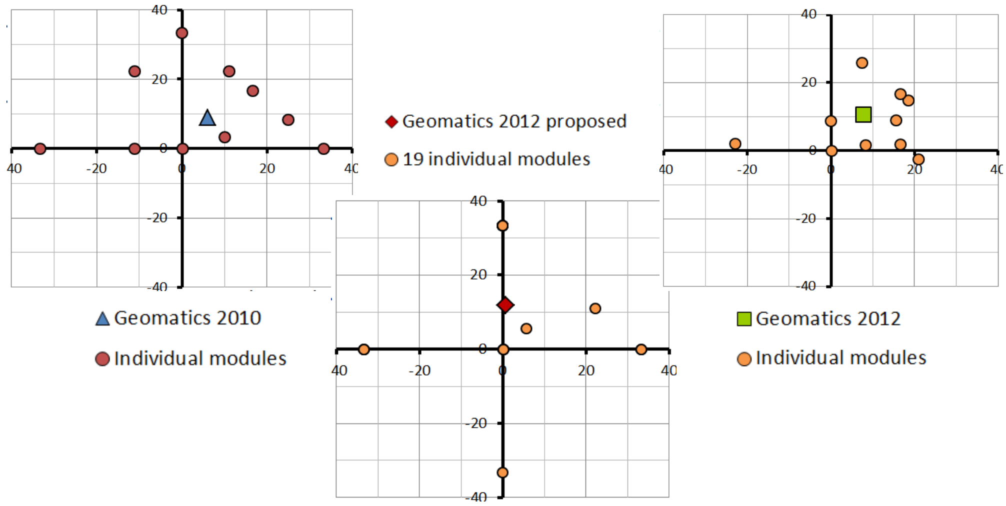

Figure 5: The clouds of centroids for the individual modules of the 3 Geomatics programmes

Learning Outcomes

Lists with LO's were available for the 2010 version and the 2012 version of Geomatics (Verbree and Lemmens 2012).

The analysis of the learning Outcomes per unit in the core programme resulted in the following average values for the performance levels of students that successfully completed the units.

Table 2: Overview of the intended student performance level for Geomatics 2010 and 2012 versions, based on the available Learning Outcomes

Core programme MSc Geomatics 2010 – 29 ECTS		Core programme MSc Geomatics 2012 – 45 ECTS	
GM1050. GIS Principles and Applications	4.2	GM.1 Sensing Technologies for the Built Env.	1.0
GM1080. Geo Database Management Systems	1.5	GM.2 GIS and Cartography	4.8
GM1090. Introduction Geomatics	2.0	GM.3 Positioning and Location Awareness	4.2
GM1210. Location Based Services	3.8	GM.4 3D Modelling of the Built Environment	5.6
GM1240. Imaging Remote Sensing	2.7	GM.5 Spatial Decision Support for Planning and Crisis Management	4.4
CIE4521. Multivariate Data Analysis	2.3	GM.6 Geo Database Management Systems	4.3
CIE4522. Satellite Navigation	2.5	GM.7 Geo Web, Sensor Networks and 3D-Geo Visualisation Technology	3.8
GE4662. Org. and Legal Aspects of Geo-Inf.	6.0	GM.8 Geo Datasets and Quality	3.8
		GM.9 Geo-information Org. and Legislation	5.2
Overall average performance level (scale 1-6): 3.1		Overall average performance level (scale 1-6): 4.1	
Remarks: For 9 modules there were 15 content descriptions, interpreted as 25 LO's. The LO-format was not used in 5 descriptions.		Remarks: Nr. of active verbs: 79 in 40 LO's. Maximum was 4 verbs in one LO. Most verbs were in vocabulary offered by Kennedy (2007).	

FINDINGS

The objective of this paper is to show the usefulness of the EduMapping method for concise description of GI teaching programmes and, in spite of that compactness, be able to compare their contents. The focus here is on showing a few steps in the evolution of the Geomatics MSc programme at Delft University of Technology. The findings from the two views on the programme versions are described below.

Edumappings

The comparison of labels in Table 1 shows many figures. Looking at the four horizontal main categories, it is clear that the study load of the GI-in-BoK category stays under 40% of the programme. In the 2011-proposal its share was 43%, an increase that apparently did not survive discussion. A second remark is, that in the 2012 edition of Geomatics no time is spent to GI subjects that are Not-in-BoK, or to subjects that are not GI. However, the textual description of the programme on the website shows that supportive courses could be taken in for instance mathematics or computer science. And that part of the Common Core is a module on GeoWeb Technology, which is not a lengthy item in GI-BoK. The programme allows students to follow an individually profiled sequence of modules. The use of EduMapping requires specific choices, otherwise links to BoK-items cannot be made. So the focus on the Common Core part is in fact too narrow to show the full spectre of the programme. Nevertheless, the GI-in-BoK category shows a nice subdivision of how the study load touches on all Knowledge Areas, and how it differs between the versions of the programme.

Figure 3, the Radar diagram, shows superimposed polylines for the GI-in-BoK category of each programme version. More pregnant than in Table 1 it shows the proposed changes in 2011 for the Knowledge Areas Data Modelling (DM), Data Manipulation (DN) and Organizational and Institutional Aspects (OI).

Figure 4 shows the centroid positions for the three Geomatics versions. On this aggregation level, the 2012 version is pretty close to the 2010 version. The 2011 version was a little more data oriented and had a considerably stronger orientation towards Society and Organisation.

Figure 5 shows all three versions in separate plots, with the centroid positions representing their individual modules. The point cloud provides more context. It shows for instance that Geomatics 2010 had three modules in the left half of the plot, whereas Geomatics 2012 only has one. This explains why in Fig.4 the 2012 centroid position is a little more to the right than the 2010 centroid.

Learning Outcomes

At first sight, Table 2 shows that Geomatics 2012 aims for a 25% higher overall average performance level by its graduates. This generates questions: For which subjects? and: Is it plausible?

To answer the first question a comparison of the EduMapping labels of the Geomatics versions is helpful, because it shows how much of the study load is directed at which GI-BoK subject. There, the different module names and the different number of modules play no role.

To answer the second question it is relevant to look at the Learning Outcomes themselves. In this case it appears that especially of the Geomatics 2010 LO's many were not LO format compliant. In the non-compliant cases, the active verbs were chosen by the authors, based on the provided sentences. The teaching staff might have chosen other active verbs, having in mind how they would examine and test the student's progress. Therefore, the calculated performance level values for Geomatics 2010 cannot be trusted. The change from value 3.1 to value 4.1 is not entirely credible, due to the quality of the 2010 Learning Outcomes.

CONCLUSIONS AND RECOMMENDATIONS

The preceding chapters of this paper showed how a GI curriculum could be characterized by making EduMapping assessments and by using the Learning Outcomes. In the opinion of the authors this approach is useful for programme management and to provide GI programme information to prospective students, GI employers and professional GI organizations.

However, remarks must be made about a number of limitations to the application of these methods.

Assessor subjectivity

The subjectivity in selecting a GI-BoK item and a time share to represent an aspect of a course or programme is unavoidable. Also, LO writing is prone to subjectivity. In this case, the edumappings were done by the person now carrying responsibility as programme director. The advantage here is in the fact that this person has also been involved with two earlier versions of the MSc programme, which implies a certain continuity and experience in linking teaching content to GI-BoK.

If this is better than a collection of edumappings made by different persons might be the subject of another paper. Asking individual members of staff to make edumappings for modules they teach would introduce the impact of personal differences in interpretation, skill (familiarity with GI-BoK) and attitude (patience to assign study loads to parts of an existing programme).

The authors see the following strategies to deal with subjectivity:

- EduMapping assessments and LO formulation should be done by the person closest to the actual teaching. This would cause the transfer of as much of the teacher's experience and plans as possible into the results.
- If GI-BoK could be compared to a language, than it would be best for the international GI community to learn that language, teach it, and use it to set up GI courses from the start. This would reduce the need to translate to and from GI-BoK.

At this place, it seems good to point at the fact that the most detailed level of GI-BoK, the Topics, consists of LO-like sentences, more than 1600 in total. In GI-BoK they are referred to as "formal educational objectives" (DiBiase et al. 2006, p.30). They are surprisingly similar to the Kennedy's LO's: they also start with an active verb. The GI-BoK Topics offer a wealth of LO-like sentences for each of the GI-BoK Knowledge Areas.

- Use subjectivity by asking less involved colleagues, or even colleagues from abroad, to make an EduMapping assessment of the same course and formulate LO's for it. Then discuss the resulting differences. These discussions might bring out different opinions on the focus of the curriculum, hidden implicit assumptions or local terminology. That should lead to adaptation of the course description.

GI-BoK imperfections

At the AGILE[5] conference 2012 in Avignon, France, one of the authors of this paper did a short poll about GI-BoK during a presentation with about 100 people present. It appeared that 80-90% was aware of GI-BoK, about 50% was familiar with it, and about 10% liked it. It seems justified to criticise GI-BoK for a diversity of reasons (usability, content, up-to-dateness). Reinhardt (2011) did so. However, this should not lead to dismissal of that work. It has been a point of departure for the Geospatial Technology Competence Model published by the United States Ministry of Labor (DOLETA 2010). It also was the basis for on-going "foundational research" (Ahearn *et al.* 2012).

This research is funded by the American National Science Foundation. The objective is to develop a successor "GIS&T BoK2" with a web 3.0 character. The GI Body of Knowledge does have a future! In this situation, the recommendation of the authors is to make do with the paper version of GI-BoK, for now. Build up experience and familiarity and in this way prepare for BoK2.

Context

The concept of EHEA, the European Higher Education Area, ensures that teaching in Europe will become more coherent between countries. The European Qualification Framework is a translator to connect teaching levels in one country to those in another country by means of Learning Outcomes. Of course a disciplinary reference is also needed. GI-BoK could be just that for GI Education.

[5] AGILE: Association of GIS Laboratories in Europe. Membership in 2012: 89 in 23 countries.

EduMapping can help to convert existing programme and course descriptions to GI-BoK referenced descriptions. In that way a “common ground” could be created for all actors in the GI education field.

In the Netherlands, an important actor is CROHO, the central register for third level education, agency of the Ministry for Education. If an already accredited programme like Geomatics wants to update or refocus, CROHO asks NVAO, the national accreditation organisation, to check if the intended changes stay within bounds. This visitation of the Geomatics for the Built Environment programme will take place before the end of 2012. The authors expect that the EduMapping results will help to satisfy the visitation committee that the change in identity of the programme does not require re-accreditation.

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Tools and Methods for Defining an Industry-Validated Model GIS&T Program Curriculum

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A great deal of effort has been expended to determine what skills and competencies should be included in curriculum for a broadly defined GIS&T profession. The recently published Teaching Geographic Information Science and Technology in Higher Education (2012) discusses this topic in depth including past efforts to better define the competencies needed by its workforce and the curriculum needed to prepare graduates for this industry. This presentation will cover one of these efforts in the USA lead by the National Geospatial Technology Center of Excellence (GeoTech Center).

The GeoTech Center, funded by USA National Science Foundation, focuses on two-year college GIS&T programs to expand the quantity and quality of graduates. In order to develop curriculum guidelines, the GeoTech Center needed to establish what specific skills and competencies a graduate seeking entry level employment in GIS&T needed to possess.

The USA Department of Labor Employment and Training Administration (DOLETA) developed a Draft Geospatial Technology Competency Model (GTCM, 2009). A Competency Model provides a framework for listing foundational and technical skills and competencies needed by economically important industry.

The GeoTech Center volunteered to collaborate with the DOLETA to finalize the Draft GTCM. David DiBiase convened a panel of industry experts and under his guidance, came to a concensus on the GTCM which was approved in the summer of 2010. While the GTCM provides a good frame-work for the industry, it does not specify the competencies for a specific occupation. The GeoTech Center, focusing on entry-level geospatial occupations, held several DACUM events. DACUM stands for Developing A Curriculum and is a process of bringing together 10 to 12 expert workers under the guidance of a facilitator (John Johnson) to identify what they do and what they need to know for their occupation.

One criticism of the process is that it is time and place specific. To overcome that objection, Johnson created a new methodology to combine the output of multiple DACUMs and have them validated by working GIS&T professionals. The Meta-DACUM was then compiled into a list of approximately 320 skills and competencies. The next step was to bring together faculty teaching GIS&T programs to help define how this list of competencies could be covered in a program. More than 70 educators participated in multiple one-day workshops to define what competencies at what depth should be included in each Model Course. Four courses have been completed including a stand alone "Spatial Awareness course" and the first 3 courses (Introduction to Geospatial Technology, Spatial Analysis and Data Management and Acquisition) in an 8 course Model Certificate Program. Three more Model Course workshops are scheduled for March and June (Introduction to Remote Sensing, Cartography and Visualizatio n, and Programming and Application Development). Each Model Course includes a syllabus, outline, evaluation rubric and other resources. All are available free at http://geotechcenter.com. A Program Assessment Tool was also created and is currently available as an Excel Spreadsheet. This Assessment Tool can be used by current programs to see how they align with the suggested needed skills and competencies and may be useful for comparing programs at different institutions.

6 universities, using the best for one nation-wide Geo-information minor

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Seven universities (Free University, Amsterdam; Delft University, Groningen University, University Twente, University Utrecht and Wageningen University) in the Netherlands offer at the moment several courses in Geo-information (GI) education at both Bachelor and Master level.

As foreseen in the Bologna education and from several discussions lead by SAGEO (the Dutch cooperation between GI educational institutes and the employers) we decided to develop a national minor in GI.

The minor aims at the best of the different universities by using best practices and each specific flavours and specializations.

The presentation will discuss several aspects:

- How to decide the objectives and contents of the minor? The results of different interviews and questionnaires with possible students are shown
- What is needed for marketing of the minor?
- How do you develop together a minor?
- How do you deal with the financial and administrative issues?

Ad 1

More than 5 meetings where necessary in order to speak each other language. Although the Netherlands is a small country and some of us know each other for a long time, it was necessary to exchange the contents of the course and methods and formats of education.

We discussed two major groups of expected students: students without any preliminary GI education and our own students with some GI introductory education. After making of a short statement, including different titles of the minor, interviews were done with prospective students, showing the material. Results indicated that the first group was very difficult to make them enthousiastic. The gap with the possible needs and interests in GI and the offer of the minor was too large.

Ad 2 Marketing

The minor is meant to students with some background in GIS, in general based on an introductory course at their faculty. However, also other students from various other disciplines than the traditional ones are an interesting target group. The major problem is how to target both groups, not only because both groups differ in GI knowledge and skills, but because of the problem how to find the non-traditional groups. Their awareness of the discipline is poor and their interest is often rather specific, based on an idea that they are working with spatially referenced data but are missing a tool to handle it.

Important in this context is SAGEO. They are able to support the development group with knowledge on marketing, contacts with professionals (the potential employers) and access to target groups. For marketing purposes, also the results of the interviews with prospective students have been used. Among the issues was the name of the GI-minor. It seemed that fancy names, such as “GI4you”, were by far the least popular. This is the reason to choose for the straightforward option “Geoinformation minor”.

Ad 3 Course development

It took quite some time, as indicated above, to find a common basis to decide to start developing the minor. Once all partners decided to “go for it”, other issues to agree on were the intended audience, objectives, structure and size of the modules, the mix of theory and practice, the number and type of guest lectures and the balance between existing and new material, the organizational “home” of the minor and which institutes were at the end really willing and able to actively participate. Once this was set, the contents of the GI minor became the prime focus.

About the structure, it was decided for a 30 ECTS minor with four modules The first two modules were about geo data acquisition and GI analysis and visualization. The third module gives the opportunity to make a choice for one of the existing specialization modules at the participating universities. Examples of such choices are location based services, remote sensing, and GI and spatial accessibility and networks. The fourth module is a case study, possibly in conjunction with an internship.

Developing takes time and time is scarce, also for those involved in developing this minor. However, there was a clear need to come with a rather detailed course plan, with for each module a complete list with topics, lectures, literature, lab activities and assignments and case studies. It was expected that allocating homework to individuals would not be efficient and would not provide the unique opportunity to base the new minor on each others strengths. The solution was found in so-called pressure cooking meetings (PCM). Two of those meetings took place in early 2012, one in January (two subsequent days) and one in February (one day).

The first PCM was used to first decide on a common structure of the first two modules in terms of issues such as teaching days, the number of contact hours and so on. Once decided, groups of lecturers worked together on the contents the two basic modules and the fourth module. During the two days, feedback on each others progress took place as well as discussion on a common issues such as course level and which textbook to use. After the first PCM, the body of the two introductory modules was agreed on.

During the second PCM, the results of the first PCM was evaluated, followed by filling in the gaps, identifying and solving the overlaps and working out each modules in terms of (guest) lectures, lab sessions, assignments and case study.

Ad 4 Financial and administrative issues

During the second PCM, the marketing approach was discussed and input was provided for website and brochure. Next, administrative issues were dealt with in order to allow the “home” university to meet the need for course descriptions, course schedules to make the necessary room reservations and all other administrative issues to take care of a proper course registration. The choice was to host the minor at one faculty (Free University of Amsterdam, VU). Students from different universities can subscribe for the minor-modules at the VU, while in the mean time they remain registered at their own university. The payment of the lectures participating in the minor will be based upon a regular tariff per lecture unit. During the development of the modules, the estimated work load was more or less equally divided among the participating universities.

The process of developing the minor was made possible by a sponsorship via SAGEO.

Final remark

By crossing boundaries of different disciplines and cultures a better, more complete and well balanced curriculum can be offered. It is interesting to note that during the development of the curriculum, there was hardly any discussion on priorities in what to teach. This is not to say that current GI courses at the distinct universities are similar. There are clear differences, based upon the type of curriculum. Each GI course is in fact a selection of GI issues that is relevant for that particular discipline. Having more hours to spend in a minor brings the opportunity to present a broader set of issues to teach.

Working together in PCM’s proved to be a success, it was focused and stimulating and the results look promising. The future will learn how it will work in practice and even more important, how our students will react.

Curriculum Design Based on the UC GI S&T Body of Knowledge Supported by a Software Tool

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INTRODUCTION AND MOTIVATION

The usage of the UCGIS Geographic Information Science & Technology (GI S&T) Body of Knowledge (BoK) [DiBiase et al, 2006] for various purposes has been discussed intensively at quite a number of workshops and conferences in the European GI communities since its introduction in 2006 [e.g. Johnson et al, 2006, Reinhardt and Toppen, 2008, Rip, 2008]. In general, these discussions reveal the BoK as a valuable tool which could be used for e.g. curriculum design and comparison. But some weak points have also been identified beyond its expediency, e.g. inadequate representation of SDI topics within the content of the BoK, missing consideration of a “depth-factor” related to the BoK etc. Moreover, some people expressed the opinion that a BoK as a pure text is not very comfortable to use and therefore, conveyed a clear demand for a machine readable implementation of the BoK so that the BoK content could be stored in a data base and further extended by developing suitable tools to handle the data and to support various user activities.

This paper deals with the usage of the BoK for curricula design, which includes a short discussion of extensions of the BoK as well as some tasks in curriculum design. The main part of the paper is to introduce a software tool which allows for the usage of the BoK and other sources for some tasks in curriculum design. The paper is therefore structured in the way that the next section includes a short discussion of possible extensions of the BoK and some comments on the way these extensions are developed. Thereafter, some selected tasks in curriculum design are described. These tasks should be supported by the software tool which is described in the following main section of the paper. Finally some conclusions are drawn.

SOME COMMENTS ON THE EXTENSION OF THE CONTENT OF the BoK

As already stated in [Reinhardt and Toppen, 2008] the BoK primarily includes a Geographic View on GI S&T and especially IT issues are not adequately represented. In [Reinhardt, 2011] a suggestion was made to add a SDI and a programming knowledge area (KA) to the BoK. For the SDI KA the following topics have been suggested:

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 …)

It was also emphasized that the content of these knowledge areas is seen as a first draft and should be defined by the community of organisations / persons involved in teaching GI issues, to make sure that the different perspectives (technical, societal …) and backgrounds (Computer Science, Geography, Engineering …) of these organisations are represented.

At the AGILE 2012 preconference workshop "Views on Body of Knowledge" (VoB) the “BoK2” initiative was presented (Ahearn, 2012) which includes a complete different approach compared to the existing BoK (“BoK1”). As BoK1 was in line with the general body of knowledge concept and presented a collection of content (knowledge areas, units, topics, themes) in form of a text book, the BoK2 project includes foundational research related to the BoK. This research includes ontology as a base to handle e.g. taxonomies and to be able to map different content. A semantic wiki and sophisticated visualization tools are also included in this research. In a later stage a platform will be developed which allows for a tool based handling of the BoK. It is planned that through this platform experts in GI can contribute to the further development and maintenance of the BoK. For more details related to BoK2 refer to (Ahearn, 2012).

TASKS IN CURRICULUM DESIGN

Curriculum design includes quite a number of levels and also of tasks from the planning of a study program down to the planning of a lecture. An overview on these levels and on different approaches can be found in [Painho et al, 2006] and in the literature given there. This paper will focus on the planning of the content of module units and lectures. As already described in [Reinhardt, 2011] the authors had to define new GI related modules in different study programs like Computer Science, Information Systems and Civil Engineering. The challenges within this were the different background and study goals of the students as well as the different number of ECTS credit points dedicated to the GI related modules. More details on these issues can be found in [Reinhardt, 2011]. The structure of our study programs is included in figure 1. The lecturers are in fact responsible for designing the module level and below; up to lecture level and the program coordinator on the other hand usually taking care of the rest of higher levels.

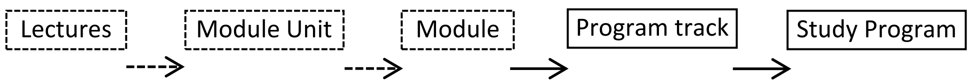


Figure 1: Structure of a study program

Only the lectures, module units and modules are dealt here in this paper. The ECTS credit point for a single module usually varies in a range of 4 to 10. The modules in general consist of two or more – but very seldom more than three - module units. Module units consist of around 12 lectures/exercises/seminars with 90 or 135 minutes each. To define the content of lectures and module units a number of considerations have to be taken into account, for example:

- The background of the students
- The goals of the study program / program track
- The number of credit points dedicated to the module unit

Along with the above mentioned considerations, the knowledge depth for each lecture has to be determined. There are three defined levels of depths.

- to know about it
- to be able to apply it
- to be able to implement it (especially GI methods/functions)

The planning of the content of a module unit can be performed based on a list of possible topics to be taught which could be the BoK or parts of it. From these topics the concrete topics have to be chosen considering the items explained in this section (background, goals, and credit points) and have to be assigned to lectures. To support this tasks a software tool was developed, which should include the following functions as a minimum:

- The possible content of GI education should be stored in a suitable structure in a data base. It should be possible to extend the content. For reasons of simplicity the BoK – and its general structure - was used as a base. The SDI extension of the BoK described in section 2 was incorporated.
- The content of the data base should be visualised to be able to view the content graphically.
- Also queries related to the content should be supported.
- The definition of the content of a module unit (or of lectures) should be supported. Therefore a graphical selection of content and an assignment of content to module units / lectures are necessary. The content of a module unit has to be stored in a defined structure in the data base to be able to present it graphically and also to modify or update it.

A SOFTWARE TOOL FOR CURRICULUM DESIGN BASED ON BoK

Since the BoK follows a consistent hierarchy, it is possible to implement it in a database system for easy update and modification. This section introduces a new software tool which implements the BoK in a database system and assists one application of BoK among many. The tool as an initial attempt of automation covers only the curriculum design application area of BoK. Further application areas of BoK such as curriculum analysis, program evaluation and assessment, curriculum revision, program articulation etc. would be incorporated in the tool in near future.

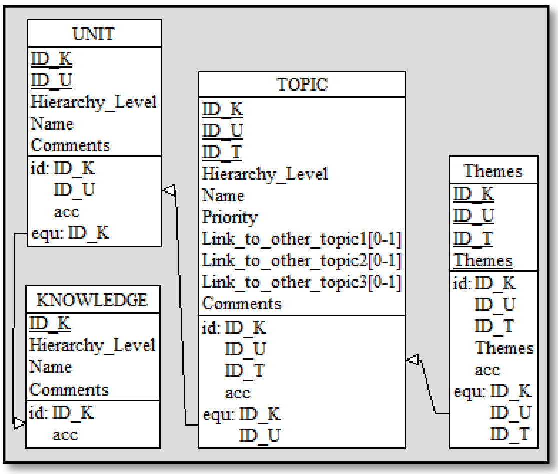
Design and Implementation of the Tool

The architecture of the tool could be compared with the three tier client-server architecture. The database of the BoK content resides in the data tier while the GUI or user interface acts as client which executes the functionalities through application or server tier. So the three tiers are: data tier, server or application tier and client tier (fig. 2). The tiers are described below in more detail.

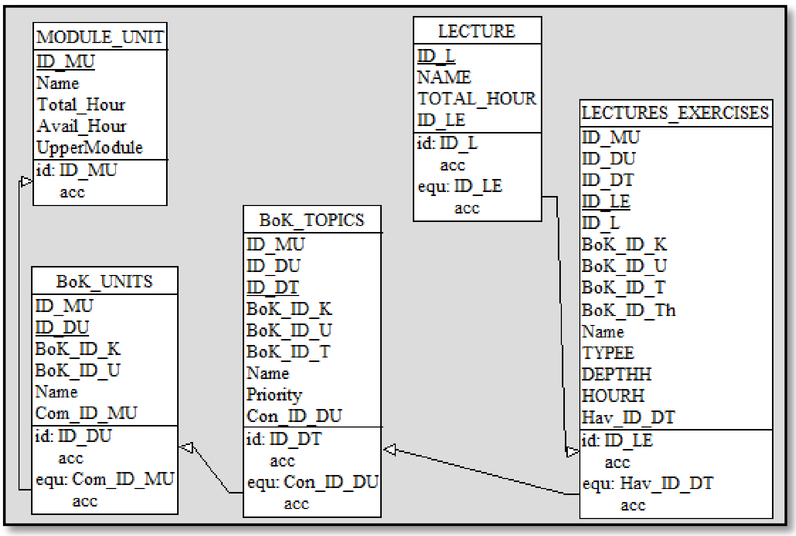
Figure 2: Simple architecture of the tool

The data tier contains the database of extended BoK content and a template of project database. Those are in fact MS Access databases with .accdb extension. Modelling of those databases has been done with DB Main - a free data modelling and data architecture tool. Figure 3 shows the data model of both databases. The consistent hierarchical nature of BoK content imposes a simple but very steady design of its data model. The superior hierarchical class is always related with its subordinate class by one to many relationship that means each Knowledge Area contains many Units, each Unit then contains many Topics and finally each Topic contains many Themes

The project data model on the other hand is almost identical with the BoK data model with a slide change. The LECTURE_EXERCISE class which is in fact derived from the Themes class from BoK data model is the main class and related with two different classes: Lecture and BoK_Topics with the relationship: many to one (fig. 3). The rest of the classes follows BoK data model in a similar way.



Bok data model



Project data model

Figure 3: Data models

All the program, queries and data technologies reside in the application/server tier. The Visual Basic .NET has been used as a programing language, SQL as a query language and ActiveX data object for .NET (ADO.NET) as a data object. The main task of the application tier is to process the commands from client as well as to provide the output to the client by making connection to the appropriate database, data retrieval and data modification etc.

The client tier contains the graphical user interface of the tool and some graphic modules to show the outputs from the application tier in a more meaningful ways. The graphical user interfaces (GUI) as well as the graphics modules are also programmed by Visual Basic .NET. The users in fact send different commands to the application tier and get visual outputs through the GUI.

EXAMPLE OF THE USAGE OF THE TOOL

The tool has mainly four basic functionalities. They are: BoK database modification, data query, graphical presentation and navigation of the database and course/curriculum design. All the functionalities are described below in more detail with necessary screen shots.

BoK Database Update

The first two sections of this paper have already described the need of a new extension of UCGIS S&T Body of Knowledge. It is, therefore, expected that the content of BoK cannot be considered as static but rather would be modified over time in form of content addition, deletion and modification. To make such kind of modification easy, BoK tool incorporates a data modification interface through which a user or respective authority can easily add, delete or modify any content area of the BoK. Obviously, the process of modification of BoK content should be systematic and could be done in many possible ways like WiKi, cloud etc. But this is another research question and is not the scope of the present paper.

BoK Database Query

The query interface enables the user to see any content area of the BoK in textual form based on its uppers hierarchical element. To be more precise, user can see all the Units that belong to a particular Knowledge Area, all the topics belong to a specific Unit and all the Themes belong to a specific topic. This interface helps the user to navigate through the BoK content in an easy interactive way. A screen shot of the interface is given below by figure 3.

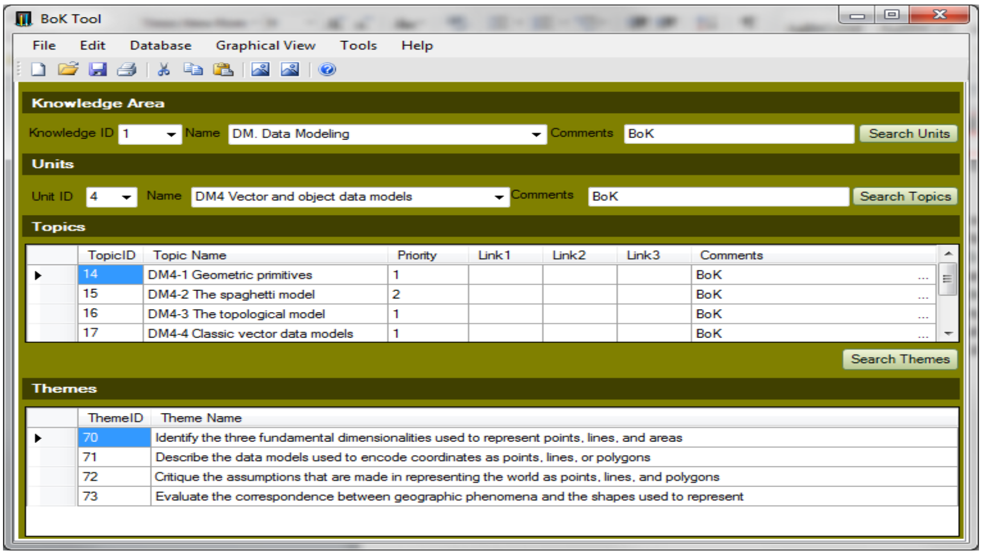


Figure 4: Data query interface

Graphical Presentation and Navigation

This interface has been designed to provide a complete overview of BoK content as well as to enable users to navigate through the BoK content graphically but at the same time keeping other content in the view area to understand the relationship of each element with others. A screenshot of the interface (generated for test purpose) is given in figure 4 which in fact covers a small portion of BoK content.

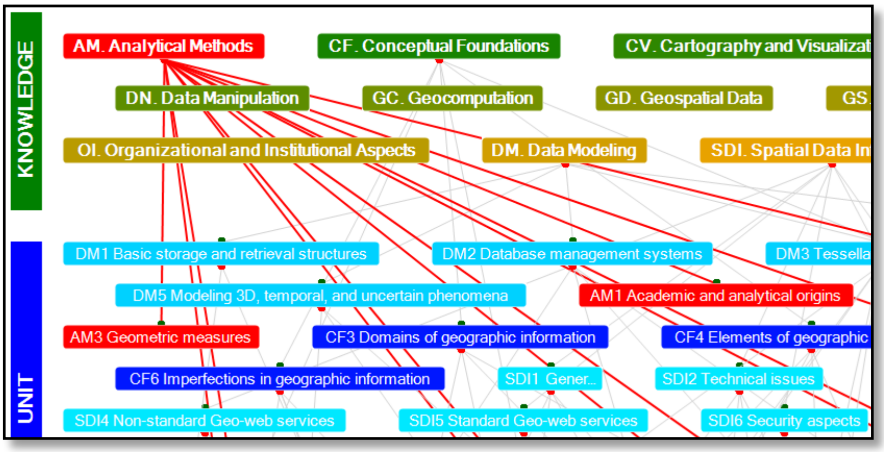


Figure 5: Graphical presentation and navigation interface

The interface draws all Knowledge Areas, Units, Topics and Themes of the BoK in a defined location. The relationship between BoK elements are further shown by straight lines. Thus a straight line between a Knowledge Area and a Unit means belonging of that Unit to that particular Knowledge Area. Since there are a lot of elements of BoK to be shown in the graphical presentation, the outlook of the interface becomes a little obscure and difficult to navigate. A number of techniques have been implied to overcome those difficulties. Firstly, different colour schemes have been applied to different hierarchy of the content which makes a clear distinction among them. In addition, a horizontal change of colour is applied to each hierarchy to distinguish each element in the same hierarchy. Secondly, the mouse over event changes the colour of each element to its upper hierarchy element. Finally, the mouse click event on any element highlights all related elements and paths in red colour. A knowledge element was clicked before taking the snapshot of the interface. As it is shown in figure 4, all the subordinate units and the straight lines of relationship are highlighted.

Curriculum Design

As stated earlier, the tool implements one application area of BoK which is curriculum/course design. The interface/GUI is shown by figure 5. The black left window is the navigation window, shows all the knowledge areas chosen by the user with their respected units and topics. The grey area on the right hand side is provided to keep the course information that a user used to design.

Design of a new course starts with finding lecture/exercise topics which are comparable to the themes of BoK. The themes that sound suitable and appropriate for the course can be dragged and dropped in the navigation pane: Lecture/Exercise topics (fig.5 right part). In this way the user can chose as many lecture/exercise as they want from all topics shown in the navigation window. Each lecture/exercise topic should be further specified by three attribute that express whether it is lecture or exercise, how depth the student should learn about the topic and allocated time for that topics. The final step is to make a group of lecture/exercise topics in to lectures. All the lectures defined by the user through grouping lecture/exercise topics are listed in the 'Lectures' navigation pane (fig.5 right part) The users have also the opportunity to get an overview about BoK topics and units which are coved by the course. The navigation pane 'BoK Topic covered' and 'BoK Unit covered' serves those functionalities.

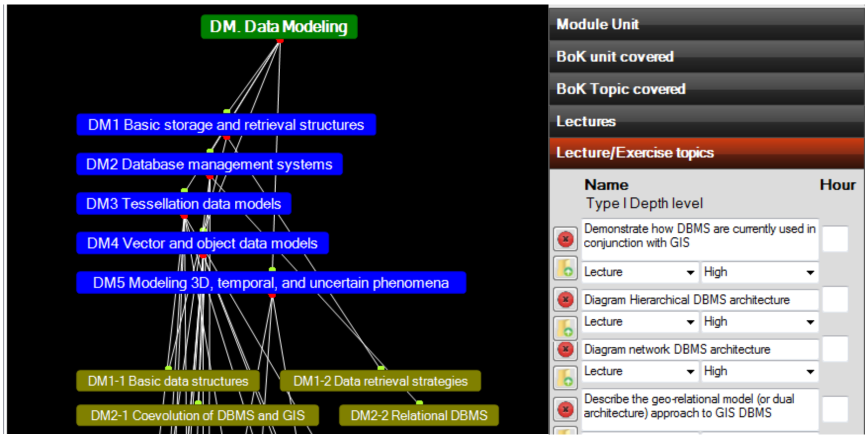


Figure 6: Curriculum/course design interface

Once a course design is complete the user can see the graphical representation of the course. An example (part of whole screen) of the graphical representation of the course is given by the figure 6 below. The figure shows that the course module 'Database' is composed of three lectures (green boxes), each lecture are further composed by several lecture/exercise topics (blue boxes) and so on.

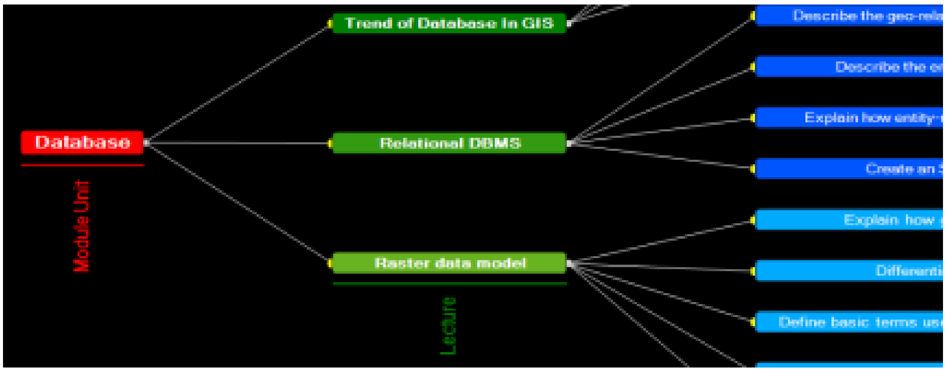


Figure 7: Graphical output of a designed module unit

CONCLUSION

Some issues related to curriculum design based on an extended BoK have been discussed in this paper and a software tool have been presented to support some tasks of designing the content of module units and lectures. The usage of such a tool makes the planning of the content of lectures /module units more easy as it uses a data base with possible content for GI education, e.g. the BoK and allows for a graphical selection of content . Of course many extensions of this tool would be possible and useful, for example to include not only hierarchical but also general relations to be able to link units/topics. Another possible extension would be a web interface which allows students to view the content of module units to support their decision of module chooses.

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Education in Geographical Information Science and Technology in Catalonia (2006-2009): A quantitative overview

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ABSTRACT

For many years, Geographic Information Science and Technology (GIST) has taken a leading role in research and teaching worldwide. Confirmation of this fact is the large number of educational and research organizations that use GIST, as well as the increasing specialized publications and international conferences related with it, without forgetting the still growing use among governmental institutions, producers and users of geographic information. This shows the importance of teaching in an area of high demand for professionals, while stimulating its scientific progress and establishing the terminology in the field of STGI. In this sense, the GIST in Catalonia (an autonomous community located in the northeast of Spain) also has a weight that should be analyzed with more depth. For this reason, the main objective of this study, commissioned by the Cartographic Institute of Catalonia (the official cartographic institution of the country), is to report the status of GIST teaching in Catalonia, through higher education subjects (pre and postgraduate, considering both the private and public universities) or as specialized courses (considering any institution or enterprise). To limit the time period, this paper takes into account the situation during the years 2006-2009. To achieve this aim we used a questionnaire delivered to all the courses coordinators (76 in total); it was divided into three parts: masters and diplomas specialized in GIST, specific subjects within master's degrees or degrees and specialized courses.

Results showed that the total number of responses was 41 (54%). The total estimation of students involved in GIST from 2006 to 2009 was of 6,457, being the 12% from outside Spain. In higher education, 42% of the subjects were given by departments of geography, although the degrees involved were very diverse (forest engineering, biology, etc.), mostly scheduled in the second and third year and with a high degree of compulsoriness (60% were core subjects). Akin to the content, there was a predominance of those related to geographical information systems, followed by cartography and, in a smaller degree, by remote sensing. The most used software packages were ArcGIS and MiraMon. The study shows a high degree of GIST consolidation between 2006 and 2009 with a tendency to increase its weight in the Catalan higher education.

INTRODUCTION

For many years, Geographical Information Science and Technology (GIST) has taken a leading role in research and teaching worldwide. Proof of this is the large number of educational and research projects, as well as specialized international publications and conferences, without forgetting its growing use in governmental institutions and private enterprises (Brox and Pires, 2004). This fact shows the importance of teaching in an area of high demand for qualified workers, while stimulating its scientific progress and establishing the terminology in the field of GIST. For example, in 1995 GIST courses and programs were available in 500 institutions worldwide (Goodchild and Palladino, 1995), whereas in 2001 the institutions offering GIST courses included about 2,000 universities

(Strobl, 2003). In 2003, just in China over 500 GIST-related subjects were set up in more than 100 colleges and universities (Fuling and Shaohua, 2008).

In Spain, in general, and in Catalonia (an autonomous community located in the northeast of Spain) in particular, there is a long tradition in GIST education. For example, since 1990 over 500 high school students attended a special summer program at the University of Girona (northeast of Catalonia) which uses GIST to study data from the Natural Park of Gavarres (Goodchild and Palladino, 1995); other examples could be the Master in Remote Sensing and GIS from 1995-96, still taught by the UAB and CREAF or the more than 20 years of contents on GIS and RS in the UAB degrees. Therefore, the main objective of this study, commissioned by the Cartographic Institute of Catalonia, the official cartographic institution of the autonomous community, is to quantify as exhaustively as possible the status of GIST teaching, through higher education, considering both private and public universities, as specialized or related courses, considering any institution or enterprise. To limit the time period, this paper takes into account the current studies during the years 2006-2009. To achieve this we used a questionnaire delivered to all Catalan educational organizations involved in GIST. This study complements another for research, which will be published in future work. From our experience in GIST, the initial hypothesis of the work was that GIST is an increasing discipline that affects many degrees, although geography is still the most important because it was one of the primary sources of GIS.

In this paper the term "Geographical Information Science and Technology" has a general sense and includes disciplines and subjects as cartography, GIS, remote sensing, geodesy, GPS, photogrammetry, among others. Therefore, GIST it highlights the multidisciplinary integration of processes and technologies for obtaining geographical information and for using it for purposes as different as analysis or illustration. According to this definition, we were interested in knowing the real offer in GIST education, trying to quantify the number of students implied, their origin, the subject-matter contents, or the most used software packages. These objectives differ from others surveys made around the world in two aspects: the more general sense of GIST (for example, the work from Roccatagliata (1994) only outlined the GIS situation, *stricto sensu*, in Italy) and the quantitative approach. This fact makes the comparison with other regions or countries without quantitative data difficult, being just possible a qualitative assessment.

METHODOLOGY

Study area

In Spain, four main layers of government exist: the "national" (state) government, the autonomous community, the provincial government and the municipality. Catalonia, an autonomous community as asserted before, is located in northeast Spain (figure 1), with a total surface of about 32,000 km2. Catalonia is delimited in the east by the Mediterranean Sea, in the north by France and in the west and south by the autonomous communities of Aragon and València, respectively. This strategic situation has favoured intensive socioeconomic relationships with other Mediterranean countries and with continental Europe. In 2011, total Catalan population was 7.4 million, equivalents to 16.1% of total Spanish population (46.1 million). In total, Catalonia has 8 public universities (4 located in the Barcelona province, one in the rest of provinces, Girona, Lleida and Tarragona, and one using a remote, non-attendance, formula) and 4 private (also one using a remote, non-attendance, formula). According to the Catalan Institute of Statistics, in 2006-2007, the total number of students in Catalan universities was 217,883 (15.4% of total Spanish students) while in 2008-2009 it was 216,786 (15.6% of total Spanish students).

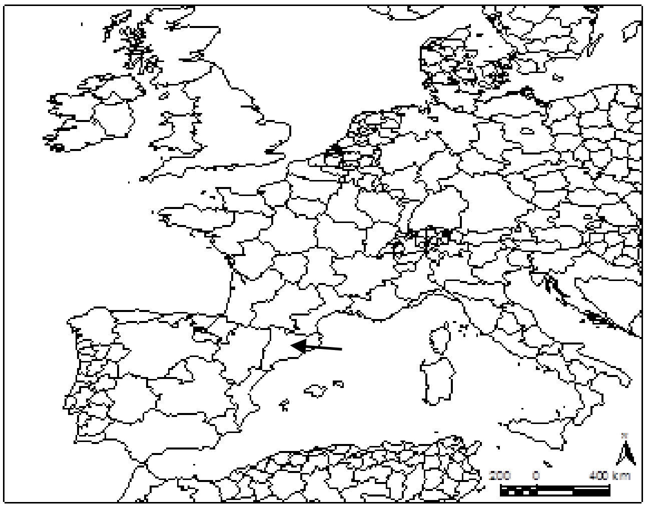

Figure 1: Catalonia, the study area, located in the northeast of Spain.

The survey

In 2008, the Spanish Association of Remote Sensing (Asociación Española de Teledetección (AET)) carried out a survey about high education in remote sensing for all Spain. The study had as objective to give information about the institutions teaching courses related with remote sensing and the name of the main subjects. Although being a very interesting work, our goal was to provide more quantitative data related with GIST, including GPS, LIDAR, GIS, etc., as asserted before.

The survey was divided in three main sets: one corresponding to university studies (both private and public) specialised in GIST (postgraduate), another equivalent to university studies (subjects) related with GIST (pregraduate) and the last one corresponding to courses specialised in GIST taught by any public or private institutions or enterprises. About 200 web pages were consulted for knowing which universities, departments and institutions were involved in GIST.

In order to facilitate the answers, reviewers had two ways of response: one following an editable PDF file sent by email and the other one using a web address (http://llibreblanc.uab.cat). The survey was sent to all the coordinators implied in GIST. Although the interest in gathering as much information as possible, we decided to pose about 15 questions for each set, in order to avoid an excessive number of questions, because surveys too long are usually not answered.

In the case of the University studies specialised in GIST, the first question asked in this section was the centre or entity that performed or taught some graduate studies specialized in GIST. We differentiated a postgraduate master from a postgraduate diploma because the number of credits and course duration is larger in the former than in the latter. From the fourteen remaining questions, one was related to the number of students involved, distinguishing their origin: Catalan students, rest of Spain and other students. In order to make easier the response, some very small intervals were proposed (from 1 to 5, from 6 to 10, etc.). This option allows us to make an estimate of the total number of students per course and origin. Other questions were related with the course content: it was requested the percentage of the total content differentiating cartography, GIS, remote sensing and photogrammetry; finally, the number of ECTS credits and the most used software package was also inquired.

The University studies related with GIST, with the same structure as above, contained a set of questions referring to individual subjects related with GIST and taught in master's degrees, diplomas or degrees. Many of the fourteen questions were identical than in the previous sections but others were specifically for this case: the type of degree (bachelor, diploma or master) and the course in which the subject was taught. This information allows us to know when the GIST knowledge was acquired (in the first year of the curriculum or in the last year, for example). The last question was to know if the subject was compulsory or optional in order to analyze the interest of the GIST subject inside the corresponding discipline.

Finally, the courses specialized in GIST included eleven questions very similar than the above sections with two differences: the institution organizer of the course and the educational level required to be enrolled on it.

Other tools

As asserted before, a web page was prepared in order to simplify and promote the responses surveyed. Another important function of the web was to list the centres involved in the study and, therefore, in case of knowing a missing course, they could send us a notification for being included in the study. This solution solved one of the main initial problems: which institutions should be included in the survey.

The survey was sent by email to the course coordinators, specifying the objectives of the study and requesting their participation. About one month later, those cases without response were contacted by phone in order to solve problems or discuss comments about the questionnaire.

RESULTS

The total number of surveys received by coordinators was 76. In total 41 responses (54% of total) arrived from 29 different teaching institutions and corresponding to nine specialized postgraduate GIST studies (being 100% of total in Catalonia), 62% subjects in higher education (61% of total) and 30 specialization courses (83% of total). The higher education subjects without response (39%) corresponded in 22 cases to postgraduate studies and 13 to degrees.

Between the academic years 2006-2007 and 2008-2009, based on the intervals explained in the survey section, the estimated total number of students implied in GIST was 6,457 (74% from Catalonia, 14% from the rest of Spain and 12% from other countries). Postgraduate students were 408, whereas 4,788 were involved in subjects related with GIST (pregraduate) and 1,261 in specialized courses.

University studies specialised in GIST

In the period analyzed, there were six active masters specialized in GIST, one of them non-attendance, and three postgraduate diplomas, one of them in non-attendance. As asserted before, the total number of students estimated during 2006-2009 was 408. By origin, it was estimated that 185 students were Catalans (45.3% of total), with a tendency to increase, 129 were from the rest of Spain (31.6%), also with a tendency to increase, and 94 were from other countries with a gradual decrease in this case (figure 2). A possible explanation of the gradual decrease from foreign students can be the economic crisis affecting many parts of the world.

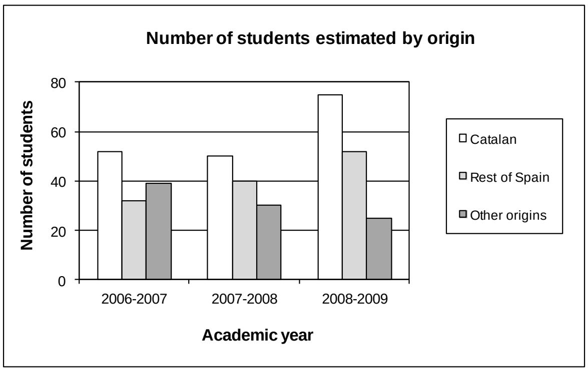

Figure 2: Evolution in number of students estimated by origin, from 2006-2009, in GIST masters.

According to the content of subjects (differentiating GIS, remote sensing, cartography and photogrammetry), the comparison among the six masters showed some differences: one master clearly giving more remote sensing than the remaining (Centre de Recerca Ecològica i Aplicacions Forestals i Universitat Autònoma de Barceloan (CREAF-UAB), about 47%), while another noticeably taught more GIS (Laboratori d'Informació Geogràfica i de Teledetecció (LIGIT)-UAB, about 80%) (figure 3). In the rest of masters, the weight of GIS was very high, above 60%, with the exception of one from the Universitat de Girona (UdG) where the percentage was only 47%. In this case the second more important subject-matter was cartography with 45%, this percentage being the highest in all the masters. Finally, a similarity in all of them was the low weight of photogrammetry, below 10%. If the comparison is made using the number of theoretical or practical hours (European Credit Transfer and Accumulation System (ECTS) credits) for each subject-matter, the most important percentages in all of them were the practical GIS and the theoretical GIS with 29% and 26%, respectively (figure 4). In the case of postgraduate diplomas, these percentages decrease: 21% and 16%, respectively.

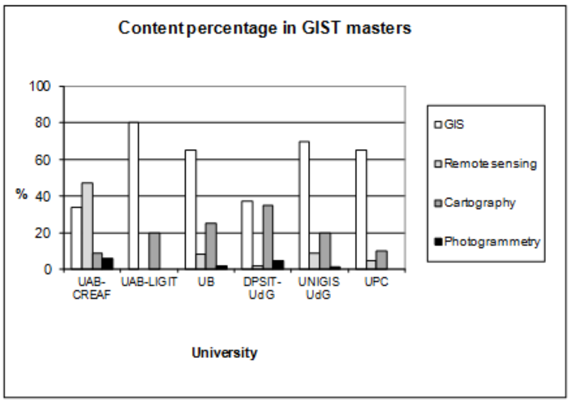

Figure 3: Percentage of content in GIST masters differentiating GIS, remote sensing, cartography and photogrammetry. UB corresponds to Universitat de Barcelona and UPC to Universitat Politècnica de Catalunya. See the text for the rest of initials.

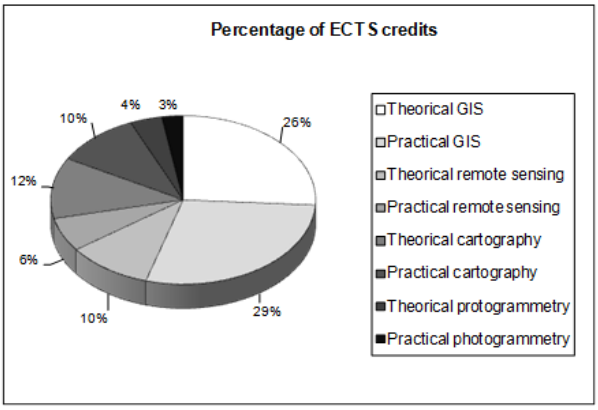

Figure 4: Percentage of ECTS credits differentiating theoretical and practical contents in specialized GIST masters.

Regarding the most used software packages, in all the masters the most applied was ArcGis followed by MicroStation (with different versions), while in four masters they used MiraMon and gvSIG (the former programmed from a Catalan institution and the latter from the government of València), in three masters Idrisi and Geomedia, in two Envi and MapInfo and, finally, in one Ilwis, Surfer and Sextante (figure 5).

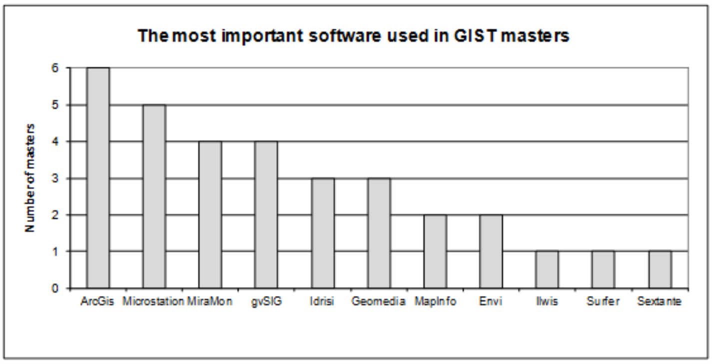

Figure 5: Number of masters according to the most used software packages.

University studies related with GIST

As asserted before, in the years analyzed the total number of higher education students involved in GIST was 4,788, of which 76% were Catalan, 12% from the rest of Spain and 12% from other countries. In this case, 75.9% of them were undergraduate students and the rest postgraduate.

A total of 20 different departments were involved in 62 subjects of both higher education degrees, masters or doctorate, 38 of them (61%) corresponded to 19 degrees in different universities and 24 (39 %) to 16 masters and doctorates. From the total number of subjects, 26 were taught in geography departments (42% of total). As shown in figure 6, the university that gave more GIST subjects, 16 concretely, was the Universitat de Barcelona (UB), followed by the Universitat Politècnica de Catalunya (UPC) and the Universitat Autònoma de Barcelona (UAB), with 14 and 13, respectively.

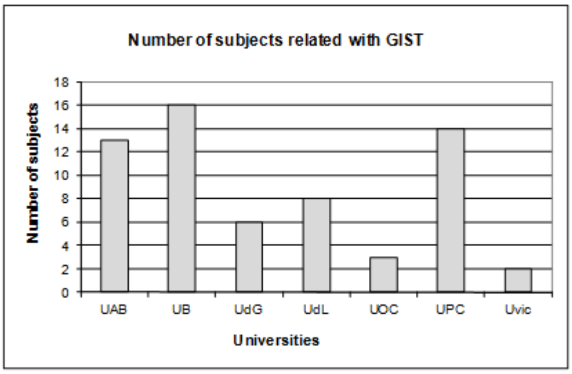

Figure 6: Number of subjects related with GIST according to public and private Catalan universities. UdL corresponds to Universitat de Lleida, UOC to Universitat Oberta de Catalunya and UVic to Universitat de Vic. UVic is a private university.

As expected, a varied number of degrees implied in GIST appeared: four degrees corresponding to Geography and four more to Environmental Studies, but also two to Geology, Technical Agricultural Engineering and Geological Engineering, and one to Forest Engineering, Civil Engineering, Biology or Architecture (Superior, not Technical). These results corroborated our initial hypothesis as asserted in the introduction section.

Other interesting results were that the main number of subjects was given during the second and third year of the degree and that from the 38 subjects of degree 60% of them were compulsory. On the other hand, in the case of masters the main part of subjects was optional, 16 from 24 (66.7%).

According to the content of subjects (differentiating GIS, remote sensing, cartography and photogrammetry), the comparison showed some differences: in 32 subjects (52% of total) the content was equal or above 50% in GIS (figure 7). Cartography in 28 subjects and remote sensing in 21 subjects showed contents between 10% and 50%, whereas photogrammetry in 52 subjects showed contents equal to zero (84% of total).

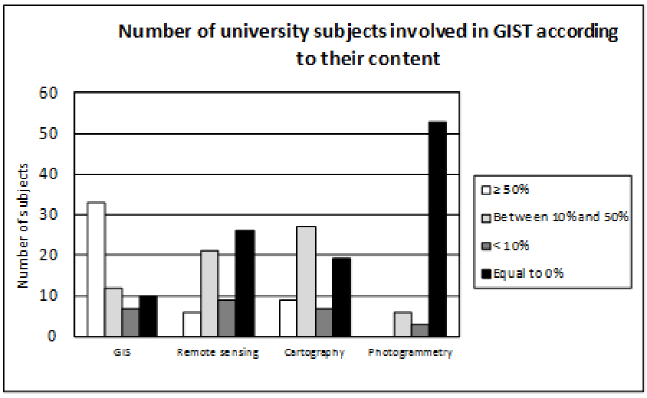

Figure 7: Number of higher education subjects involved in GIST according to their content.

If the comparison is made using the number of theoretical or practical hours for each subject-matter (ECTS credits), the most important percentages were the practical GIS and the theoretical GIS with the 23% and 19%, respectively. Following in importance, the practical and the theoretical in cartography were 15% and 14% whereas in remote sensing were 13% and 10%, respectively. The most used computer programs were ArcGis, 30%, MiraMon, 23%, Idrisi, 14% and gvSIG, 10%.

Courses specialized in GIST

The total number of courses specialized in GIST included in this work was 30. As asserted by Strobl (2003), GIST educators were related with GIS software institutions, institutions of higher education and research organizations. They appeared courses with a long tradition, with more than 15 editions, as the "MiraMon standard course", taught by CREAF or the "Digital cartography with Microstation" course taught by the Geology Department from the Universitat de Barcelona. Other courses with long experience were the "Specialization course in ArcGis" offered by the Universitat de Girona, and the ones taught by LIGIT directly related with ESRI products ("ArcIMS, ArcGis, ArcInfo, ArcObjects") and other specialised MiraMon courses ("GIS for geologists", "Advanced GIS", "Analysis with GIS" and "Open Geospatial Consortium map servers").

The total number of students from the analyzed courses was 1,261, being 79% Catalan students, 14% from the rest of Spain and 7% from other countries. The study showed a gradual increase, from 340 students in 2006-2007 to 548 in 2008-2009. Akin to courses content, 77% of total had a percentage equal or above 50% in GIS and 39% and 20% had practical and theoretical GIS content, respectively. Therefore, compared with masters and higher education subjects, specialized courses were clearly more dedicated to GIS. Finally, the more used software packages were ArcGis, 27%, and MiraMon, 18%, showing the rest a high atomization

CONCLUSIONS

This survey has led to an intensive effort, especially in the monitoring section of answers, because as it is known the cost of answering questionnaires is high, usually for lack of time. We believe that given the number of responses (54% of total, not of a sample) this study is a good indicator of the GIST teaching status in Catalonia during the period analyzed.

Based on the answers extracted from small intervals, the results showed that the number of students that have been involved in GIST training was about 6,457 with an important attraction of students outside Catalonia especially in the case of postgraduate studies. This outcome is a positive parameter that needs to be taken into account for the future educational planning. In this sense, we estimated that the weight of GIST subjects (19) related with all the subjects offered in Catalonia (161) was about 11.8% and 10.4% in the case of all not specialised masters (16 in front of 153).

Another conclusion extracted from the study is that GIS (practice and theory) is the main content inside GIST, both in masters as in degrees and specialized courses. This fact reinforces the weight of GIS followed by cartography and remote sensing and the low importance of photogrammetry in terms of teaching effort. On the other hand, according to the number of subjects involved in GIST, the main disciplines concerned in GIST were geography and environmental sciences as in other European countries (Austria or The Netherlands, for example) (Strobl, 2003). In addition, and as in other countries, engineering and architecture were moderately involved in GIST compared with computer sciences, with a low implication.

According to the answers, in degree studies the GIST subjects were programmed in the second and third undergraduate year, which means that a certain amount of experience and knowledge for applying GIST was required. In this sense, it should be highlighted that 60% of subjects were compulsory as a signal of its recognition as an important discipline to be considered. Probably, this recognition remarks the long tradition in masters and specialized courses available from 2006 to 2009, with more than ten editions. Also maybe, this long tradition explains the use of software programmed in Catalonia (in the case of MiraMon) and in València (in the case of gvSIG) together with international software as ArcGis or MicroStation.

Therefore, from this study we can conclude that GIST is an important discipline in Catalonia, with a weight above 10% considering all the educational system as asserted before, and with a high importance in geography but also in other disciplines especially, in part probably thanks to its GIS tools experience. In this sense it would be interesting to reapply the survey in the future to see the GIST situation and as well as making a comparison at national or European scale. In this sense, we cordially invite other actors to perform a similar study (even using the same form) in their area.

ACKNOWLEDGEMENTS

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The Italian landscape of Geomatics for the faculties of Agriculture: novelties from those who get used to play second fiddle

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ABSTRACT

Going along with our previous intervention Would Google Earth be a proper GIS? (Marcheggiani 2011), had during last LeGIO-workshop held in Leuven (Belgium) in November 2011 our intention is to take advantage of the incoming 8th European GIS Education Seminar to attest the arguments we displayed. A step further has been the involvement of GIS-teachers from the broader Italian context. With this in mind a survey has been conducted considering the whole Geomatics background for the Agriculture faculties in Italy. A special attention has been paid to potential kernels of new ways of GIS and Geomatics teaching emerging by teachers and scholars. To do this a questionnaire has been devised to test students background and to collect their opinions. The survey wants to be a gaze on the ways in which GIS is taught in Italy today.

GIS AND GEOMATICS IN THE AGRICULTURE FACULTIES: THE STATE OF PLAY IN ITALY

Because of their high multi-disciplinary, the Agriculture faculties in Italy have always played a minor role in the teaching of engineering and technological subjects, if compared with other faculties such as Civil Engineering and Urbanism. That has been due to a patchy historical evolution of the higher education system, whose curricula have been strongly separated within a number of uncommunicative faculties. In addition, the Bologna Accord (http://www.ehea.info/) has found the Italian education system slightly unprepared to gather a “three plus two” frame, typical of North Europe heritage, which was not fitting with its traditional scheme.

That has affected in particular the most innovative technological sectors and all the related national scientific subjects. In particular, recalling 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 term Geomatics makes its first appearance in the Italian faculties of Agriculture only at the eve of year 2000. The first Italian book was that of M.A. Gomarasca “Elementi di Geomatica”, edited by the Italian association of Remote Sensing (AIT) in 2004. Before that the Italian background remained unchanged until the ’50s, when Topography and Cartography were often taught within patchy courses called Genio Rurale. Remote Sensing techniques and GIS were introduced twenty years later, by Carlo De Carolis an Italian plant-pathologist and by Giovanni Lechi, a pupil of Gino Cassinis. All that has made up a situation in which the faculties of Agriculture are playing a second fiddle to the whole offer of Geomatics and Geographical Information Systems (GIS) courses. In spite of the ability to manage spatial information is one of the main requirement to obtain a qualified job as agronomist or bio-engineer, this vital part of the academic offer is often underrated and have to suffer for the lack of coordination and of financial and human resources (i.e. high cost for the maintenance GIS's laboratory, insufficient propaedeutical predisposition of students, etc.).

Nevertheless in recent years, innovative approaches, have been devised, to encourage students to focus since the early stages on GIS platforms deemed more intuitive and user-friendly. In addition to specific commercial (CCSS) or open source (FOSS), GIS students are more often introduced to new frames, such as Google Earth®, Build a Map® and Bing®, and Sketchup®, enabling students to identify and annotate spatial features in an intuitive-fashion environment. All that opens the faculties of Agriculture to new scenarios in which new distributed and volunteered geo-information well matches with the needs of students to be effectively introduced to analyse and assess the characters and changes of studied territories and landscapes.

THE WIDENING OF THE GIS APPROACH

It is universal recognised the capacity of maps to offer an overview of and insight into spatial patterns and relations (Kraak, 2004). To query and consult the maps used and produced during the Geomatics courses it is necessary the adoption of specific and suitable GIS software package: this is a limit to the spread and sharing of the Geospatial data.

Thanks to recent advances in geospatial technologies, it is possible to effectively overcome this problem by using and exploiting specific web-based GIS environments and applications, suitably developed. The most popular in our experience is Google Earth® (http://www.google.com/earth/index.html), although nowadays several other similar platforms and environments have been developed and made available. Among them we can mention "Build A Map" (http://www.buildamap.com/), "World Map" (http://worldmap.harvard.edu/), "ArcGIS Online" (http://www.arcgis.com/), "GeoCommons" (http://geocommons.com/) and "Indiemapper" (http://indiemapper.com/). In particular, "WorldMap" has been conceived to provide scholars anywhere in the world with a set of open tools to discover, organize, visualize, create, share and publish geographically referenced information.

The significance of such applications resides in their capability to fill a growing function between powerful desktop-bound mapping applications and lightweight web solutions. Further, these systems make use of a range of great open standards, protocols, and data formats to encourage geospatial collaborations including several standards: WMS, GML, KML, ESRI Shapefile, etc.

The above mentioned applications play a crucial role into the development of approaches based on the so-called Volunteered Geographical Information (VGI), in which data are created by non-professional people (or rather without formal qualifications) after a rapid training (Heipke, 2010). Some authors (Heipke, 2010; Steiniger & Bocher, 2009; Ramm, 2008) also use the term "crowdsourcing" to describe this typology of data acquisition by large and diverse groups of people, using web technology and specific data sources. Considering the aim of the present paper, it is important to outline how these tools enable the students not only to access and investigate on-line maps by the WebGIS services (De Longueville, 2010), but also to create new georeferenced features and data. In particular, the latter task can be carried out by using mobile devices (such as SmartPhones and Tablets enabled with GPS). Then, the collected data can be recorded into WebGIS systems by mobile Internet access.

In this way, teachers and students can use the above described approach to visualize, analyse, share, and study information geographically in a user friendly environment. Moreover, they can report the status of the study area through its geographical components and produce ad hoc information, timely and at local scale. Potential external viewers of created maps can control the data layers seen on their PC or Tablet (using Apple or Android OS) and can choose to view the data, for example, on top of Google Maps or OpenStreetMap (http://www.openstreetmap.org/) map tiles. Therefore, from an overall point of view, as well as creating their own maps, users can search and view maps from the hundreds of maps already created. The added value of VGI in educational activities, the enabling technologies, collectively termed Web 2.0, and ad hoc geospatial tools to develop and diffuse, collect, synthesize, verify, and redistribute this information have been extensively discussed and investigated by the scientific and technological communities (see, among others: Goodchild, 2007; Laituri, M. &Kodrich, 2008; Marcheggiani et al., 2011).

GIS'S TEACHING: WHAT ABOUT STUDENTS' OPINION?

This new way of teach GIS through distributed online resources looks promising, but is internet a solution to students problems? In addition, would Google earth ever be a proper GIS? We are in transition times towards new ways of teaching and all available information are needed about all the actors involved in the process. Considering students as one of the most important stakeholder a study has been conducted with the aim to explore their opinion. A survey has been devised to make the point on the Italian situation for the faculties of Agriculture for the 2010–2012 semesters. To do so an online anonymous questionnaire focusing on Geomatics and GIS has been given to Bachelor or in Master students to test their knowledge and to profile the appeal of GIS. The survey has involved four of the major faculties of Agriculture across Italy: Marche Polytechnic University (Univpm), Mediterranean University of Reggio Calabria (Murc), University of Udine (UoU) and University of Perugia (UoP). About 300 students have been contacted, about the half of them have replayed fulfilling 130 questionnaires. The results are shown and a synthetic appraisal is discussed hereafter.

The questionnaire structure

To perform the online survey we have made use of the Google Doc® (known as Google Drive) repository. This free Web-based suite allows users to create and edit real-time documents online. Google Docs combines the features of Writely and Spreadsheets with a presentation program. Documents, spreadsheets, presentations can be created with Google Docs, imported through the web interface, or sent via email. Documents can be saved to a user's local computer in a variety of formats. This allows for easy surveys which responses can be therefore saved in Excel® format and post elaborated as figures and chart in automatic way. The whole questionnaire accounts for eighteen questions divided on four main topics: a first cluster of questions to profile the sampled population, a second cluster to test students' skills before to attend the courses, a third set of questions to ask which have been the main issues encountered during the GIS and Geomatic courses, and lastly a self-evaluation of courses appeal and consistency.

Marche Polytechnic University (Univpm)

Analysis conducted at the Univpm concerns students attending the third and final year of the bachelor degree in Agricultural Sciences and Forestry. Before to be on a Geomatics course the 68% of students had never been in touch with basic theory and a significant 11% do not respond. In spite of that, the most of them declare of being already experienced to practice GIS (73%) and CAD (44%). The 84% are used to access web-based geo-information systems such as: Google Earth® (87%), Bing® (10%), but none knew Map Built®). Then again, only nearly half of the respondents declare to recognise Internet as a potential tool for locating places of interest or to plan journeys. Even thought, the interest in geospatial information resources and services is substantial: 81% of students consider as important the opportunity to exchange geographic data through mobile devices (tablets or smart phones), and the 38% of them find that extremely useful; just a few (2%) score for a “no value” assessment. No one has been able to give a correct definition of GIS, indicating the need for preparatory courses in the first stage of Bachelor training. The definition of CAD has been more clear, probably because this tool has been learned at secondary school. In contrast with the expectations, 40% of students has not been able to express preferences for Open Sources GISs vs. commercial ones (11% prefer commercial software and only 29% open sources) whilst the 50% do not respond. The above result indicates that students from the Univpm are less equipped with basic of informatics than others from the other three universities, and probably out of the debate which sees young people closely interested to the open and software philosophy. This trend is also confirmed by the responses concerning both the level of education at the beginning of the course, where 78% were poorly trained, and had a lot of difficulties to work with GIS. Apparently 96% of students have found the GIS too hard to be effectively used t deploy the final project-work during courses (only 4% expresses no difficulty), while a same difficulty level is expressed by just 47% when working with CAD. Confirming that despite CAD is a less important tool for agriculture engineers remains a most friendly tool at least for those who come from secondary technical school.

Unlike the students from the other three university only the 50% of respondents consider the knowledge gained during GIS and Geomatics courses very or extremely important for future professional life. Whilst a large cluster (24%) consider it less important. The same trend is about the perception of the importance GIS as a way to gain a valuable training curricula. In spite of that the 50% of students consider enough the time (in term of credit) spent to practice GIS showing a low interest to invest credits to fill the lack knowledge in Geomatics as emerges from the previous responses. These results reflect the Bachelors’ curricula offered at Univpm which profiles are deeply rooted more in the domain of biological sciences than agriculture engineering technical issues. Despite the overall assessment of Geomatics courses quality is still generally positive (50%), with a 11% of students whose found course very positive, a high 11% evaluated the courses in negative way. This could be interpreted as a symptom of uneasiness that students have had working with GIS software without an adequate preliminary preparation which make the class work less appealing.

University of Udine (UoU)

All the students were from Bachelor. The most of them (80%) already know the meaning of the term Geomatics before to attend the courses, but only a few (15%) have had previous experience with GIS. It is interesting to note that 10% of students declared to have been introduced to principles of Geomatics during secondary schools and another equivalent quote has received basic knowledge of GIS and CAD. Whilst a significant 34% declare to be used to work with GIS and CAD during secondary education without any theoretical knowledge. All respondents (90%) are habitually used to access online web resources to virtual exploration of places and Google Earth, with the 95% of sharing, is resulted to be the most wanted tool. Remarkable (78% of medium and very high rates) is the interest in new applications of GIS technologies that enable for the exchange of geographic information by mobile devices such as SmartPhones, Tablets, ecc. Accessing and managing geo-information through GIS seems highly appealing and an easy for the most of the students (79% express a low or medium-low difficult in working with GIS).

All the involved students have been introduced to a specific GIS software and the 70% have given a correct definition of it, but too high still remains the quote of non-responders (30%).

Geomatics and GIS are considered relevant both for education and professional activities (38% very important, 55% medium important) but the role of GIS as problem solving tool is perceived as more important for the professional activity. The answers have shown an overall preference Open Source GIS (84%) because of its free availability giving the possibility to get in touch with these tools even outside the faculty labs, but even for a general natural predisposition of younger pupils toward free software initiatives. The overall assessment of Geomatics courses in terms of quality and organisation shows a satisfactory evaluation (54% considers the offered courses of very high quality, as well as the 26% high, 15% medium, and a 5% very low).

Mediterranean University of Reggiocalabria (Muorc)

In this case the sampled population of students seems split in two halves. A 62% of involved students did not know the theoretical principles of Geomatics before attending the courses and either have no experiences with GIS, on the contrary the 43% were already well trained on the use of CAD.

Nearly the whole of sampled students are used to regularly access Internet sites to locate places of interest and to plan their journeys. Unsurprisingly Google Earth® is the most famous tool (90%), if compared with other resources, e.g. Bing® (10%). Also accessing and managing geo-information through mobile devices is considered a good opportunity for the 90% of students and 62% of them worth the possibility of exchange geographic data through mobile devices assigning it a very high interest. Quite all the students have given a correct definition of GIS and 71% of them expressed a preference for Open Source GIS; just a few (4%) prefer commercial solutions, 10% do not answer.

Regarding the self-evaluation of personal expertise before the courses results show a 52% of inexpert beginners, a 47% of people declaring a mid-expertise. Despite this low skills surprisingly a significant half (57%) declare to have no difficulties to work with GIS, even a 19% declare none difficulties at all. The proportion of those that feels itself confident with the software tool growth to 48% with CAD, but at the same time the proportion of those who begin to get hampered by medium problems increases (from 29% to 33%). The importance given to be trained in Geomatics shows a 95% of students that consider GIS important or very important. And a 76% of them consider the number of hours dedicated to GIS practices too low.

In synthesis, answers show an overall satisfactory evaluation about the results of the courses (81% give a high rate), especially regard the technical expertise in GIS, perceived by students as a key element for their professional skills.

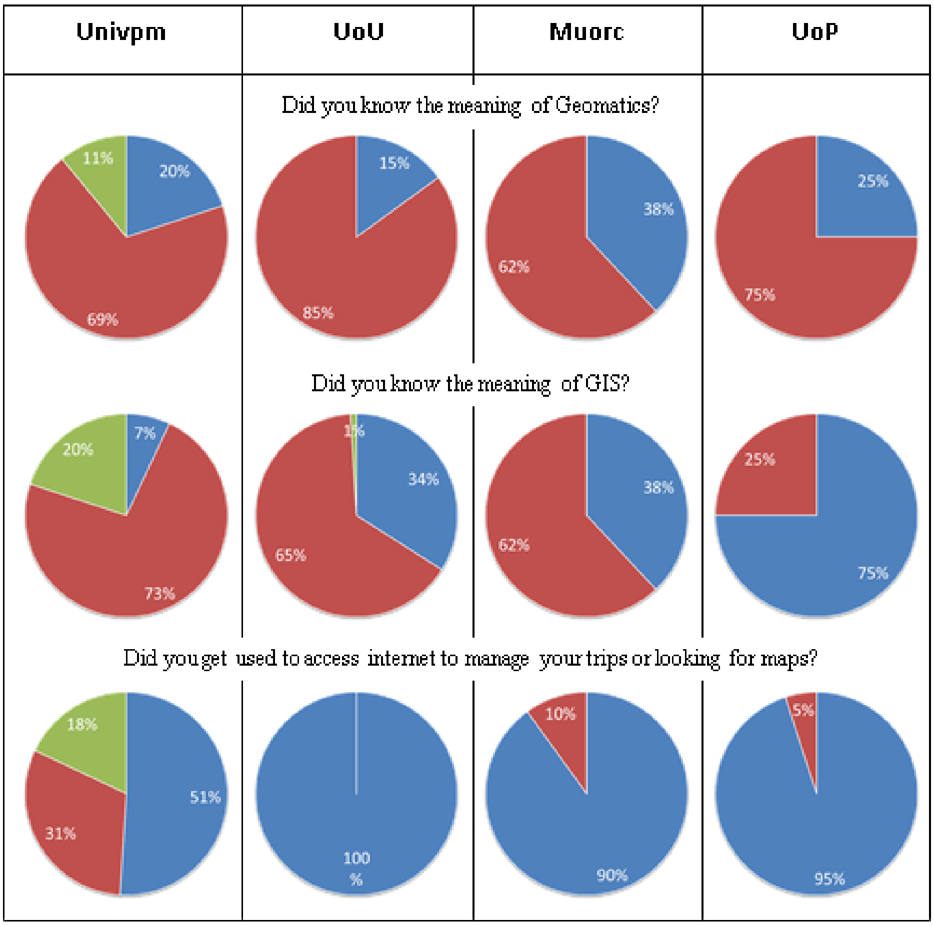

Figure. 1: the 90% of students are used to make use Internet to explore places, search for events, or to view maps and to plan trips (in blu the percentages of respondents scoring for a Yes, whilst in red those answering No and in green the quote of non-respondents). But stat Geomatic and GIS courses with any specific propaedeutical literacy, even during the secondary school. As shown in figure the percentage of students which have already have received base Geomatics or GIS knowledge decline to 20%. Remarkable is the high rate of non-respondents at the Univpm highlighting as still strong inhomogeneous Italian situation.

University of Perugia (UoP)

The survey conducted at the University of Perugia has involved about 40 students attending Geomatics courses at Bachelor or Master. The most of the students (75%) did not know the meaning of Geomatics and Geo-information before to attend the courses, whilst almost all were used to access Internet sites and applications for locating place of interest and for planning journeys. Predictably Google Earth, thanks to its very effective and appealing interface is the most known tool for such purposes. Also accessing and managing geo-information through mobile devices (i.e Tablets and SmarthPhones) seems appealing for many of the students (35% medium, 15% high, 45% very high interest). The students at the Master course were already trained to specific GIS (75%) and CAD (55%) software and all have given a correct definition of these systems. The results show a preference for Open Source software (85%) because its free usability and for the appeal of open approach. All the involved students consider Geomatics relevant both for their own university training as well as for their future professional activities (35% medium, 45% high, 20% very high relevance). Time dedicated to Geomatics is considered not sufficient principally by the students who give high and very high relevance to GIS matters. Student's skills on Geomatics before the courses appear very poor (35%), poor (35%) and medium (30%). Concerning the learning difficulties faced during the course the answers are very patchy but with a clear tendency toward the lower levels, both on GIS and CAD, showing a good effectiveness and "student-friendliness" of the teaching methods. Moreover the answers show an overall satisfactory evaluation about the outcomes of the Geomatics courses (50% very high, 30% high, 15% medium, 5% very low).

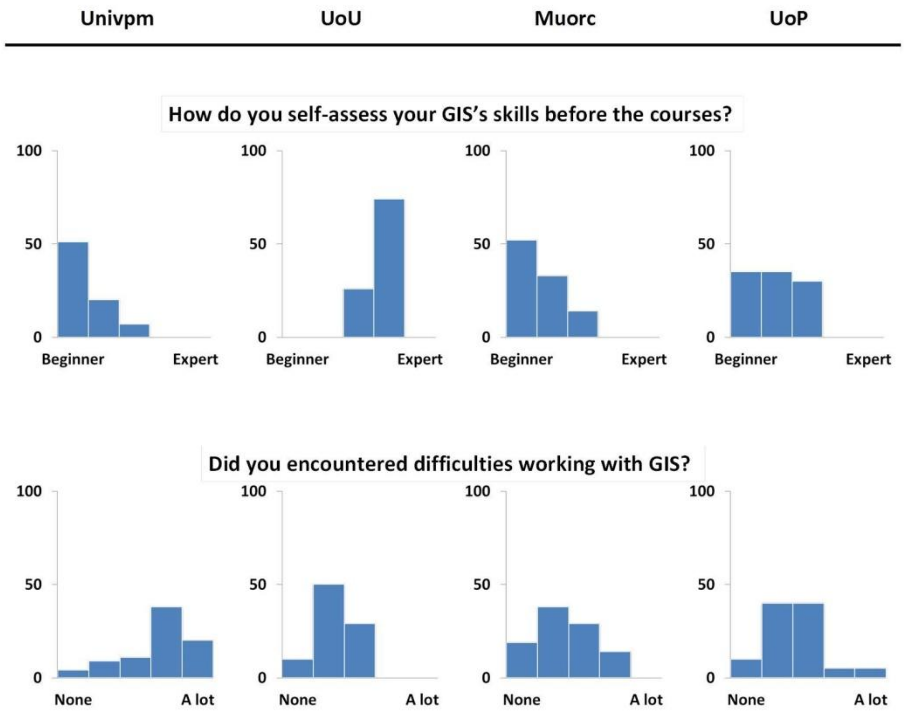

Figure 2: few students develop during secondary school the needed expertise to attend university's courses of Geomatics. However students often declare intermediate difficulty in using GIS technology, the gap between the mere use of software and the deepen of theoretical basis of spatial planning, analysis and land management is still far too large to allow for an effective transmission of the due knowledge.

DISCUSSION

The crux of the matter has been twofold. On one hand our aim has been to put the finger on some major issues limiting the potential of Geomatics in Italy. On the other, by involving GIS teachers from four of the major faculties of Agriculture across Italy and a research unit namely the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), we have aimed to depict the state of play today. Results suggest different scenarios for the surveyed Universities, however some general trends can be indicated. The survey in general confirmed student's awareness on the importance of Geomatics and GIS as an effective tool to improve their competences, skills and to obtain a qualified and satisfactory professional life. As matter of fact the majority of interviewed is persuaded on the central role of GIS for planning and spatial information management (see Fig. 3). The preferences are for open source software, and remarkable is the interest in new applications of geo-information and GIS technologies which enable friendly and distributed tools (i.e. virtual globes such as Google Earth® and Bing®) and the exchange of geographic information thorough mobile devices, such as SmartPhones and Tablets. Such a trend confirms how active exploration of places will be an important asset of future improvement of Agriculture faculties offer where open GIS solution will have the more and more have to easily match the needs of students for a number of modes to access geo-information which students routinely shall use to perform their training.

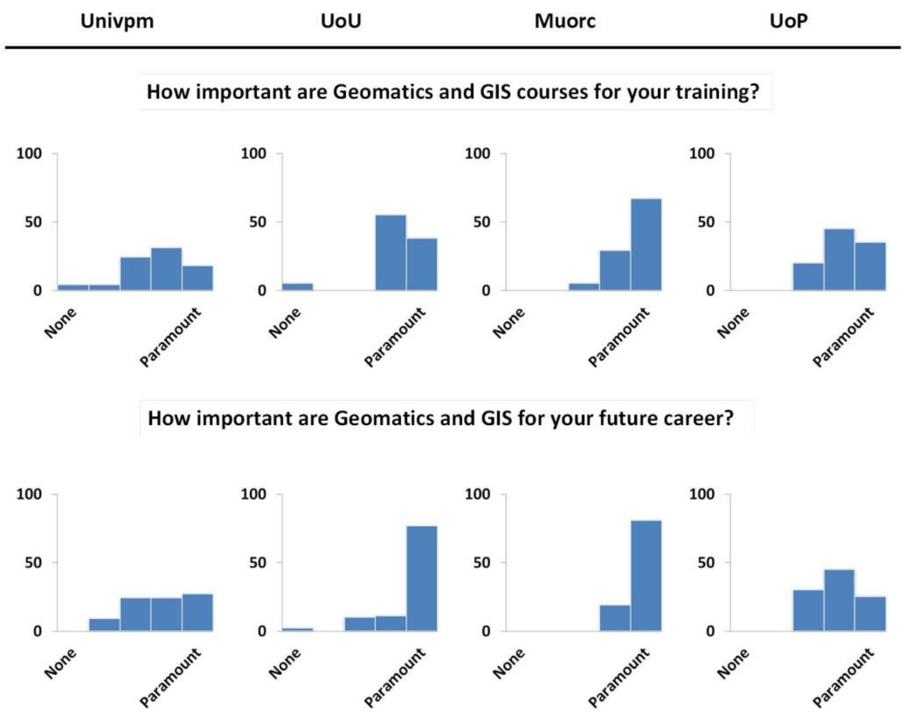

Figure 3: the results of survey have in general confirmed student's awareness on the importance of Geomatics and GIS as an effective tool to improve their competences, skills and to obtain a qualified and satisfactory professional life. As matter of fact the majority of interviewed is persuaded on the central role of GIS for planning and spatial information management.

In average the 90% of students are used to make use Internet and its wide web resources to explore places, search for events, or to view maps and to plan trips. But this has to be fostered by a more integration of curricula between secondary and higher education, as confirmed by the trend that sees students generally start GIS course whit any base knowledge (see Fig. 1). Only a very few of them develop at the secondary school the needed expertise to attend university's courses of Geomatics. However students often declare intermediate difficulty in using GIS technology, the gap between the mere use of software and the theoretical spatial planning, analysis and land management paradigms is still far too large to allow for an effective transmission of the due knowledge (see Fig. 2). For Agriculture Faculties problems arises non only because this lack of coordination with secondary schools. So far the amount of credits dedicated to Geomatics and GIS and still few if compared with the number of hours dedicated to bio-sciences. Efforts should have to be done at the level of academic structures when the assignments for each scientific subject are decided, every three or five years averagely in Italy. But the unresolved division seeing Agriculture faculties out from the cluster of engineering faculties in Italy and a stronger inclusion in bio-sciences domains hamper any potential improvement of the number of credits in favour of technical and engineering subjects.

Education of students in Agricultural Science faculties on GIS issues is generally positively assessed. Anyway, differences emerges within each study case, marking the specificity of the four surveyed faculties. Students generally require additional credits to deepen specific scientific applications and project works with GIS. However a minority of them still remains reluctant mainly because the high technical and computing efforts required. This is in contrast with the maths and IT requirements needed to attend traditional agricultural and biological courses. The main critical point, as often expressed by respondents, is not on the quantity of hours dedicated to Geomatics but on the scarce integration of GIS class works with the other courses. That highlights for one of the biggest issue in Italian higher education systems nowadays: the lack of interdisciplinary coordination among the different scientific subjects. This limit is particularly strong in the faculties of Agriculture where the multidisciplinary is at the highest level if compared with other faculties. Despite the geospatial approach would benefit a number of scientific subjects taught, such as: economy, soil science, hydrology, botany, marketing, planning, botany, etc , in the matter of fact the level of integration is very low generating a conceptual disconnection of Geomatics from the other subjects and a progressive decay of student's acquired skills.

In last words, the major problems emerging from the teaching experience can referred to two main situations. The unbalance between the time needed to train students over a specific GIS software and the less time spent to introduce them to theoretical principles and methodological frameworks. On the other hand, this scarce theoretical improvements relegates GIS's applications as mainly oriented to the cartography and maps production, and less for deepening the potential of GIS as powerful analytical tools for spatial purposes and to spatial planning. One of the most appealing aspect of GIS, which is its deep character of problem solving tool integrating technologies with human resources should be further improved by applications to on real study cases, because that would great benefits the creativity and the critical thinking of each student. The whole GIS educational process enable them to form their own ability to tackle concrete cases enhancing their own design ability to build a personal visions of the world.

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Session 2: GI S&T versus Geo-ICT: an artificial boundary?

Discussion session

Session 3A: GI S&T-education & SDI

National SDI portal and SDI education

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ABSTRACT

Development of national and regional SDI portals has become more intense and co-ordinated after INSPIRE directive has been adopted in May 2007. In 2012 it can be stated that national geoportals are practically functioning in many countries of the EU. More and more people use them for searching map-related information, browsing of maps and downloading geographic data. Soon the time will come, when finding, use and analysis of geographic information becomes a part of daily life for the major part of the society. The NSDI portal in Lithuania (www.geoportal.lt) has been launched in 2009. During the last three years we have observed interesting changes in user dynamics that indicate a trend of transformation of the geoportal from a rather rigid and limited use system to a true Web 2.0 collaborative medium that has a huge potential of further user involvement. We believe that such environments make a significant impact on development of geographically aware society. In ord er to use the full potential of NSDIs and geoportals, they must be correspondingly introduced in geographic information studies of different levels: from the ideas of geographic crowdsourcing in secondary or even primary schools to understanding of metadata and geographic web services as a component of general university education. Issues of GIS business, management and innovations must become a natural part of all higher level geographic information study programmes, including geography and cartography. Specialized SDI-orientated modules should be developed for spatial planners, environmental managers and other target groups that make decisions based on combined heterogeneous geographic information. Whereas consistent SDI education is still more a vision that reality, the national geoportal itself can serve as the starting point. Along technical and functional enhancements of the Lithuanian geoportal, two supporting lines of development are planned: research on geoportal qu ality and user education 'inside' the geoportal. We expect that geoportal quality research will result in a methodological framework for objective evaluation of a geoportal in several aspects such as functionality and usability. The goal of user education is building and expanding a community of proactive geoportal users who would then be able to educate the others. The SDI education outside the geoportal would help bringing new users; however, it alone cannot guarantee that they stay. It is thus important to foster geographic communication, crowdsourcing/cloud projects and social networking by geoportal tools and environments. Meanwhile geoportal.lt user community has no identifiable structure and standard communication measures such as forum, community channels and interactive glossary of GI terms are barely used. It is partly due to still limited geoportal.lt contents, but also the need for more user-involving projects and services is obvious. Therefore a cloud service is planned to be included in geoportal.lt in 2014.

Software Tool Development for Higher Education on Geospatial Technology

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ABSTRACT

People who have knowledge on Geospatial Information Standards are not enough, even though the Spatial Data Infrastructure (SDI) is constructed widely in the world. One of reasons is that only a few educational organizations open courses on the related knowledge in Japan. We should consider a development of the educational tools to improve such a situation. This paper aims to propose the design of the introductory course, course materials and the open software tool on Geospatial technology based on the knowledge behind Geographic Information Standards.

Keywords: GIS education, Geographic Information Standard, open educational tool

INTRODUCTION

Today, the construction and utilization of global, international, national, and sub-national SDIs are promoted rapidly. We can point out at least three reasons. The first is the natural resource depletion caused by the world population growth. The second is the escalation of disasters and environmental issues. The third is the social demand to make spatial data interoperable. ISO/TC211, OGC and other related organizations provide Geographic Information Standards to realize the spatial data interoperability. EU published INSPIRE Directive in order to establish an infrastructure for Spatial Information in the member countries (European Union, 2007). Japanese government enacted “Basic Act on the Advancement of Utilizing Geospatial Information” in the same year (Murakami, 2008). Also the US Ministry of Labor identifies the Geospatial Industry as the high growth industry (US Ministry of Labor, 2010).

Meanwhile, UCGIS published GIS&T Body of Knowledge (BoK) in 2006 (DiBiase et al., 2006), and an education initiative in the Association of Geographic Information Laboratories in Europe (AGILE) is investigating BoK and education, qualification, and certification systems. In Japan, the initiative on a GIS&T BoK was undertaken by the research project "Development of geographic information science curricula and sustainable web library systems for serving their contents" [Chair: Atsuyuki Okabe, University of Tokyo] from 2005 up to 2007 (Ota et al., 2008). Also the research project "Geographic Information Sciences Education and Spatial Thinking" [Chair: Yasushi Asami, University of Tokyo] is running from 2009 to 2013. The Japan Society for the Promotion of Science (JSPS) funds both projects. International Conference on Spatial Thinking and Geographic Information Science to promote the later research activity was held from September 14 to 16, Tokyo (Asami, 2011).

The author is a member of both projects and developing teaching aids for the introductory course of Geospatial Technology on the viewpoint of the dissemination of Geographic Information Standards (Ota, 2010). There are two reasons to emphasize GI Standards. One is that there are few educational tools to learn knowledge behind SDI in Japan, even though the SDI construction and its utilization are urgent issues. The other is that GI Standards can be seen as a gateway to the knowledge of Geospatial

Technology. For example, ISO 19107 - Spatial schema (ISO, 2003) provides well-structured spatial geometry and topology.

This paper will focus on designing of the lecture notes (slides) and the software tool for a semester course brought for undergraduate students and beginners in the GIS industry. At first, we will discuss designing the introductory course on Geospatial Technology. At second, the software tool called "GeoPack" will be reported in preliminary fashion as it is still under development. And finally, we will remark the future works and the schedule of the development.

DESIGNING OF THE COURSE ON GEOSPATIAL TECHNOLOGY

We will discuss the purpose, constraints, topics, and syllabus of the semester course for undergraduate students and for beginners working in GIS industry in this section.

Purpose

Purpose of the course is that students will have an overview of Geospatial Technology, the role of each knowledge unit in the BoK of Geospatial Technology, and how to acquire, store, analyse, exchange and represent geospatial data. Furthermore, we have a plan so that the students will be able to get tips on the geospatial software development, if they ask for.

Constraints

We have to accept several constraints before designing the course. There are time limitation, volume of knowledge that students can learn, and prerequisites. Standard lecture hours are 22.5 hours as 15 lectures (1 credit) in Japan. In addition, students are expected to study 22.5 hours before and after lectures. It means that the total length for students is 45 hours and it is divided over 15 lectures. Thus, appropriate volume of lecture notes (slides) for teachers and aids for self-learning are required. We cannot request long list of prerequisites to students, as long as they are beginners of this research field. However, we expect they have knowledge of high school level mathematics (In case of Japan, it may happen that students who did not select mathematics as the subject of entrance examination are included in the class), because they will learn geometric attributes (point, curve and surface) of geographic features, basic idea of coordinate reference system and fundamental algorithm (distance, centre, point in polygon, etc.) of spatial analysis.

Topics

In accordance with the scope of ISO/TC211 (http://www.isotc211.org/scope.htm), standards provided by TC211 may specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations. Meanwhile, GIS&T BoK (DiBiase et al., 2006 on page 5-6) defines Geospatial Technology as it supports a wide variety of uses, from data acquisition (e.g., aerial imaging, remote sensing, land surveying, and global navigation satellite systems), to data storage and manipulation (e.g., GIS, image processing, and database management software), to data analysis (e.g., software for statistical analysis and modeling) to display and output (e.g., geovisualization software and imaging devices).

In this paper, Geospatial Technology (in other words, Geomatics, or Geographic Information Science and Technology) is defined as a discipline of modelling, acquisition, management, analysis, exchange and representation of geospatial data. Each element of Geospatial Technology can be seen as a knowledge unit of the BoK on this research field.

1) Modelling

Modelling is a process to describe "feature" as an abstraction of the real world phenomena. An abstraction process is called modelling. A structural cluster of models is constructed in the human brain by assimilation and accommodation. However, to think of digital data acquisition following the model, it is impossible to get well-structured data, if the model contains ambiguity. It means that data acquisition is not possible without formal description of model, in other words the schema. Therefore, the schema description language such as UML is important to achieve un-ambiguity.

Geospatial data is a special type of data as it relates to the position/location on the earth. So, we need the restrictions to the schema. General Feature Model (GFM) defined in ISO 19109 (ISO, 2005) provides them as a meta-model for the formal description of feature and association between them. GFM includes rules how to define attributes and operations of a feature and an association. The author simplified the GFM defined in ISO 19109 for the elemental education (Figure 1).

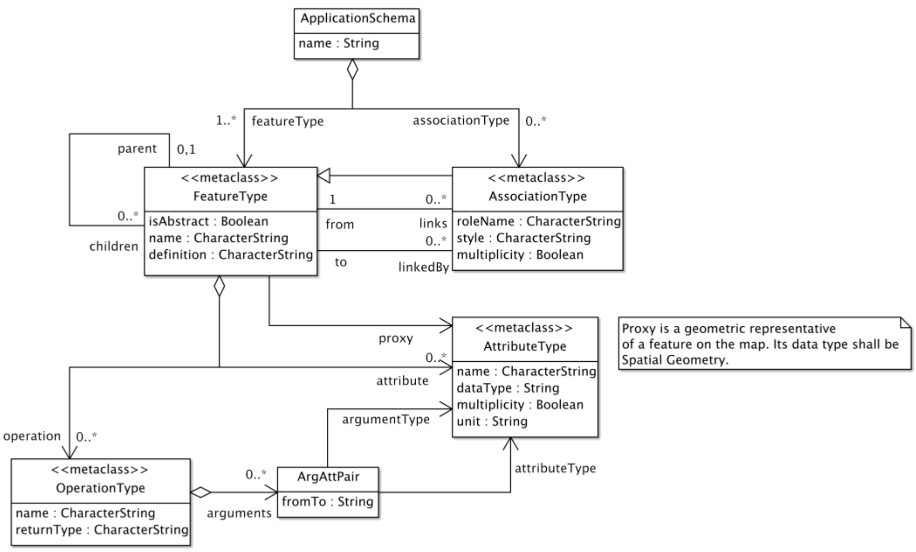


Figure 1: General Feature Model (GFM) for the elemental education of Geospatial Technology.

Attributes are classified as spatial, temporal, thematic and location. The schema made in compliance with GFM is called an application schema. In case of the semester course, spatial attributes are limited up to two topological dimensions. It means that geometric primitives are point, curve and surface. But a coordinate can be three-dimensional. Temporal primitives are zero-dimensional instant and one-dimensional period. Thematic attributes are for example, character string, number, image and movie. Location is a place on the earth identifying indirectly.

Operation is a function to get characteristics of a feature processing by an application. It returns a result of operation by input attributes as arguments. Association is a connection between features. The strong association is called composition. “Strong” means if a feature is eliminated, connected features are also eliminated. As long as an association is a real world phenomenon, association is a feature.

2) Acquisition

Acquisition is a production process of spatial data, in other words a set of feature instances. This knowledge unit contains not only methods but also spatial and temporal reference systems and data quality. Actually the scope of this knowledge unit is huge. For example, paper map digitizing, ground survey, GPS survey, photogrammetry, remote sensing, hydrographical survey, geological survey, meteorological investigation are all acquisition technologies. However, it is impossible to teach them in the limited time. Thus the lecture is limited to paper map digitizing, spatial/temporal reference systems and data quality. Because, students can experience paper map digitizing rather easier than other acquisitions, and concepts of reference system and data quality are important for almost all acquisition process.

3) Management

Management, in this case, means the action to store, access, and transfer data files (e.g., a set of feature instances, application schema and metadata). Metadata is defined as "data about data" (ISO, 2003). The actual metadata used in clearinghouses is complicated as it was designed for general purpose. However for the fundamental education, we need at least what is it and how it works. Therefore, enough elements of metadata for basic education could be title, overview, responsible party, geographic extent, temporal extent and publication date.

4) Spatial Analysis

Huge variety of spatial analysis methods is developed for different research fields. Therefore, it is impossible for students to get whole image of spatial analysis in this course. We recommend learning the basic computational geometry, for example, showing below, because we presume computational geometry is the most fundamental knowledge of spatial analysis.

Centre – gravity centre, centroid
Algorithm to judge “point in polygon”
Distance – Euclid, Manhattan
Fundamental algorithm of the shortest path
Algorithm to judge “point in line buffer”
Introduction to Voronoi diagram
Introduction to 9 intersections
Allen’s temporal relationships

5) Representation

Representation is a process to make information from data. For example, map is information produced by visualization of geospatial data. People may find the meaning from maps but may not from geospatial data, as it is just a sequence of codes.

Structure of maps and portrayal schemas selected from the basic knowledge of Cartography are introduced in the lecture. A map consists of content (symbols and labels), title, subtitle, legends, scale, orientation, inset maps and illustrations, frames and neat lines, description of producer, resource, lineage and date of publication. Meanwhile, portrayal schema defines the structure of symbols and labels by using UML. Students will learn how to illustrate these elements on maps.

6) Exchange

Data exchange is defined as data transfer from one system to another. If the style of data management is different, then a sender encodes data from internal to standardized external format, and a receiver decode data to its own format. To achieve encode and decode, the rules to describe standardized data shall be required. ISO/TC211 and OGC standards adopt XML as a common rule. For example, a coordinate is defined by a sequence of number and dimension. It can be described as follows. Component is a sequence of coordinate elements, while dimension is a number of coordinate elements.

<Coordinate component="575.8,278.2" dimension="2"/>

We exchange spatial data but also application schema, metadata, portrayal schema, etc.

Syllabus

The author has got an opportunity to teach a semester course of Geospatial Technology at University of Tokyo from 2008 to 2010 (Ota et al., 2009). The topics and volume the students can learn during a half-year became clear through this experience. Table 1 shows topics for the course. As long as SDI is the means to assemble geographic information that describes the arrangement and attributes of features and phenomena on the Earth (National Research Council, 1993) and its overriding objective is to facilitate access to geographic information assets, modelling (the real world recognition and its formal description) and exchange, in other word data sharing are both important subjects in Geospatial Technology.

Table 1: Topics for semester course “Introduction to Spatial Technology”

Classes	Topics	Knowledge Units
1. Introduction (Geospatial Technology and Society)		-
	· Maps and Images on the Web · Augmented reality in SF Movies/Animations and mobile-phones · Official geospatial applications and information sharing · Crisis mapping and disaster response · The definition of Geospatial Technology	
2. Spatial Thinking and Modelling		Modelling
	· Spatial thinking - cognition, reasoning and discovery · Cognition - equilibration and three mountain task by Jean Piaget, conceptual modelling · Spatial cognition - The Image of the City by Kevin Lynch, etc. · Reasoning - deduction, induction and abduction, the first low of geography by W. Tobler	
3. Formal Description of Models		Modelling
	· Model and meta-model, and consensus making · The definition of a feature · UML as a schema language · Class diagram and its notation	
4. General Feature Model and Application Schema		Modelling
	· General feature model · Application schema and its design process	
5. Formal Description of Feature Instances		Modelling, Exchange
	· How to describe feature instance following application schema in XML	
6, 7. Spatial Schema		Modelling, Exchange
	· 2D geometric primitives - point, curve and surface · 2D geometric complex	
8. Temporal Schema		Modelling, Exchange
	· Time in our dairy life	

	· Temporal primitives · Feature succession as temporal association between features · How to describe "change" on attribute level and feature level	
9. Reference Systems and Place		Modelling, Exchange
	· Spatial referencing by coordinate · Spatial referencing by geographic identifier · Temporal reference system - calendar and clock, ordinal time · Position, location and place	
10. Coverage		Modelling, Exchange, Analysis
	· Object view and field view · Coverage - point, curve, surface · Coverage - discrete, contiguous · Coverage schema and algorithm to get value at the given position	
11. Spatial Data Acquisition		Acquisition
	· Spatial data acquisition and its process · Acquisition methods · Data product specification	
12. Conformance and Quality		Acquisition
	· Conformance of application schema · Data quality - completeness, positional and temporal accuracy, logical consistency, and thematic accuracy	
13. Spatial Data Management and Exchange		Management, Exchange
	· Metadata and clearinghouse · Encoding - application schema, spatial data, etc.	
14. Spatial Analysis		Analysis
	· Introduction to spatial analysis · Computational geometry as spatial analysis method	
15. Representation		Representation
	· Separation of visual data from spatial data · Portrayal schema and portrayal dictionary · Map design	

GEOPACK

In this section, we introduce how the student will experience and learn through exercises. GeoPack is software as a teaching aid for exercises on Geospatial Technology. Each knowledge unit corresponds with each module of GeoPack as shown in Figure 2. The module "Application schema designer" corresponds with the knowledge unit "Modelling" and it allows the students to design the schema through definitions of feature types and association types. Students will be able to understand how people recognize the real world, what modelling means and how to describe schemas for his/her universe of discourse.

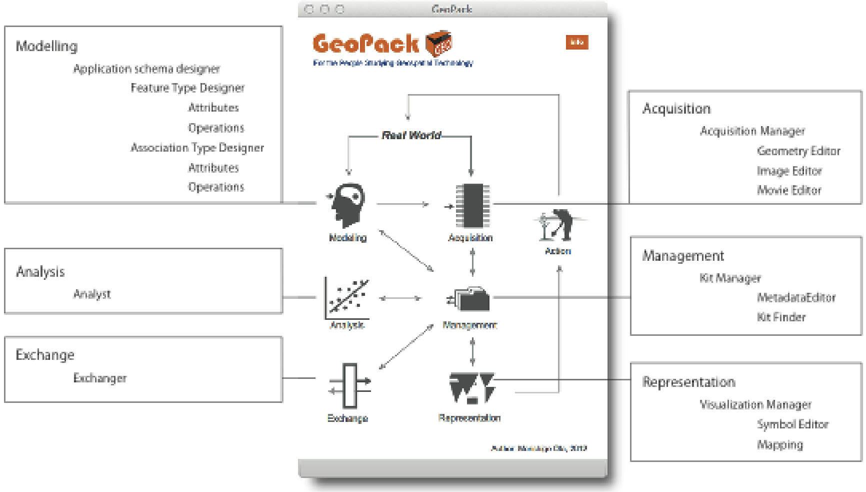


Figure 2: Module hierarchy of GeoPack

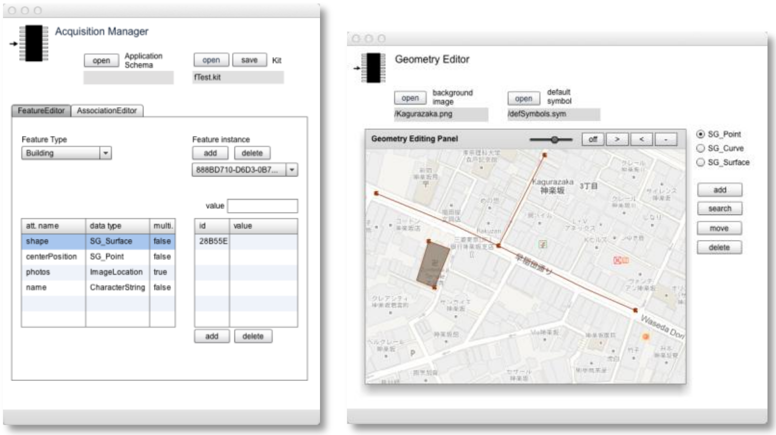
Modelling

Application Schema Designer is used to compose a formal conceptual model. Application schema has two components. One is Feature Type Designer and the other is Association Type Designer. People who share the universe of discourse should use the same application schema. In the exercise, students design application schema independently at first. Then, they will work to build consensus through the group discussion.

Acquisition

In GeoPack, data acquisition is realized as digitizing geometry on the base map, inputting texts and attaching photos and/or movies on a feature instance. The sequence of exercise for data acquisition will be as follows.

1. Prepare the base map for digitizing geometric attribute and texts, photos and/or, movies for thematic attributes of features.
2. Select the application schema on the Acquisition module.
3. Set parameters
   - Coordinate reference system and projection
   - Portrayal dictionary
4. Create feature instance, digitize geometry, and input or select temporal, thematic and location attributes
5. Store a “kit”, a set of feature instances, application schema, and default symbol dictionary.



(a) (b)

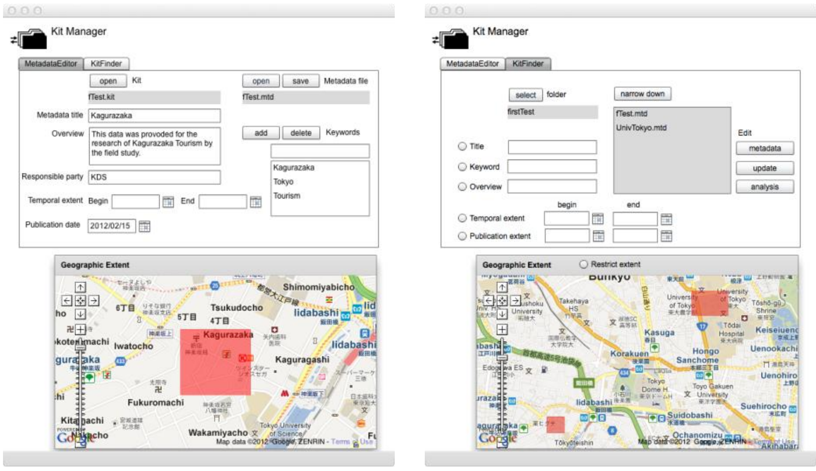
Figure 3: Acquisition Manager (a) and Geometry Editor (b)

Management

Data Management is act of receiving, storing, accessing and sending data. In case of GepPack, we can manage spatial data using metadata. The sequence of exercise is as follows.

1. Describe metadata for the kit. Metadata elements for GeoPack are,
   - Title
   - Overview
   - Responsible party
   - Publication date
   - Geographic extent
   - Temporal extent
   - Keywords.
2. Find a kit through narrow down of metadata in the selected folder by restricting element values.
3. Update or analyze feature instances in the kit.

Kits are stored in the folder of user's PC, as GeoPack is desktop software. It means that this exercise is not the experience to use public clearinghouse or catalogue service. However, the student can understand how to manage and access the spatial data by using metadata.



(a) (b)

Figure 4. MetadataEditor (a) and KitFinder (b)

Analysis

The operation defined during feature type design analyses the feature instance. The result of analysis is stored in the feature instance as an attribute value. For example, imagine spatial attributes "shape: SG_Surface", "centerPosition:SG_Point" (SG means Spatial Geometry), and an operation "getCentroid (surface:SG_Surface):SG_Point" is declared in a feature type "Building". The declaration "an argument surface responds to an attribute shape" allows “getCentroid” active. To push "run" button on the module, "getCentroid" will run using the shape of building and the result will be stored in "centerPosition". Anyone will be able to add new operations, because we are planning to publish GeoPack as open source software.

Representation

This module will have sub-modules for designing symbols and labels, designing maps, displaying maps on the screen, and printing out on the paper. However, we realized only the symbol designer at the moment of writing this paper. The sequence of symbol design is as follows.

1. Design line symbol: Select colour, thickness, transparency, caps, joints and interpolation method
2. Design area symbol: Select filling pattern and borderline
3. Design point symbol: Set the size. Digitize lines and areas after selecting line symbol and area symbol

Exchange

This module simply encodes and decodes data. Target data are, application schema, symbol style schema, kit, and metadata. In GeoPack, interior data format is Action Message Format (AMF), because the program is written in ActionScript V3.0. The sequence of the typical exercise is as follows.

1. Encode a kit to XML document.
2. View the XML document on the text editor
3. Change an attribute value (for example, text, colour and coordinate value)
4. Decode the XML document into inner format
5. Confirm the change on the screen

FINAL REMARKS

We have a schedule to publish lecture slides and GeoPack around the end of 2012. However, GeoPack is still under-developing at the moment writing this paper, we need to add the consistency between lecture slides and GeoPack. We also need to add the manual of GeoPack.

ACKNOWLEDGEMENTS

Lecture slides and GeoPack are developing in the research group of Geospatial Technology under the research project "Geographic Information Sciences Education and Spatial Thinking (Chair: Yasushi Asami, University of Tokyo)" funded by The Japan Society for the Promotion of Science (JSPS). The special thanks goes to Koichi Kubota, Masatoshi Arikawa, Hideyuki Fujita, Taichi Furuhashi, and colleagues in JAG Kokusai Kogyo Co., Ltd. for their valuable comments on the developing of both Lecture slides and GeoPack.

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Session 3B: Life-long learning of GI S&T

GIS-Training in Spatial Epidemiology: the Race Between Long-Term Distance Learning and Short-Term Release of Open Source GIS Packages.

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SUMMARY

Avia-GIS offers courses, from an intensive 3 week face to face course to courses that last several months via their e-learning platform. As participants use a slightly different configuration this can cause interoperability problems between software and tutorials. In this paper we focus on the challenging race between the creation and refresh rate of educational software tutorials and the fast(er) release of (open source) GIS packages, and especially the specific problems that appear when using Open Source GIS programs together with conventional tutorials.

Two courses on spatial epidemiology are compared and discussed. We localized the problems and discussed the use of ‘software independent tutorials’ to solve the problems.

It seems that we can win the race by applying software independent tutorials in future GIS courses!

INTRODUCTION

The GIS technology development started in the 1960s with the Laboratory for Computer Graphics and Spatial Analysis at the Harvard Graduate School of design with the development of a number of important theoretical concepts in spatial data handling and the development of a grid-based mapping program that served as a model for later GIS systems (Mark et al., 2012). In the early 1980s, commercial software vendors like Environmental Systems Research Institute (ESRI) and Earth Resource Data Analysis System (ERDAS) entered the software business and became major GIS software-players. At the same time GRASS started their development, first proprietary but in the 2000s released as public domain software. The development of Quantum GIS just started in 2002. Since then GIS software development, research on both methodology and application of GIS was fast growing with a maximum publication output in 2005 (Figure 1).

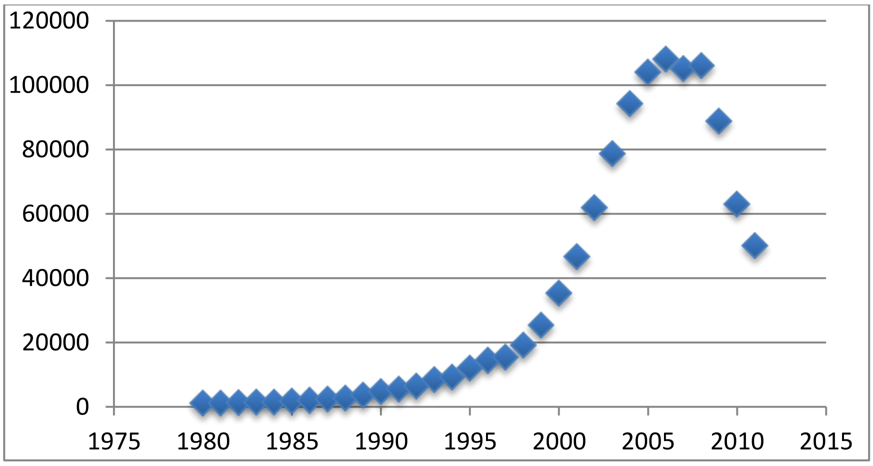


Figure 1: Yearly number of publications/citations referred by Google Scholar when searched for 'GIS'.

Currently, GIS has become an established tool for many different research and application fields ranging from engineering and social science to spatial epidemiology and beyond. Although the total number of general GIS papers is currently decreasing, figure 2 shows that in the specific case of epidemiology the number of papers related to GIS published is still increasing which indicates a fast growing interest in the use of GIS in this specific research field.

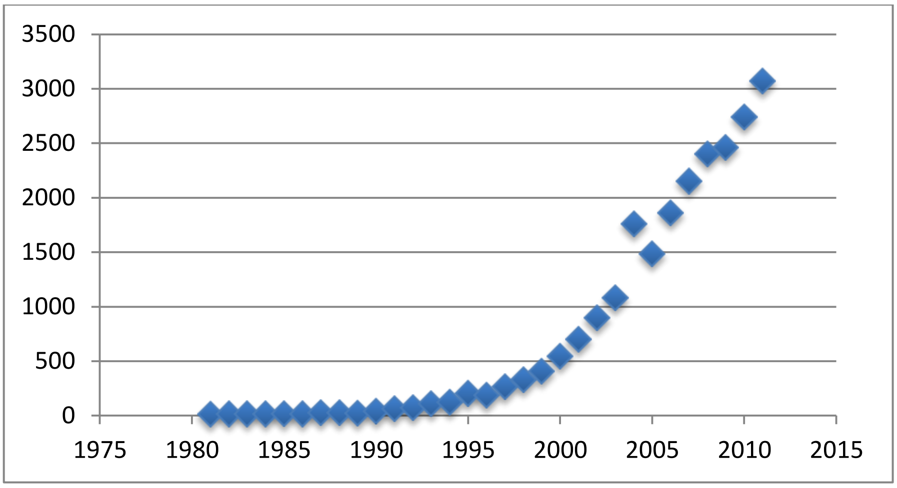


Figure 2: Yearly number of publications/citations referred by Google Scholar when searched for 'GIS'+ 'epidemiology'.

As a private company specialised in spatial epidemiology, Avia-GIS has a long and outstanding reputation in developing learning materials and in training post-graduate and post-doctoral students both in developing countries as well as in Europe. Training is provided through regular curricula of master and post-doctoral programs (ITM, Antwerp; UP, Pretoria) and on-demand as part of international collaborative FP7 funded R&D projects (e.g. EDEN, ICONZ, EDENext, GLOWORM and OH-NEXTGEN). The training is characterised by an increased specialization and specific (software) training according to the user needs. The GIS education method is an active and problem-based approach with case studies taken from the context of veterinary and public health practitioners. The participants use the same GIS-software, and most likely the same release of the software, to complete the tutorial.

TRAINING 'GIS & SPATIAL EPIDEMIOLOGY'

Participants of the Avia-GIS training programs have specific needs focused on the use of GIS in spatial epidemiology. In contrast to the more general courses on GIS that are developed to a broad audience of participants we apply a "quick-to-the-core approach", which has been proven very efficient and successful (Goossens et al., 2011). Instead of a complete overview of all the GIS topics, participants are able to create their learning path according to their needs. This approach is supported by De Bakker (2011) who states that students need Geo Information topics in relation with their activities.

The course material is very visual, screenshots and screen casting of actions that need to be undertaken with the GIS-software are interspersed throughout the learning materials. A screenshot of the outcome of a requested operation is given so that participants can verify if they completed the exercises correctly.

The training is organised around different topics (e.g. Raster Modeling) where each learning cycle is characterised by a successive contextualization and decontextualization of the learning materials. The learning cycle can be divided into three parts that are tightly interwoven: A. Theory, in which participants acquire insights in spatial thinking, combined with a conceptual understanding of the role that GIS can play in epidemiological studies. B. Hands-on exercises to complete their conceptual knowledge using a particular GIS-software package followed by a "real life" casus that they need to solve by creative thinking and applying the conceptual insights ánd GIS skills they acquired sofar. C. 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.

This approach was developed during the last years and was applied on the MSTAH – Master of Science in Tropical Animal Health course at ITM, Antwerp with veterinarians as target audience– organized by the Department of Animal Health (DAH). The mission is to generate, distribute and apply scientific knowledge on tropical diseases in livestock for the improvement of human health and well being in developing countries. This includes our intensive, full-time 3-week GIS training. In general a session starts with theory, and continues with appropriate exercises. The students finish with a short personal project and presentation. The course is intensive and based on a strong interaction between tutor and students. The software used is Manifold 8 and the tutorials were course and software specific developed.

Currently, our training courses are increasingly based on open source GIS programs. The programs are available for multiple operating systems and they launch new releases frequently. Using open source software is free of cost, students can install and use GIS software on their home computers, even after the GIS course, and the licence allows modifying and distributing applications (Tsou and Smith, 2011). Wheeler et al. (2007) describe it as follows: "Open Source Software / Free Software (OSS/FS) are programs whose licenses give users the freedom to run the program for any purpose, to study and modify the program, and to redistribute copies of either the original or modified program." An overview of the existing GIS products is given by Steiniger & Hay (2009), Steiniger & Bocher (2009), Ramsey (2007), and Hall & Leahy (2008).

Open source software was used during the EDENext workshop and distance learning, where European partners are investigating the biological, ecological and epidemiological components of vector-borne disease introduction, emergence and spread, and the creation of new tools to control them. Within this context the Spatial Data and GIS course was organized, starting with a 3day workshop dealing with GIS theory and introductory exercises, followed by the distance-learning program. The exercises from the distance learning are presented on our e-learning Moodle platform that offers the possibilities to present course content and an interactive support and evaluation. The software used was QUANTUM GIS and the tutorials were course and software specific (QGIS 1.7.0). The participants come from various backgrounds and include biologists, entomologists, PhD students on statistical modeling and veterinarians.

Both of the courses were evaluated by 8 students of that particular course. The MSTAH evaluation was a short paper questionnaire to evaluate the course content, approach, and intellectual challenge. The EDENext evaluation was a web-based questionnaire, conducted in July 2012, presented on our Moodle e-learning platform. Moodle offers the opportunity to create an extended web-based evaluation that is time-efficient and easy to use for students and that offers an automated summary of the results for the tutor. The first part of the questionnaire was similar to the MSTAH evaluation and the extended questionnaire was based on a questionnaire already created by Hubeau et al. (2011) which makes the results comparable. Here the participants are asked to their 'level of agreement' in order to evaluate specific parts of the course setup and -content.

COURSE EVALUATION

Based on the student evaluations, the results of both courses are compared and discussed. The general evaluation of the course as a whole for both, the MSTAH and EDENext course, more than 80% of the participants assessed the course between ‘Excellent’ and ‘Good’. For MSTAH everybody assessed the course as ‘excellent’ (Fig. X), while for the EDENext the evaluation is spread from ‘fair’ (1) till ‘very good’ (1), but on average ‘Very good‘ and ‘Good’.

On the question ’Was the course beneficial for the future?’ the answers were mostly ‘(very) beneficial’, with again a slight better evaluation for the MSTAH-course, where almost everybody found the course ‘Very beneficial for the future’.

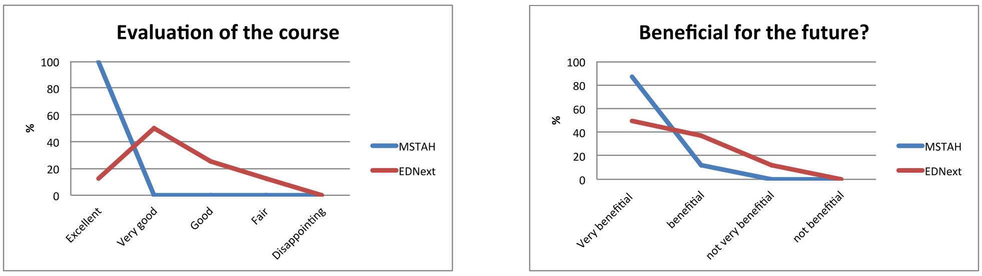


Figure 3: MSTAH and EDENext course evaluation.

While the participants evaluated the intellectual challenge exactly the same, there is a better evaluation of the MSTAH-course.

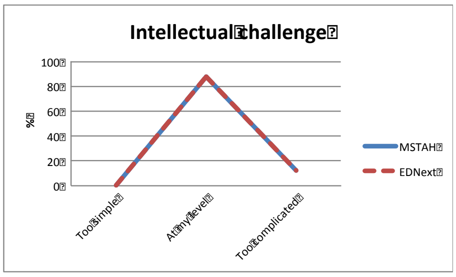


Figure 4: Intellectual challenge.

As the course content was similar, the difference in course evaluation is probably due to the educational setup (tutor guided versus distance learning) and/or the use the GIS program (Manifold or Quantum GIS). To explain the different evaluation of the two courses, the detailed evaluation of the EDENext course is analysed based on the following hypothesis:

1. The EDENext course takes several months, based on an e-learning platform; participants may need more or other support than provided.

Generally spoken, the evaluation of the teaching approach and support of the tutor was relatively good, although some participants indicate that they could use more ‘human support, advice, and feedback’ and that the tutor should stimulate more their creative thinking and problem solving attitude.

The support of the tutor as a whole was:	a. Excellent 3 38%	b. Very good 3 38%	c. Good 2 25%	d. Fair 0 0%	e. Disappointing 0 0%
The tutor stimulated my creative thinking and problem-solving attitude	a. Almost always 2 25%	b. Often 1 13%	c. Sometimes 5 63%	d. Seldom 0 0%	e. Almost never 0 0%

Most participants (strongly) agree with the used teaching approach used for the distance learning, which gave them the freedom to work independently and was time efficient for most of the participants. The course was also stimulating for dealing actively with the course materials and learning process.

I am satisfied with the teaching approach of the EDENext 'Spatial Data and GIS'-course.	1. Strongly Agree 4 50%	2. Agree 2 25%	3. Rather Agree 2 25%	4. Rather Disagree 0 0%	5. Disagree 0 0%	6. Strongly Disagree 0 0%
I'm satisfied with the form of the tutorial of the exercises.	1. Strongly Agree 0 0%	2. Agree 5 63%	3. Rather Agree 0 0%	4. Rather Disagree 3 38%	5. Disagree 0 0%	6. Strongly Disagree 0 0%
The course 'Spatial data and GIS' was time efficient.	1. Strongly Agree 0 0%	2. Agree 4 50%	3. Rather Agree 1 13%	4. Rather Disagree 2 25%	5. Disagree 1 13%	6. Strongly Disagree 0 0%
Human support, advice and feedback were sufficiently available.	1. Strongly Agree 2 25%	2. Agree 2 25%	3. Rather Agree 2 25%	4. Rather Disagree 1 13%	5. Disagree 1 13%	6. Strongly Disagree 0 0%
The exercises were sufficiently clear.	1. Strongly Agree 0 0%	2. Agree 4 50%	3. Rather Agree 3 38%	4. Rather Disagree 0 0%	5. Disagree 1 13%	6. Strongly Disagree 0 0%
The form of the course gave me the freedom to work independently	1. Strongly Agree 3 38%	2. Agree 4 50%	3. Rather Agree 0 0%	4. Rather Disagree 0 0%	5. Disagree 1 13%	6. Strongly Disagree 0 0%
Experience with the software prepares for professional use.	1. Strongly Agree 1 13%	2. Agree 2 25%	3. Rather Agree 3 38%	4. Rather Disagree 2 25%	5. Disagree 0 0%	6. Strongly Disagree 0 0%
The form of the course was stimulating for dealing actively with the course materials and the learning process.	1. Strongly Agree 0 0%	2. Agree 5 63%	3. Rather Agree 2 25%	4. Rather Disagree 1 13%	5. Disagree 0 0%	6. Strongly Disagree 0 0%
The theoretical background of GIS became more clear.	1. Strongly Agree 1 13%	2. Agree 5 63%	3. Rather Agree 1 13%	4. Rather Disagree 1 13%	5. Disagree 0 0%	6. Strongly Disagree 0 0%

The level of satisfaction about the form of the tutorials and exercises is twofold, from 'agree' (60%) to 'rather disagree' (40%). Some participants indicate that the exercises could be more clear and should prepare more for the professional use, but almost everybody agreed that the theoretical background of GIS became more clear.

2. The EDENext course takes several months; participants may use a slightly different QGIS version causing interoperability problems between software and tutorials, or Open Source (QGIS) software issues.

During the course, almost everybody had several software problems. This comes back in the questionnaire, when we asked the students if they had additional remarks or comments':

'Sometimes I got stuck with QGIS (bugs) and it was impossible to understand why. I needed help several times. ... I hope that in the future such bugs will be fixed, because I'm afraid not having someone to help me every time I will need! '

'I found QGIS sometimes not working properly. If possible, I would like to use also a different program: I like the idea of free software but sometimes it was really difficult just to repeat the same analysis due to software problems. '

'There are many problems with the software. ... Sometimes I had the feeling that exercises were not updated because what I saw in the image was not the same with what I saw in my QGIS project. As a result, I wasn't sure if I did it right. At the end all the previous can be good because you are forced to think more, but if you encounter many problems at each step, it gives you great psychological pressure.'

'The biggest problem on the course was the software QGIS. ... At least the beginning would have been easier with user-friendly software, so that not so much energy would have been spent on solving technical problems and banging your head on the wall with some trivial detail.'

This was supported by the questionnaire, most of the people 'Strongly agree' that the software contains too many bugs. These software problems seem to be a 'key' issue for the course, but 75% of the participants have the intension to re-use QGIS.

The software contains too many bugs	1. Strongly Agree 5 63%	2. Agree 1 13%	3. Rather Agree 1 13%	4. Rather Disagree 1 13%	5. Disagree 0 0%	6. Strongly Disagree 0 0%
Do you intend to re-use Quantum GIS?	a. Yes 6 75%	b. No 2 25%				

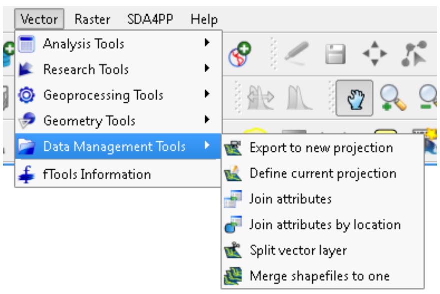
This is a short overview of software and plugin related problems during the distance-learning course with QGIS, from tutor perspective:

Unexpected QGIS behaviour / crashes

Some participants reported unstable behaviour of QGIS causing a software crash. Reinstallation of QGIS solved most of these problems. More problematic from teaching point of view are student errors that were impossible to reproduce. Even tests with an identical OS and QGIS version and with student files deliver correct results, but the student isn't able to reproduce the correct output on his pc. Tell students that their error is unsolvable and that they need to reinstall QGIS creates an unreliable haze over the software.

Use of different QGIS versions

Between the start and end of the course, the QGIS version was upgraded from 1.4.0 to 1.4.4, including several changes in layout and functionality.



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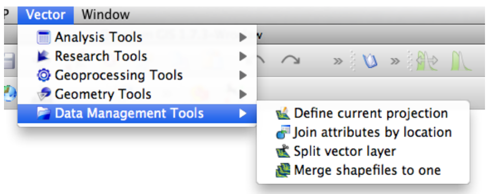

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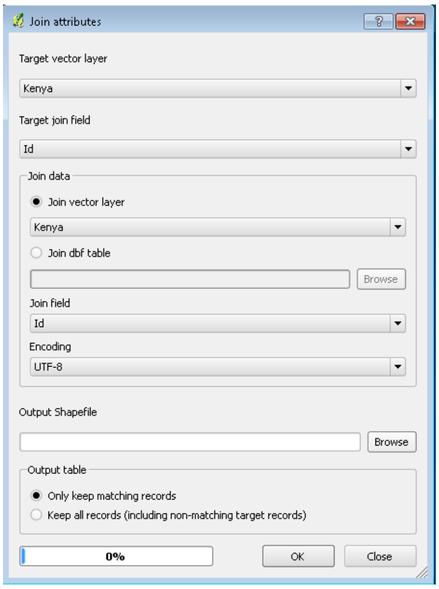

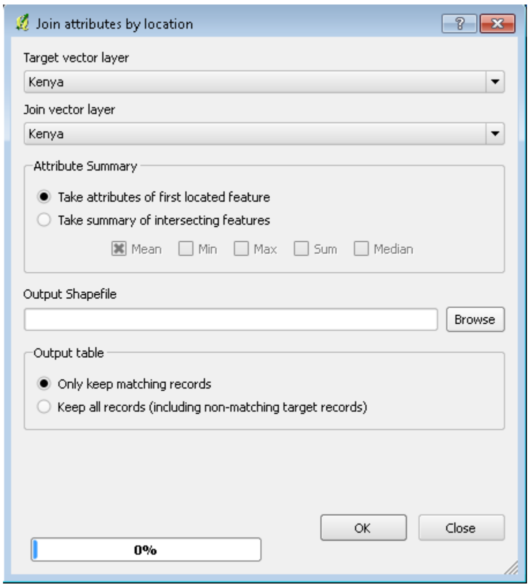

Differences between 1.7.1 (win) left and 1.7.4 (mac) on the right: “Export to new projection” and “Join attributes” are left out in version 1.7.4 where only right-click – save as… can be used to change the projection of a vector layer. These problems are problematic using a visual approach. With any difference between software and course materials, even if the content is only one month old, the course appears to be already out-dated!

SOFTWARE INDEPENDENT TUTORIALS

The use of software independent GIS tutorials, as presented by Hubeau et al. (2011), could solve a lot of problems described before. Software independent tutorials creates the possibility for a flexible software environment combined with solid GIS tutorials, which offers the knowledge to the students to develop their skills to think spatially and to construct their own conceptual knowledge of GIS. There are no specific learning material provided, so the participants need to gather the software information by themselves, and once used to search and solve the students acquire the skills to solve problems related to software, hardware, and data-interoperability (Hubeau et al. 2011).

DISCUSION & CONCLUSION

In general, a Manifold course based on the visual teaching approach is easier to create, maintain, and supervise compared to the open source variant QGIS. The use of ‘software independent tutorials’ without specific learning material provided, is less based on a visual approach could help to solve the impression of working with out-dated tutorials when using open source software with an active developing team.

The participants of the EDENext GIS course want to be more stimulated into creative thinking and the development of a problem-solving attitude; the use of software independent tutorials could increase their creativity to solve both software- and GIS related-problems. This could also increase the satisfaction about the tutorials, exercises, and prepare the student better for their further GIS work. Internet provides a lot of information, although that could be difficult for some QGIS starters. Creating and stimulating an interactive discussion-forum with a ‘self-supporting’ community, supervised by the tutor can encourage their problem-solving attitude. This is common for open source software. The open source software community offers in general “free” user-to-user assistance, and as Lakhani et al. (2003) states, most of the effort expended by information providers in fact returns as direct learning benefits to those providers. Within discussion fora real-world problems (exercises) are delivered and answered by the ‘user community’ while actively building on their knowledge. This fits perfectly in our training philosophy that knowledge is constructed from experience and that the focus should be shifted from systems of delivery of knowledge to the construction of knowledge. The same approach will be applied in the future software independent course where the participants will be motivated to post their questions into discussion fora, so they are urged to take an active role in building their knowledge. This is supported by Siemens (2005): “Let the learner share his information with others”. He 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.

The use of software independent tutorials seems very promising for solving the problems that appear using Open Source Software in GIS tutorials. The software independent tutorials are currently under development and from august on they will be tested. Maybe some preliminary results can already be presented during the conference.

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A questionnaire to evaluate the GI job market in Flanders: first findings

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ABSTRACT

At present, it is unclear whether graduated GI students in Flanders are ready for the GI job market or not. A questionnaire has therefore been developed by the Geography Department of the Ghent University, aiming to (i) assess the required profile of an employee in the domain of 'geo-information' (GI worker) by questioning GI employers; (ii) check whether the university GI education meets the need of the market; and (iii) evaluate the quality of GI education in secondary schools. The target group of this survey was very broad: private companies, consultancy firms, governmental organizations and educational institutions.

The questionnaire was carried out in spring 2012. In addition to the general characteristics of the GI job market, information on the profile of current GI workers, the need of GI employers and the GI education, were collected, as well as various GI aspects (data mining, data processing, image processing, presentation, databases, programming, web development, geo web development, data modeling, juridical knowledge and management).

The questions about the profile of current GI workers deal with education and qualification level and numbers of people working in different GI categories (i.e. GI users, data managers, Geo-ICT experts, coordinators). The needs of GI employers were investigated by questioning if organizations face an increased need for Geo-ICT, how they cope with this issue, which technical competences are necessary for a GI worker, and which levels of required expertise per GI domain are necessary. The GI education was evaluated by questioning the skills of graduated GI students.

In this paper, the first findings of the questionnaire are presented by giving a summary of the most important conclusions.

INTRODUCTION

In an online survey taken during the months of April and May 2012, Flemish employers were asked for the desired profile of an employee in the domain of 'geo-information'[1] (abbreviated 'GI worker'). An additional aim was to test whether the current Flemish programs meet the needs of the GI employers. The target audience of surveyed employers was very broad: both companies, consultancies and government departments.

[1] The definition of geo-information as used in the survey: geo-information = GI = geographic information = all spatially referenced information (information is that part of the selected data relevant for a particular use or purpose).

Based on the answers it was possible to gain insights in the needs of the Flemish GI labor market. In this way the higher educational institution can adjust their programmes in order to prepare students more efficiently for the labor market.

The survey consisted of five parts:

- General
- Profile of current GI staff
- Needs of GI employers
- Training
- Final questions

The answers were processed confidentially and with the utmost discretion. Also, answers were generalized, so a specific answer cannot be linked to a particular organization or name.

SURVEY DESCRIPTION

The link to the online survey was distributed through different channels:

- AGIV website (April 2012)
- AGIV digital newsletter (May 2012)
- FLAGIS mailing list (May 2012)
- AGORIA Geo-ICT mailing list (May 2012)

A total of 103 respondents participated in the survey, but only 20 of them completed the entire questionnaire. This can probably be explained by the extensiveness of the survey as some respondents indicated to find the questionnaire too long. For the presentation of the results per question, the maximum number of respondents is used (i.e. at least 20 per question). For each question the value "N" (bottom left for the figures and top left for the tables) indicates how many respondents completed this question. Since only descriptive statistics are given and no comparative statistical tests that combine different questions, the variation of the sample size is no problem.

Representatives of both private companies (e.g. Geo-ICT companies, architects, surveyor agencies), government (municipal, Flemish and federal level) and higher education institutions participated in the survey. The distribution of respondents is similar for the Flemish provinces (Figure 1), only Limburg is weakly represented. The majority of the participating organizations are from East Flanders (26%) and Antwerp (24%). Despite its small size the Brussels Capital Region apparently houses a large number of GI employers, since 18% of the respondents is based there.

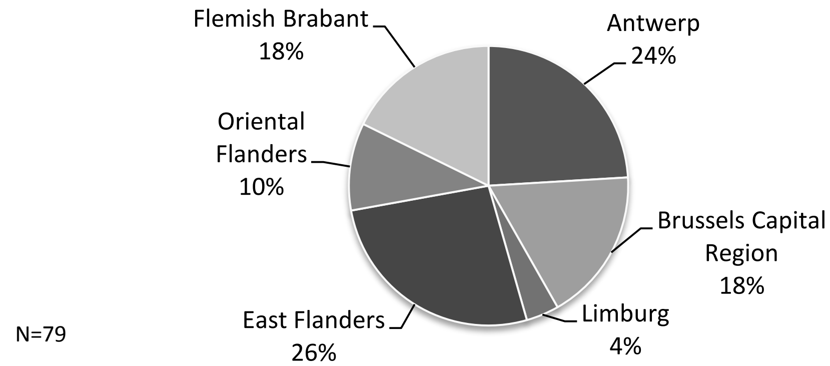


Figure 1: Response percentage for the Flemish provinces

The lower response rate in some provinces is probably due to a lower number of GI employers based in those provinces. Since the survey was distributed via e-mail, it is unlikely to explain the lower response rate by a heterogeneous distribution of the survey. The majority of respondents (84%) indicate to be informed of the survey by e-mail (Figure 2) and this presumably through the AGIV newsletter as this is an electronic newsletter.

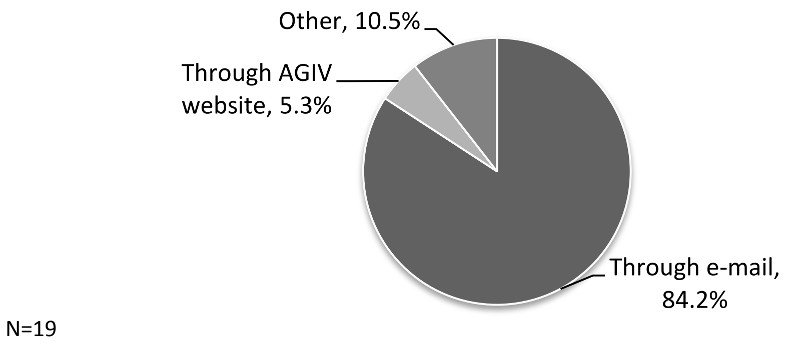


Figure 2: Percentage per distribution method

The main activities of the respondents (Figure 3) consist for the majority (47%) of non-defined activities such as education, architecture, Geo-ICT, services, measurement solutions, a combination of several activities. Many organizations are mainly concerned with data processing (21%) and to a lesser extent with databases (9%), presentation (6%) and data mining (5%)[2].

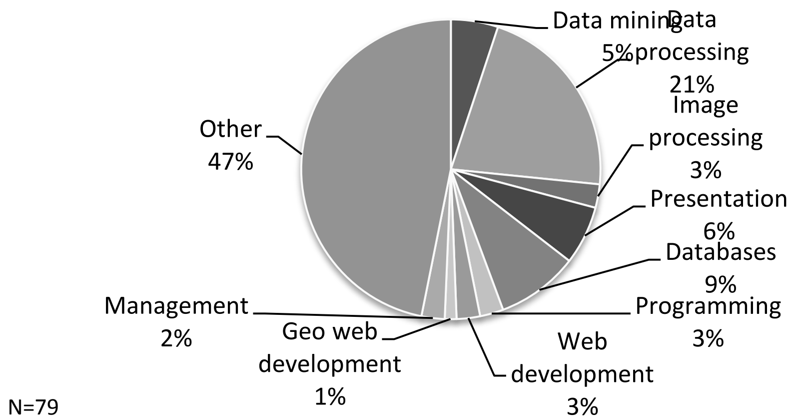


Figure 3: Average percentage per main activity

[2] These GI categories appear in a large number of questions throughout the survey. Category definitions are as following:
• Data mining: capture of spatial data without processing
• Data processing: processing of spatial data to a geographical product
• Image processing: recording, saving and editing geographic images in the form of electronically encoded image elements in a computerized environment
• Presentation: visualization of geographic information
• Databases: a place where information (whether or not geographic) about certain topics is collected, stored and may be consulted digitally
• Programming: writing a computer program or application
• Web development: Web development
• Geo web development: Web development in which geographical information is made available
• Data modeling: describing how geographic information data is structured.
• Legal knowledge: knowledge about regulations for geographic information
• Management: how a process, project or organization is headed

The functions of the respondents (Figure 4) vary widely: the majority indicates to practice a non-defined function (e.g. GI coordinator, lecturer, policy...). Furthermore, many respondents hold functions such as director (22%), project staff (15%), project manager or department head (11%).

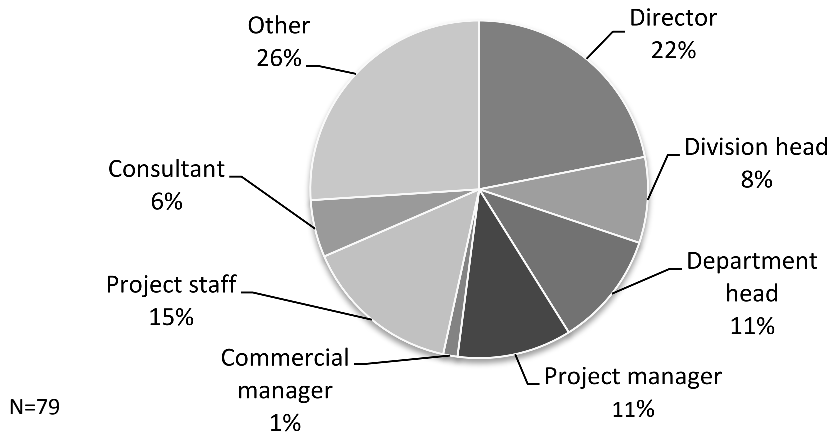


Figure 4: Average percentage per function

Figure 5 shows how many workers there are per participating organization. Mainly large companies (251-1000 employees) participated (23%), followed by organizations of varying sizes. The reason for this large proportion of respondents from big organizations may be due to the fact that several respondents probably work for the same organization, which may cause a slight deviation of the results.

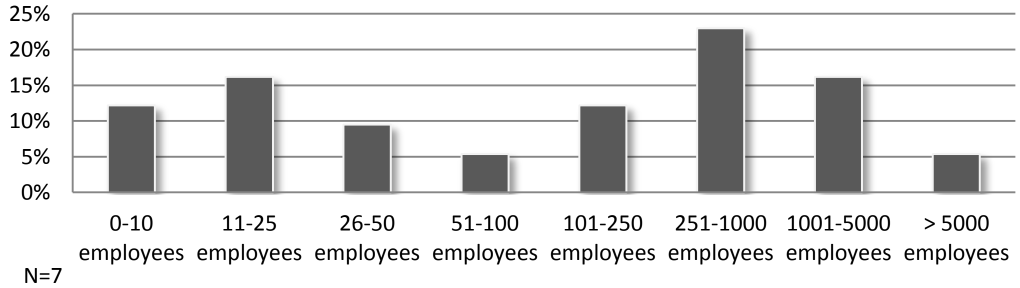


Figure 5: Average percentage of the number of workers in the organization

The age categories within the organizations (Figure 6) vary widely, the majority of employees is situated in the age group of 30 to 40 years (39%). Workers older than 50 are represented the weakest (13%), which is lower compared with the average for the sector of informatics and communication in Flanders (16%, VDAB 2012) and Belgium (20%, VBO 2011).

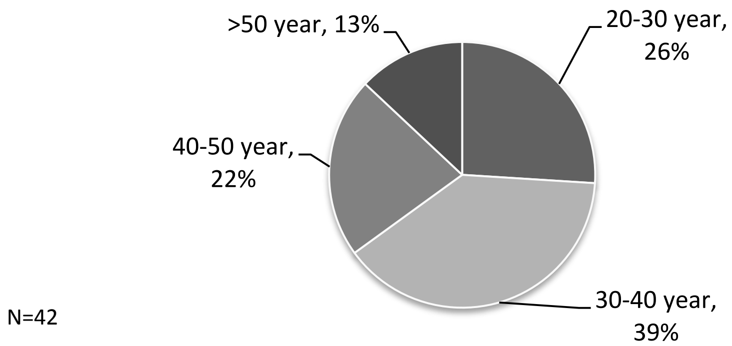


Figure 6: Average percentage of employees per age category

As for the gender information, 67% of the employees of the participating organizations are male and 33% female (Figure 7). This is for the whole sector of informatics and communication in Flanders (VDAB, 2012) 69,8% male and 30,2% female employment., in Belgium (Van Hootegem, 2008) 75% male and 25% female.

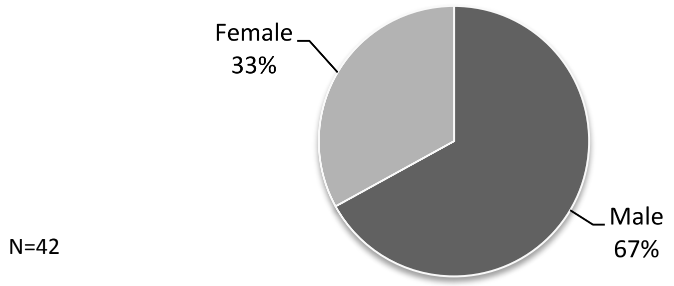


Figure 7: Average percentage of employees per gender

The majority of the employees of the participating organizations have a university degree (38%), followed by a non-university Bachelor's degree (26%) (Figure 8). There are also 16% of employees with a non-university Master's degree, 13% with a secondary diploma and 7% with a degree in elementary education. This indicates that GI employers mainly employ the highly educated.

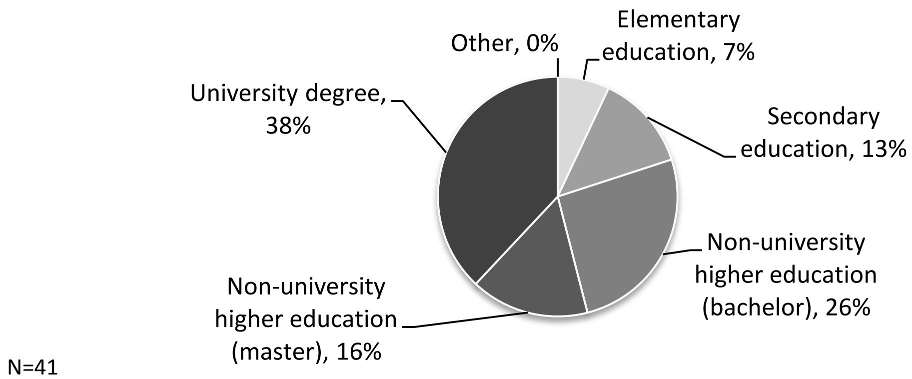


Figure 8: Average percentage of employees per education level

PROFILE OF CURRENT GI STAFF

This part of the report takes in account results on the GI workers, which means the workers that perform tasks specifically linked to geographic information. On average 41% of the total number of employees per organization perform GI tasks (Figure 9), although there are organizations where this percentage rises up to 100% (e.g. Geo-ICT companies), indicating the strong specialization of some organizations.

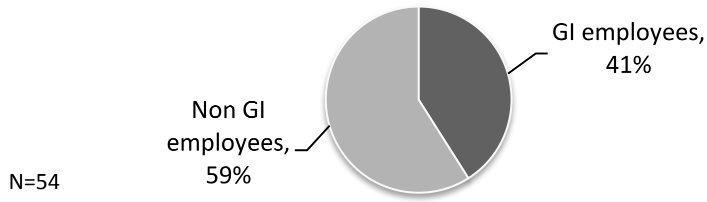
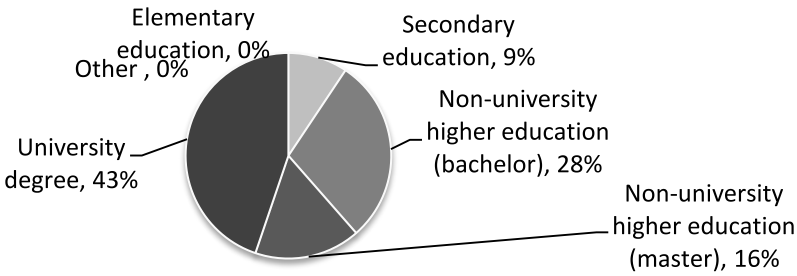


Figure 9: Average percentage of GI employees per organization

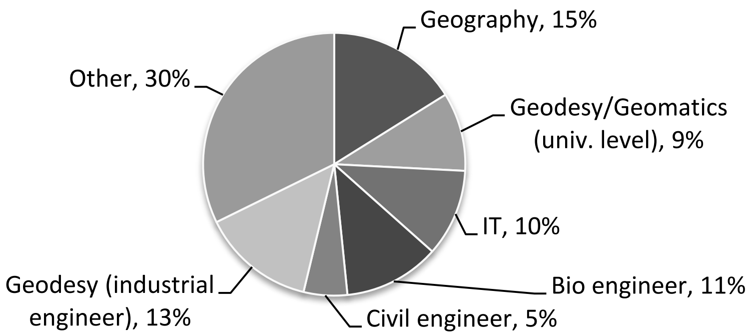
The majority of the GI employees hold a higher university degree (45%, Figure 10). There is also a large number of workers with a non-university Bachelor's degree (29%) or a non-university Master's degree (17%). It is noteworthy that 9% of the GI employees only completed secondary education, which is e.g. the case with municipalities, land survey offices, Geo-ICT companies and mapping institutes.



N=34

Figure 10: Average percentage of GI employees per education level

Looking into the specific qualifications of the GI workers (Figure 11), 32% is covered by diverse non-defined categories (e.g. spatial planning, engineering, geology, biology, linguistics, real estate, economics, chemistry). This is a remarkable phenomenon, as we would expect such positions filled in by a person with a GI related degree. The other workers do hold GI related diplomas such as geography (16%), Geodesy - industrial engineer (14%), bio-engineering (12%), informatics (11%), Geodesy - university level (10%) and a very limited degree in civil engineering (5%).



N=32

Figure 11: Average percentage of GI employees per qualification category

In Figure 12, the GI workers are viewed per category as defined by De Bakker and Toppen (2009)[3.] 32% of current employees are considered a Geo-ICT expert, 22% a user[4], 22% a coordinator and 18% a data manager. 6% of the GI employees could not be placed in one of these classes (e.g. service engineer, product manager, developer, general management). Remarkably, nearly 1 out of 5 GI workers has a coordinating role.

3 The classes defined by De Bakker and Topping (2009) are:
- User: person who makes use of geo-information within specific domains (e.g. spatial planning, water, mobility, ...)
- Data manager: person responsible for the management of geographic information and metadata
- Geo-ICT expert: person responsible for IT tasks that are linked to geographic information (e.g. geoportal, spatial databases, Web services, ...)
- Coordinator: person who coordinates the various tasks linked to geo-information (e.g. project manager, department head geodata ...)

4 A large number of respondents considered all GI workers as 'User', whereas it was intended to consider only their main task for this question. In this case, during data processing the total number of GI employees was decreased with the number of employees from other categories (data manager, Geo-ICT expert, coordinator and "Other") to withhold the number of real ‘users’.

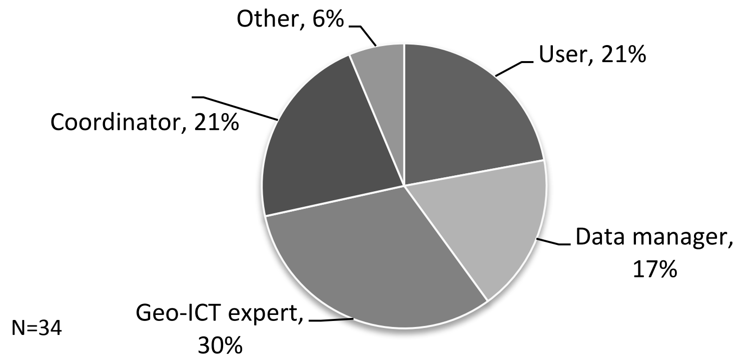


Figure 12: Average percentage of GI employees per GI category

NEEDS OF GI EMPLOYERS

In the previous sections of the report, results on the current GI employees were displayed. This section presents results of the needs towards future GI employees.

Figure 13 shows that the vast majority of respondents (90%) pinpoint a growing demand for know-how in the Geo-ICT domain.

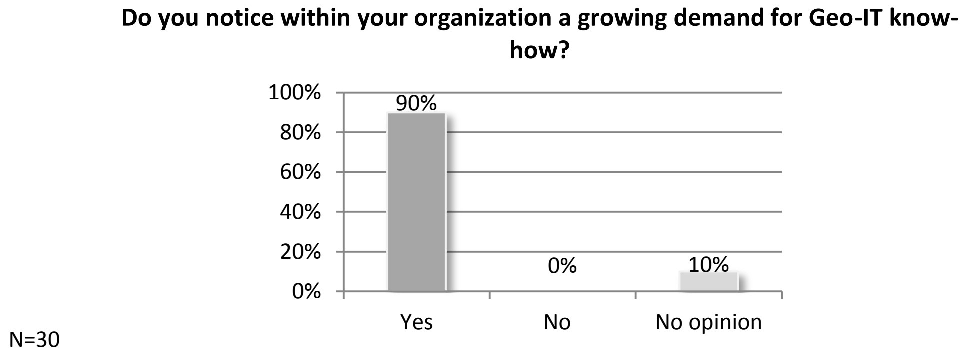


Figure 13

Figure 14 displays different ways to deal with this growing need. This figure shows that most employers ensure their GI employees to grow, either through an external course (72%) or through self study (66%). Very often specific Geo-ICT profiles are hired (48%) and in 28% of cases tasks are outsourced to external specialists. When asked whether it would be useful to organize Geo-ICT-related training courses in Flanders (Figure 15) a majority of the respondents reply that this would be very helpful (76%). There is no further proof needed to point out that there is a market for additional Geo-ICT courses.

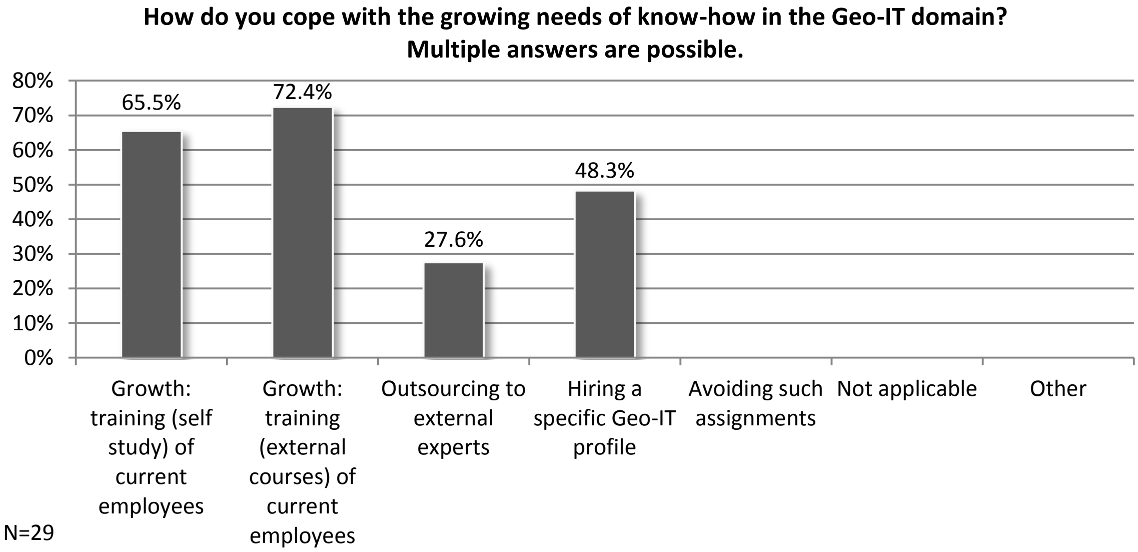


Figure 14[5]

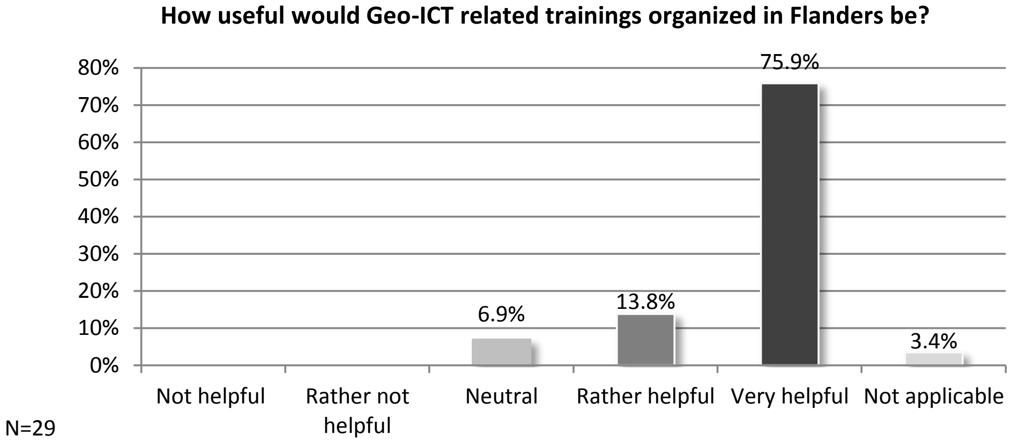


Figure 15

The next questions ask for the requirements (technical skills, required expertise, expected evolution, required educational level, desired qualifications) for the different GI categories discussed previously in Figure 3.

Figure 16 states clearly that GI employers particularly demand knowledge of data processing, databases and geo web development.

[5] As multiple answers are possible in Figure 14, the sum of the percentages is in many cases higher than 100. Therefore results for this question are represented in a bar chart and not in a pie chart, as the sum of the percentages is by definition equal to 100 in this chart type.

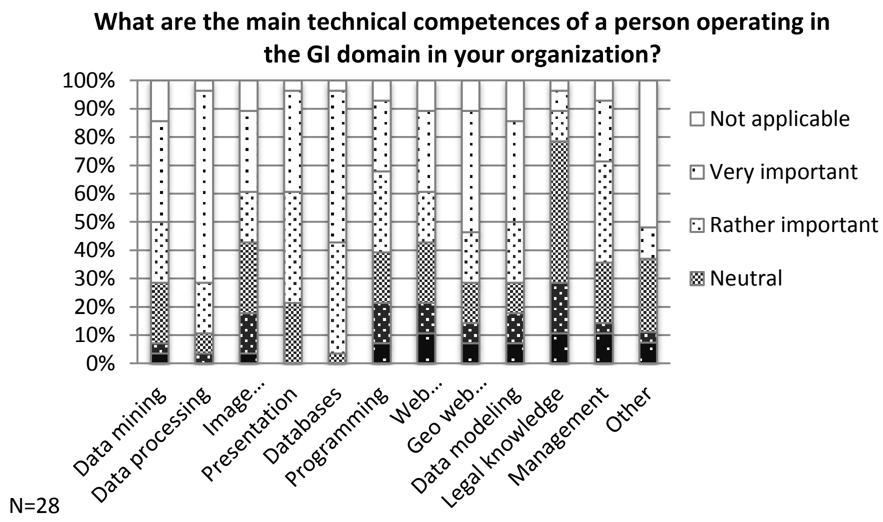


Figure 16

From Figure 17 can be deduced that the main growth is expected within the domains of geo web development, databases and data processing.

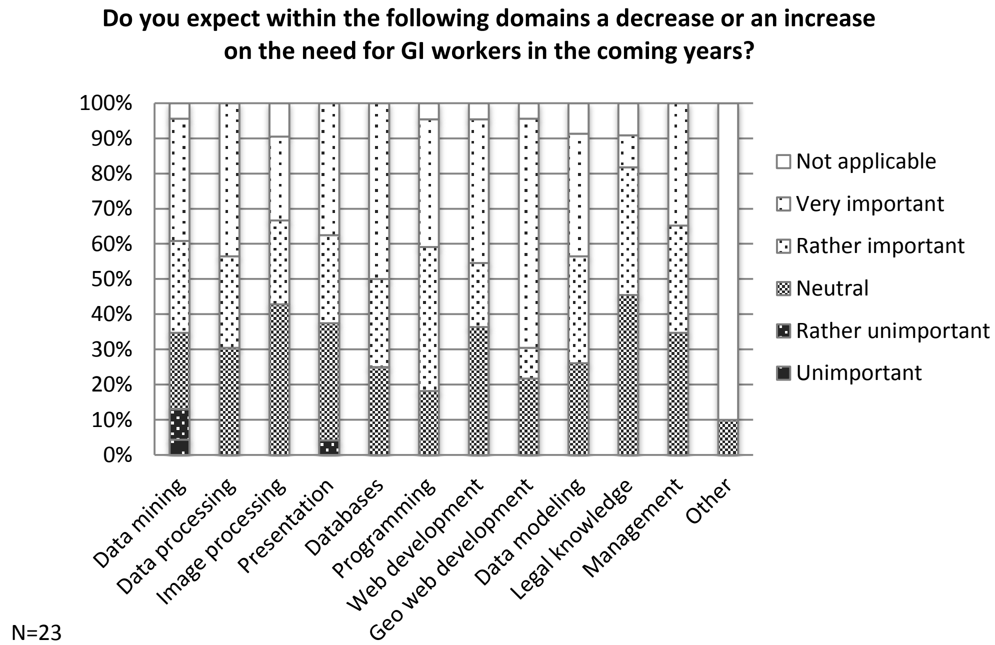


Figure 17

Figure 18 shows that for the domains databases, data modeling, legal knowledge and management preference is given to holders of a university degree, while in data mining, data processing, presentation, programming, web development and geo web development a non-university Bachelor's degree is picked more easily. Figure 19 shows that for the domains of databases, programming, web development and geo web development IT profiles are hunted on. Other qualifications such as Geography and Surveying / Geomatics are surprisingly not particularly desirable for any GI domain, despite the fact that spatial qualities do seem an important characteristic of GI workers.

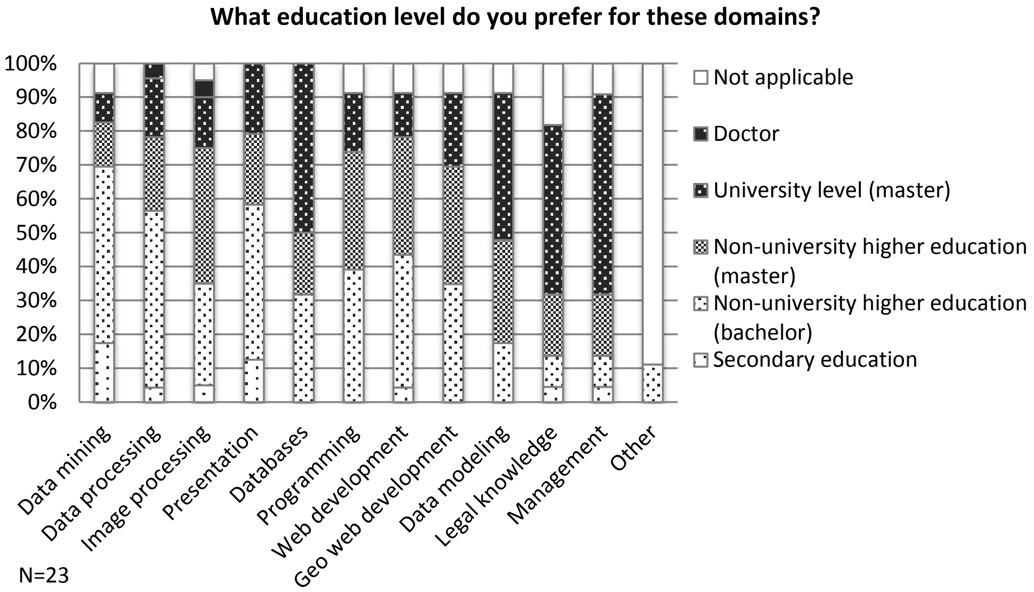


Figure 18

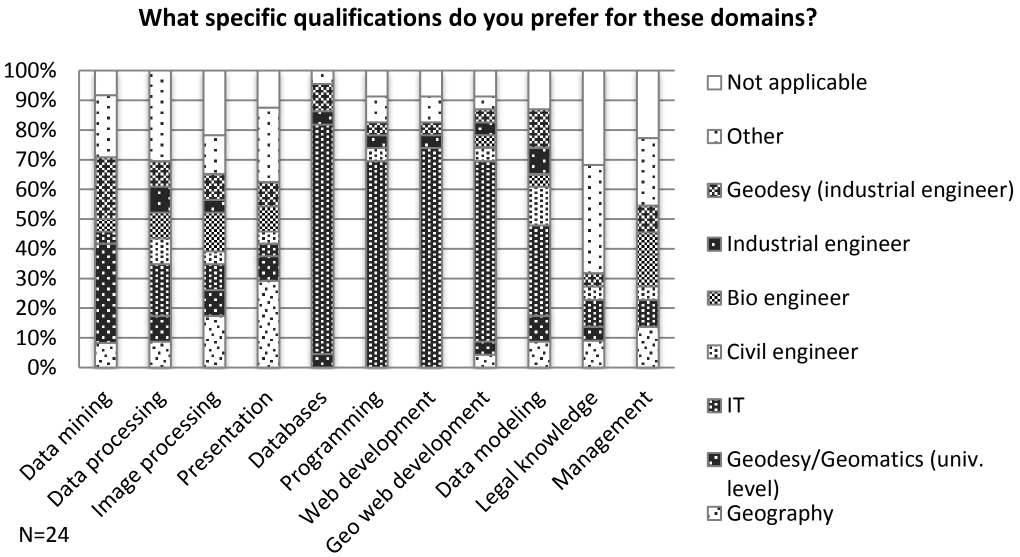


Figure 19

Figure 20 shows that the respondents believe that there are not enough skilled graduates available for the GI job market (64%). A minority (27%) think this number is sufficient.

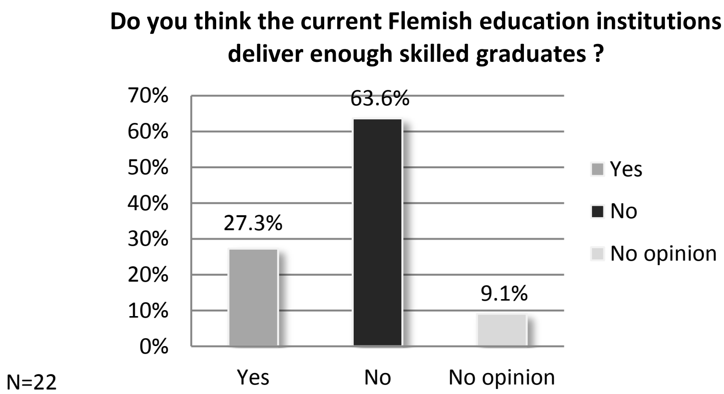


Figure 20

Figure 21 shows that young graduates have sufficient knowledge for the domains of data mining, data processing, image processing and presentation. These same young graduates however lack skills about databases, web development and geo web development.

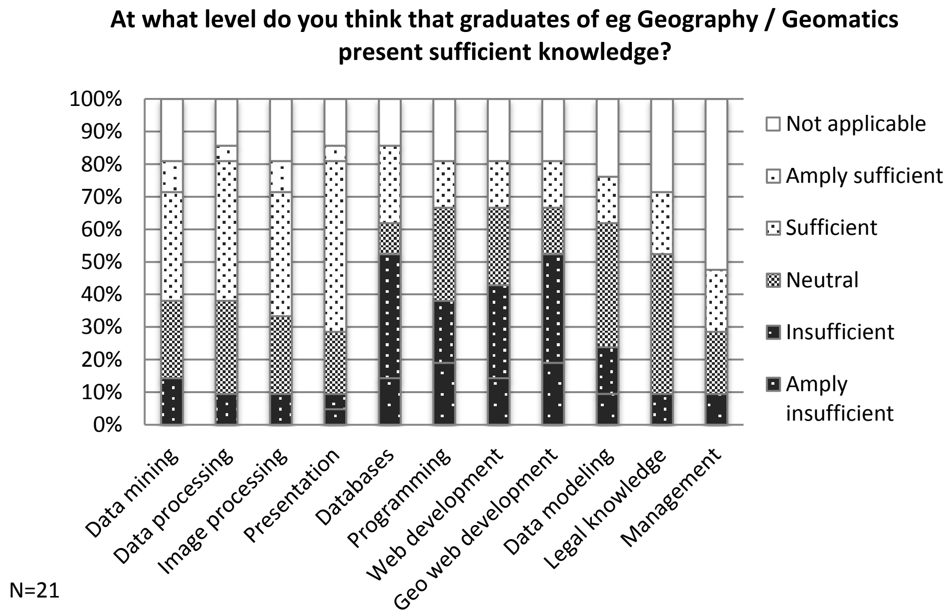


Figure 21

The next question (Figure 22) shows that employers are mostly eager to offer their employees training possibilities and especially for the domains of geo-databases and web development - to a lesser extent for the domains of data mining, data processing, image processing, programming, web development, legal knowledge and management.

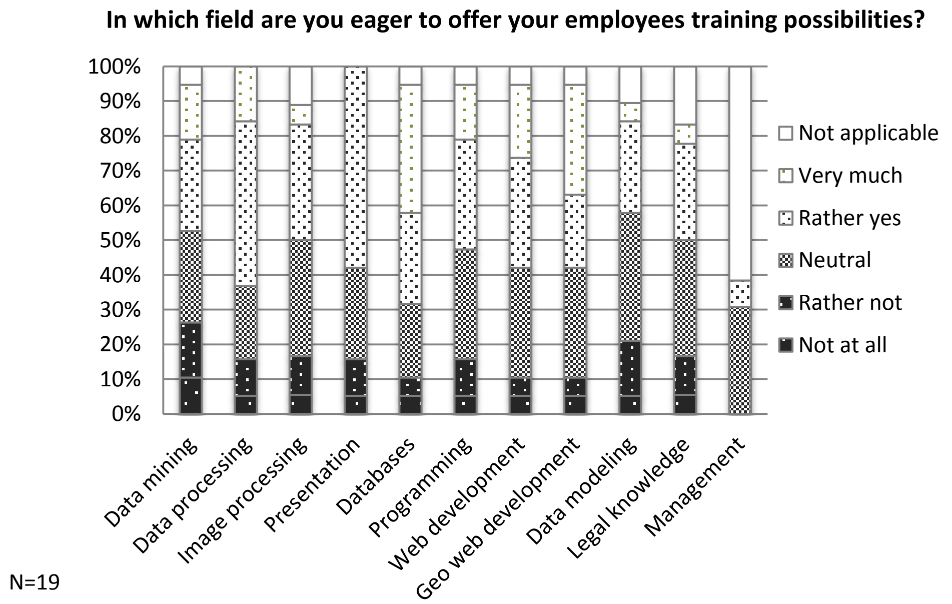


Figure 22

Regarding the provision of internships for students (Figure 23), the majority of respondents (62%) affirm to be willing to offer unpaid internships.

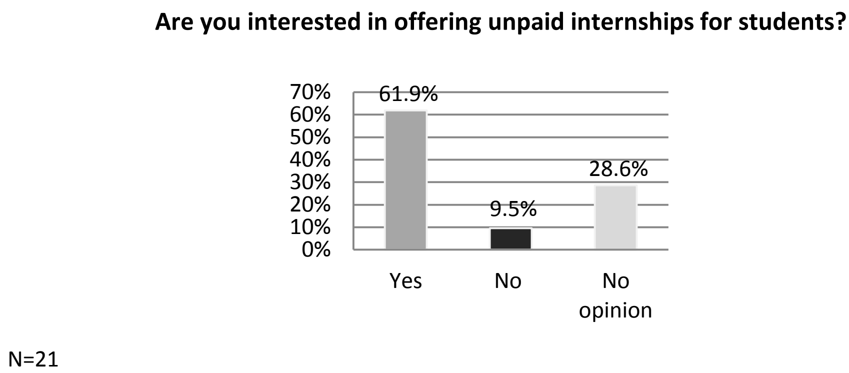


Figure 23

CONCLUSIONS

In this report, some first results of the GI survey held in April and May 2012 are presented. The major conclusions of this survey are summarized below. Since the number of respondents was low, this study cannot be considered representative for the whole GI labor market, but it can help us to get first insights in the needs of GI employers.

The skills that are currently most important for GI employees are knowledge about data processing and databases. In terms of data processing (and data mining, image processing and presentation) GI employers are satisfied with the knowledge of graduates, while they are less satisfied with the knowledge of databases (and geo web development and web development). There is a clear and growing demand for Geo-ICT know-how.

Organizations currently cope with this lack of knowledge by offering training sessions to their employees or to recruit specific profiles. However, the supply in terms of training seems not to suffice, because the majority of respondents would find it very useful that additional Geo-ICT training is organized for their employees. In cases GI employers recruit specific profiles, the desired qualification for the domains of databases, programming, web development and geo web development (all Geo-ICT domains) is a degree in IT. Remarkably, other qualifications (e.g. Geography or Surveying / Geomatics) are much less explicitly sought-after while there is a need for workers with strong spatial insights and knowledge.

Based on this survey, it is possible to establish a new survey for future purposes, which takes less time for respondents to fill in and which will create a more representative picture of the needs of the GI labor market. Moreover, a reward for completed surveys (e.g. a book token to win) could have a stimulating effect.

A GI domain that was not currently included, is the aspect of GI mobile applications (e.g. smartphones, tablets,...). GI is growing strongly in this domain and will be included in future questionnaires.

Some considerations coming forward from this survey:

- Geo-ICT is a hot topic.
- A clear demand exists for more Geo-ICT training.
- IT degrees are currently the most desired qualifications within the GI labor market.

- Other qualifications (e.g. Geography or Surveying / Geomatics) do not provide graduates with a specific Geo-ICT profile and could act on it by offering more practical Geo-ICT training in strong cooperation with the GI market (companies administrations, ...). This training could be started as interaction between various university and high school groups (e.g. Geography, Surveying, Computer Science,...).

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Creating a learning line on spatial thinking in education

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ABSTRACT

Spatial thinking in education should be a fixed value in addition to other such as linguistic and mathematical thinking. It is part of the everyday life. As research showed one of the best tools to introduce spatial thinking in education is geography. It offers al the tools for the three components of geography: skills, subject matter and perspectives.

But nevertheless the introduction and use of GIS in education is not a success. Researchers have described many reasons, among others the lack of education standards on the use of GIS in the curriculum.

Therefore the Digital Earth project creates a benchmark with learning outcomes through the educational curriculum. To make it practical a learning line – including an increasing level of complexity – in using GIS should be developed.

Key words: GIS, spatial thinking, education, learning outcomes, skills, competences

SPATIAL THINKING IN EDUCATION

Many reports state that spatial thinking in education should be a fixed value in addition to other such as linguistic and mathematical thinking. According to the National Research Council (Down e.o. 2006) thinking spatially enables knowing about

- Space – e.g. different ways of calculating distance, coordinate system
- Representation – e.g. effect of projections, principles of graphic design (semiology)
- Reasoning – e.g. different ways of thinking about shortest distances, estimate the slope of a hill from a map of contour lines

A spatially literate person has following characteristics:

- He has the habit of mind of thinking spatially – he knows where, when, how and why to think spatially,
- He can practice spatial thinking in an informal way – he has deep and broad knowledge of spatial concepts (such as distance, direction, scale, and arrangement and representation (maps, 3D-models, graphs…),
- He can adopt critical stance to spatial thinking and evaluate quality of spatial data, he can use spatial data to construct, articulate.

Spatial thinking is integral to everyday life. It is the concept of space that makes spatial thinking a distinct form of thinking. We live in a spatial world, we solve spatial problems. Thus it is a basic and essential skill that can and should be learned, besides other skills like language, mathematics and science.

LINKING SPATIAL THINKING TO THE USE OF GIS

When referring to GIS mostly is mend ‘Geographic Information System’: a set of computer technologies that allows visualizing and manipulating geodata in an easy visual method. In this paper GIS refers to this definition. But GIS can also be called ‘Geographic Information Science’ (Goodchild, 1992), thus also involving a way of methods and ways of looking at the world (Milson, 2012), whereby GIS is used to obtain spatial thinking skills.

Freeman (1997) stated ‘changes in technology pervade the pedagogy and methodology of geography’ so with the possibilities offered to use GIS nowadays (free software, available datasets, computers with internet common) we can now longer ignore the use of it in education. Koutsopoulos (2010) mentions two approaches for using GIS in education:

- We can use the powers of GIS to teach geography for it can help us understand our world through both the natural and the man-made manifestations which are the essence of geography
- In teaching with GIS a positive effect can be created on the development of spatial thinking and reasoning.

Thompson (1991) states that GIS is an ‘educational delivery system for improving the student’s knowledge of the world in which she or he lives.’ GIS is able to answer all the questions that knowledge, understanding and application in geography education requires (Koutsopoulos, 2010).

Because of its capabilities GIS is inherently an excellent vehicle in expressing the five themes of geography, as defined by the Joint Committee on Geographic Education (1984): location, place, relationships with places, movement and region.

Koutsopoulos (2010) developed a conceptual framework for using GIS. For his idea he uses the Geographic Education Standards Project (GESP, 1994), stating that geography is composed of three components: skills, subject matter and perspectives whereby all three are necessary to be ‘geographically informed’ and thus should be examined (Figure 1).

Geographic skills are a series of tools and techniques, including asking geographic questions, acquire and organize spatial information. The purpose is mainly focused on the level of knowing (“where is it?”), although some questions will lead to the process of understanding (“why is it there?”) or even applying (“what if …?”).

The subject matter is divided - according to GESP - into six “essential elements”. Most of these refer to the process of understanding.

A geographic perspective is a lens through which geographers look at the world. It involves the ways that knowledge and understanding can be used to solve geographic problems (process of applying). The specific aspect of geography – linking human and physical systems in a spatial lens – provides everything to solve spatial problems by active participation.

Geographic skills, subject matter and perspective correspond to the processes of knowing, understanding and applying: by “learning the concepts and vocabulary of geography (knowing) students may begin to think about what they mean (understanding) and apply to real problems (applying)” (NAEP Geography Consensus project, 2010).

Knowing is in spatial terms expressed by the questions 'What is it?' and 'Where is it?', in GIS this means processing spatial data.

Understanding is expressed by questions such as: 'Why is it there?', 'What has changed?', 'What is the pattern?', 'What is the interaction?', in GIS this is spatial analysis.

Applying is expressed by the question 'What if ...?' to solve spatial problems, in GIS this means planning.

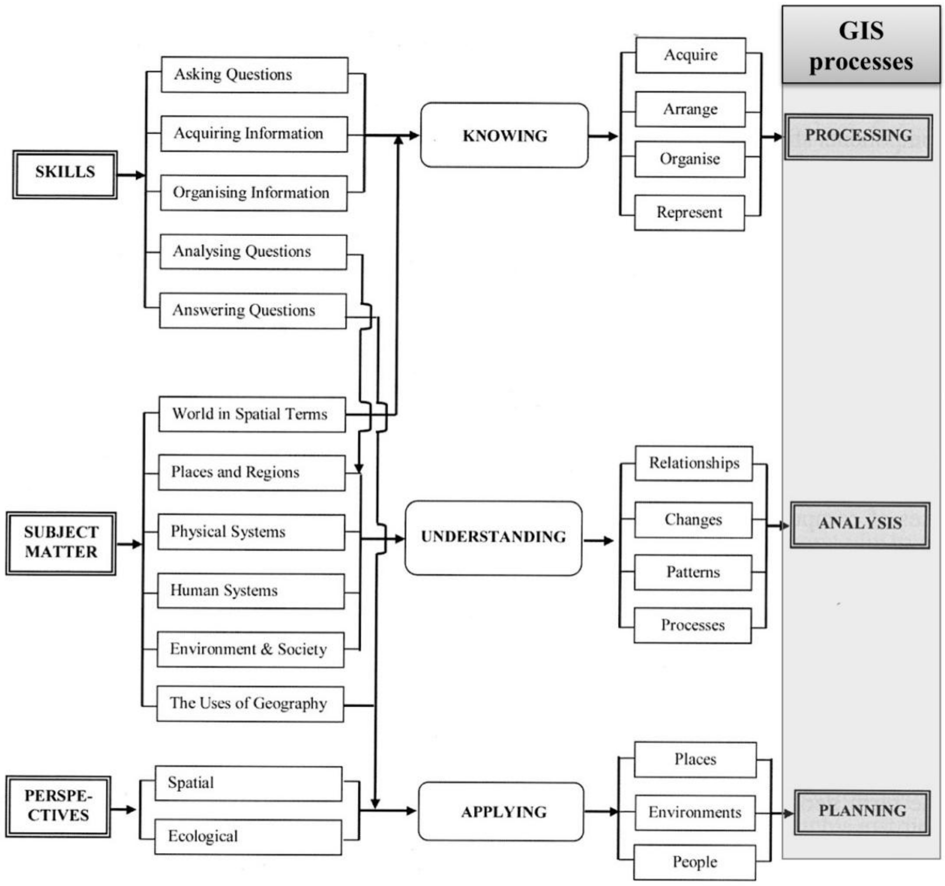


Figure 1: Linking the science of geography to GIS *(Koutsopoulos, 2010 & own edit)*

Koutsopoulos (2010) linked the 3 GIS processes with the questions and the five themes of geography – created by the Joint Committee on Geographic Education (1984): location, place, relationship with places, movement, and region (Figure 2).

His framework shows very clearly the impact and importance of GIS in answering the questions on the level of the three processes. He results that "GIS can serve as an unique educational tool in which the manipulation, analysis and presentation of spatial data can support the teaching of geography" (Koutsopoulos, 2010).

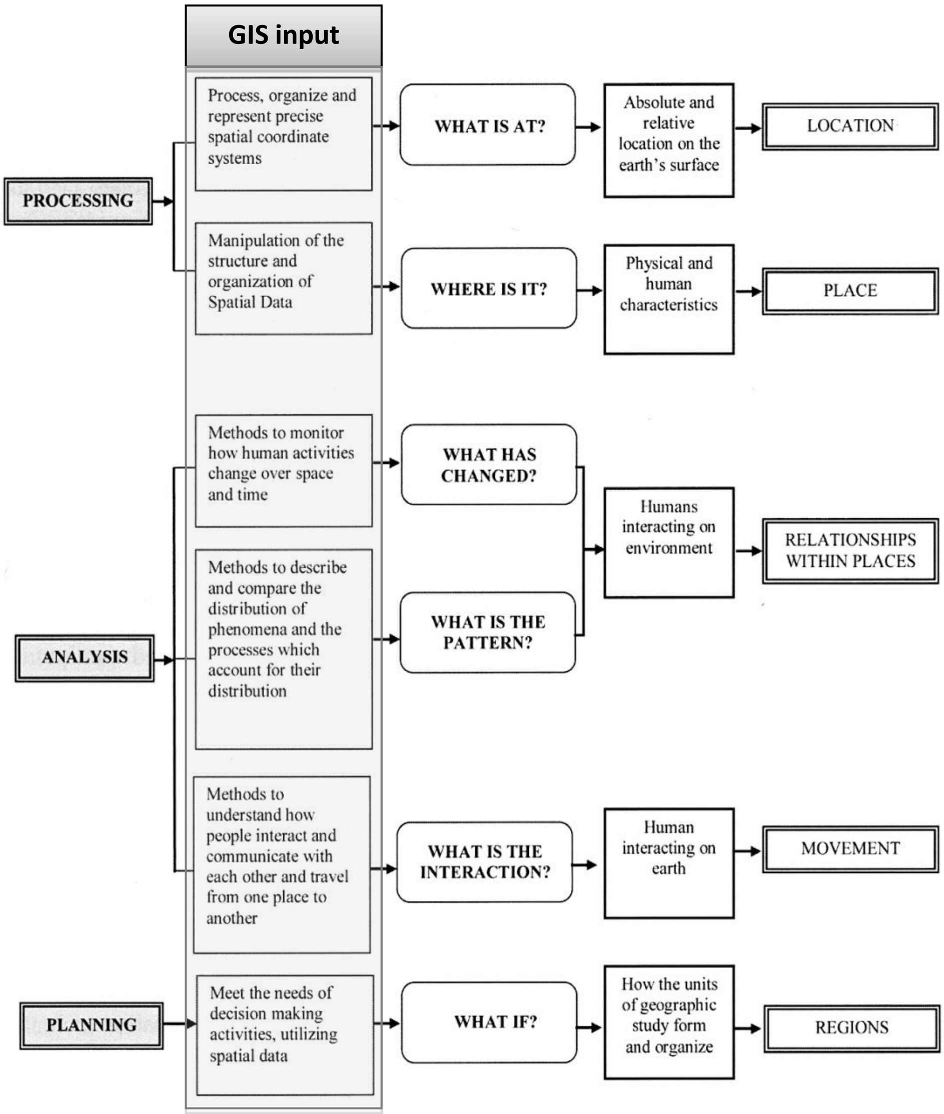


Figure 2: A conceptual framework in Instructing with GIS *(Koutsopoulos, 2010 & own edit)*

More specific typical spatial thinking skills are enhanced using GIS. By involving student activities using GIS "students not only learn by hearing and seeing, they also have the ability and opportunity to personally apply the knowledge using higher-order skills such as problem solving and synthesis" (Sanders, 2002) In order to foster such skills teachers and students may need to work in new ways such as through enquiry based methods and problem-based learning.

The approach developed by Koutsopoulos follows one of the four GIS schools described by Kemp (1992, quoted in Sui, 1995): GIS as an enabling Technology for Science, arguing that GIS is not an goal in itself but a means to use spatial thinking skills.

INTEGRATING SPATIAL THINKING – USING GIS – IN EDUCATION

"Geography educators have justified GIS's introduction using three competing and yet complementary rationales that correspond to GIS's strengths: (1) the educative rationale: GI Science and GIS support the teaching and learning of geography; 2) the place-based rationale: GIS is the ideal tool to use to study geographical problems at a range of scales; and 3) the workplace rationale: GIS is an essential tool for knowledge workers in the twenty-first century. These arguments have not appealed to large numbers of teachers however.” (Bednarz and van der Schee, 2006). According their research the main reasons are:

1. In teacher training (pre-service and in-service) GIS is not a core item
2. More and more geography is taught by non-geographers, “this lack of specialist geography teachers means that many teachers have limited pedagogical content knowledge, defined as knowledge about the best way to teach subject matter. The result is that few teachers assigned to teach geography recognize the potential opportunities GIS offers to teach geography content and skills” (Bednarz, van der Schee, 2006).
3. The curriculum doesn’t include or impede adoption to include GIS
4. The availability of free data and software
5. The attitude of teachers. “Innovations that are complex in form and function, hard to grasp and affect multiple aspects of the teaching–learning system are less likely to be implemented”(Bednarz, van der Schee, 2006). It seems difficult to persuade teachers to use new technologies, certainly if they are highly technical demanding.

They made 3 recommendations,

- Address the key internal issues related to GIS implementation: teacher training, availability of user friendly software, ICT equipment in schools
- Use a community of learners approach.
- Institutionalizing GIS into curricula, making sure that it is aligned with significant general learning goals like graphicacy, critical thinking and citizenship skills. The same recommendation was made by The National Academy of science (2006) stated as one of the primordially recommendations the development of spatial thinking standards and curriculum material.

So spatial literacy must start in education, but therefor we need to answer some questions:

1. How may GIS be incorporated into existing standard-based instruction in all knowledge domains across school curriculum
2. How can cognitive developmental and educational theory be used the develop new versions of GIS that are
   1) Age appropriate in their design
   2) Age appropriate in their scope and sequence

The second question is a matter of developing easier to use software with data access. On both fields a lot of progress is made. There are a lot of free GIS viewers or open source full GIS software programs available. Also more and more governments are offering datasets (for free) or provide open access to database servers.

The first question is one of the aims of the Special Interest Groups 3 and 4 of the Digital Earth project: develop goals / learning outcomes for using GIS in education.

GIS LEARNING OUTCOMES THROUGH EDUCATION[1]

The **digital-earth.eu** project examines the use of geographic media in schools and teacher education. Geo-media is the

[1] This benchmark statement has been produced as a result of the digital-earth.eu COMENIUS network SIG 3 (Teacher education and teacher training) meeting in Brugge, Belgium in October 2011
www.digital-earth.eu

visualization of information from different media sources and is concerned with digital content and it's processing based on place, position and location. Many geographic media are widely used for navigation and routing purposes. Cartographic communication has never been so easy to implement, therefore 21st century school education needs to include geo-media into daily work. Innovative approaches to teaching and learning are needed to study environments from local to global scale.

The digital-earth.eu network seeks to provide broad access to resources, promoting innovation and best practice in the implementation of geo-media as a digital learning environment for school learning and teaching. The goal is to raise the profile of learning with digital earth tools and resources. The network encourages the sharing of innovative practices and rewards organizations and individuals displaying 'excellence'.

Special Interest Groups (SIGs) are working on following topics:

1. Resources, technologies and geoinformation
2. Learning and teaching with geo-media and geoinformation
3. Teacher Education and Training in geo-media
4. Curriculum aspects and geo-media.

Developing spatial literacy assumes the availability of digital earth tools, which allow students to interact with geoinformation, to answer questions and critically reflect using a geographic approach. They can also clearly communicate the results to a broader audience.

Therefore, teachers must understand basic geographic concepts and be able to support students' learning needs. Taking in account the different levels of age and education, teachers must be enabled to apply different methods and tools in the respective learning environments. Appropriate evaluation and assessment methodology has to be developed and implemented by Europe's 21st century teachers, teacher educators and trainers.

Goals for teacher training and education in Europe:

- Spatial literacy
- Create digital earth citizens that are aware of basic spatial concepts and able to use digital earth tools
- Increase active citizenship in spatial decision making
- Increase employability opportunities for teachers
- Encourage lifelong learning

Competencies:

- Spatial thinking:
    - To know concepts of spatial thinking
    - Be able to use tools of spatial representation,
    - To apply processes of reasoning (Where is it? Why is it there? What if it was somewhere else? Making informed decisions and defend personal points of view)
- Pedagogic and didactical skills for the use of digital earth tools in school
- Ability to use spatial skills in real world problem-solving context
- Understanding complex and changing interrelationships
- Awareness and understanding for the digital earth concept
- Ability to use digital earth tools (also technological skills)

- Lifelong learning competencies: ability to find training opportunities, time management, planning competency, communication competencies
- Being able to identify and evaluate resources
- Social learning:
  - Being able to work with others – teamwork
  - Use professional social networks (virtual and face-to-face)

In order to prepare teachers to effectively implement digital earth in their practice, teacher training and teacher education needs to appropriately prepare teachers for different levels of education.

Primary school teachers need to be able to enable students (year 1-6) to

- Open digital maps and virtual globes on a computer
- Indicate the different parts of digital maps/virtual globes (navigation bar, menu, scale, map window)
- Interpret symbols on digital maps
- Work with digital maps and 3D representations of the world:
  - Find significant locations (their home, school or town) on a virtual globe
  - Pan, zoom, orientate
  - Make measurements
  - Use the layers to focus on specific features
  - Update maps
- Be aware of generalization levels applied in different zoom levels (e.g. road density)
- Access information efficiently and effectively, evaluate information critically and competently (see maps as manipulated representations created by people/organizations with a certain purpose, e.g. classification methods, color schemes, map contents)
- Use digital maps and virtual globes for a variety of different purposes

Secondary school (year 7-12)

In addition to the learning outcomes of primary school, secondary school teachers need to enable their students to

- Know the digital earth concept and its tools
- Understand the basic purpose and application of digital earth to real world problems
- Be able to gather and evaluate information
- Use advanced digital earth tools for learning (starting with Web-GIS, GIS viewers to GIS software)
- Manipulate maps
  - Display information on maps
  - Create own maps
  - Communicate cartographic information
- Understand the construction of digital maps as a representation of the real world
  - The power of maps (reliability of data, classification and color schemes)
  - Topology: points, lines, polygons
  - Layers
  - Database
- Know about the professional use of GIS and other digital earth tools
- Gather information from data resources or through fieldwork activities (use GPS devices, mobile applications)

- Use digital earth tools for investigation/research
    - Interpret content
    - Identify and ask significant questions that clarify various points of view and lead to sustainable solutions
    - Frame, analyze and synthesize information in order to solve problems and answer questions

CREATING A LEARNING LINE IN GIS

Taking in account the age and level of complexity the best option is to work with a learning line in education, thus covering at least the six years from age 12 to 18, but even better starting in primary education.

A learning line is defined here as the educational term that refers to the construction of knowledge and skills throughout the whole curriculum. This learning line reflects an increasing level of complexity, ranging from easy (more basic skills and knowledge) to difficult.

As an example the Flemish geography curriculum (LEERPLANCOMMISSIE AARDRIJKSKUNDE (2010) defines these learning lines in the secondary geography curriculum:

5 learning lines:	Fieldwork	Working with images	Working with maps	Working with statistical material	Creation of knowledge
Level 1	**Perception** – knowledge of facts				
Level 2	**Analysis** – selection of relevant geographic information				
Level 3	**Structure** – look for complex connections and relationships				
Level 4	**Apply** – thinking problem solving				

Some existing examples:

Learning line maps

- Level 1: Recognize and name the elements of the legend on the map. Distract the scale.
- Level 2: Retrieve from the map those geographic elements that are relevant within a research context.
- Level 3: Classify and relate elements on the geographic map.
- Level 4: Interpret a map.

Learning line images

- Level 1: Describe the image
- Level 2: Retrieve from the image those geographic elements that are relevant within a research context
- Level 3: Examine the correlation between the different elements by using various techniques (map studies, surveys, statistics ...).
- Level 4: Make up a synthesis of the image

When applying the learning line concept to the learning outcomes (described in the previous section) we get this result:

Level 1: **Perception -** being able to work with digital maps and virtual globes:

- Open digital maps and virtual globes on a computer
- Indicate the different parts of digital maps/virtual globes (navigation bar, menu, scale, map window)
- Interpret symbols on digital maps
- Understand the construction of digital maps as a representation of the real world (topology, layers, database)

Level 2: **Analysis** – selection of the relevant geographic information

- Work with digital maps and virtual globes: find locations, pan, zoom, orientate, make measurements
- Access information efficiently and effectively, evaluate information critically and competently
- Be able to gather and evaluate information from data resources or through fieldwork activities
- Interpret content

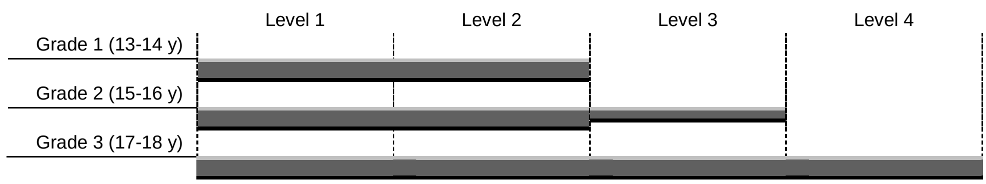
Level 3: **Structure –** look for complex connections and relationships

- Use digital maps and virtual globes for a variety of different purposes
- Identify and ask significant questions that clarify various points of view and lead to sustainable solutions
- Manipulate maps by creating own maps
- Communicate cartographic information

Level 4: **Apply** – thinking problem solving

- Be aware of generalization levels applied in different zoom levels (e.g. road density)
- Understand the basic purpose and application of digital earth to real world problems
- Use advanced digital earth tools for learning (starting with Web-GIS, GIS viewers to GIS software)
- Frame, analyze and synthesize information in order to solve problems and answer questions

For introduction in the different grades of secondary schools the level would depend of the age, thus grade:



CONCLUSIONS

Spatial thinking in education should be a fixed value in addition to other such as linguistic and mathematical thinking. Because of its capabilities GIS – Geographic Information System – is inherently an excellent vehicle to obtain the essential spatial thinking skills. The framework developed by Koutsopoulos shows very clearly the impact and importance of GIS in answering the questions on the level knowing, understanding and applying. GIS can serve as a unique educational tool in which the manipulation, analysis and presentation of spatial data can support the teaching of geography.

The introduction of GIS in secondary education is not easy. Most reasons why previous attempts didn't succeed are overruled by recent developments. But the main reason to persuade teachers is the implementation in the curriculum. The benchmark created by the Digital Earth project SIG 3 is a first step. When adding the concept of learning lines we can construct the content depending of the pupil age. With input from others this might lead to a real curriculum reform.

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Session 4: GI S&T-education without boundaries

Providing easy access to GIS students in north-south cooperation. A case study in Paraguay

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ABSTRACT

Accessing cartography is always a major concern when dealing with students who do not have enough GIS knowledge or there is not much accessible cartography in the country. Both conditions existed in a north-south cooperation GIS lessons taught by Centre for Ecological Research and Forestry Applications (CREAF) and the Universitat Autònoma de Barcelona (UAB), in Catalonia, Spain, performed at the Universidad Nacional de Asunción (UNA), in Paraguay, during October and November 2011. Enrolled students were mainly post-graduated (environmental sciences, forestry, etc) and public servants, but also professionals from several sectors.

There are only a few examples of publicly available maps in Paraguay, not even in paper format, so the basic cartography for the course was difficult to obtain. On the other hand, Spatial Data Infrastructures are not mature in Paraguay, so their role could not be used for discovering existing datasets not for accessing them. The software used was MiraMon, developed by CREAF and then easily adaptable by the MiraMon team to new requirements and tools if necessary. This choice was important for two reasons: firstly, it allowed not only having a primer contact with GIS, but to cover advanced topics in topology building, spatial interpolation, remote sensing or standard metadata edition; secondly, because of the near free nature of the software, it allowed that most of the students are currently using this solution in their professional or academic development. In this complete environment some already existing properties of the program were intensively used whereas new ones were adapted to fulfill all the needs aroused (working with several spatial references systems, current and ancient, global and local, for example).

Some of the existing tools used to approach spatial data to students were the Favorite Maps Collections interface, and the use of OGC WMS standard compliant servers from all over the world. A collection of favorite maps of Paraguay was created and made available in the software as a result from these lessons.

Finally we humbly believe that the presented program course can be helpful to other colleagues involved in education in the field of Geographic Information Science and Technology in a context of North-South cooperation.

INTRODUCTION AND OBJECTIVES

Geographic Information Systems (GIS), are important and very necessary tools for resource and landscape management and widely used within management disciplines. South America is a very diverse region and so there are different levels of technical development among them. Thus, while Argentina and Brasil are more technical countries, Uruguay, Bolivia, Paraguay, etc are still lacking a functional GIS structure, specially in the public administration sector.

Paraguay is a South American country with an estimated population of 6.3 million and an area of about 406752 km2, being Asunción the capital and largest city. Though it remains one of poorest regions and least-developed countries, in 2010, Paraguay's economy grew by 14.5%, the largest economic expansion in Latin America, and the third fastest in the world after Qatar and Singapore. By 2011, economic growth slowed but remained high, at 6.4%.

There is little official reference cartography in Paraguay, in terms of topographical maps and orthophotographies, although it has its own cartographic institute since 1941, the Military Geographic Institute (Instituto Geográfico Militar - IGM) (Mugnier, 2007). Whenever this basic cartography exists, it is not freely available for most of GIS users. However, there is an evident and increasing amount of thematic cartography elaborated by the public administrations like the Secretaría del Ambiente (SEAM), the Instituto Forestal Nacional (INFONA), several NGOs operating in the country like Guyrá Paraguay or international ones like World Wildlife Fund (WWF), or other organizations specific of Paraguay like the Asociación Colonia Neuland.

Due to the claim of the scientific community in Paraguay to deepen the use and understanding of the GIS science and tools among all the professionals involved in, the Universidad Nacional de Asunción, UNA, through the Faculty of Agrarian Sciences, invited CREAF and UAB to give a GIS applied course for all interested users in the sector.

The course was taught in October-November 2011 in the UNA and was attended by 20 students from several institutions of Paraguay like SEAM, Guyrá Paraguay, INFONA, Asociación Colonia Neuland, the Directorate of Meteorology and Hidrology (DMH) of the government of Paraguay, and many students from the last course of Forestry Engineering of the UNA.

The main objective of the lessons were to provide basic knowledge in the GIS science and fundamentals, as well as to provide attendees with a sufficient level of autonomous work when performing their own maps based on existing cartography of Paraguay or by means of using other global sources of spatial information like Landsat satellite imagery, the ASTER and SRTM Digital Elevation Models of 30 and 90 metres of resolution, the ecoregions map of the WWF, etc.

MATERIALS AND METHODS

Until 1962, IGM was dedicated to low-order surveys with the exception of a period of four years when with the help of an Argentine Technical Mission, IGM reproduced four topographic map sheets at a scale of 1:50,000 for the metro area of Asunción. These sheets were cast on the Paraguay Gauss-Krüger Transverse Mercator projection (Mugnier, 2007). There are no much more reference maps in Paraguay since that. Moreover the current national geographic reference system of Paraguay is UTM 21S WGS84 although some existing ancient maps are in other reference systems.

For this reason, it was very difficult to find and prepare basic cartography with which to perform the practical exercises for the course. The materials used to this purpose were:

- Administrative boundaries layer with the basic administrative structures: municipalities, districts, departments and regions.

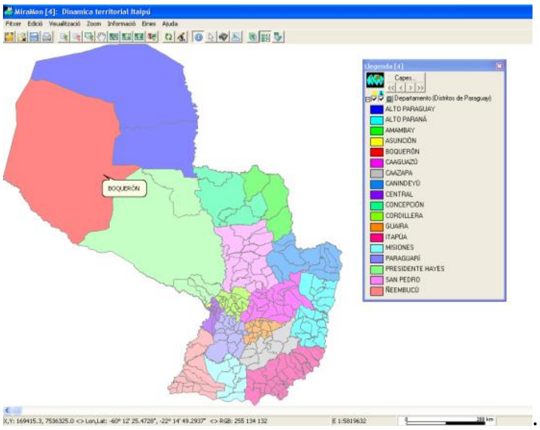

Figure 1: Paraguay administrative boundaries.

- Digital Elevation Models, not available in Paraguay, from the ASTER and SRTM platforms at 30 and 90 metres of resolution.
- Landsat satellite imagery from Landsat 5-TM of the area of Asunción and other interested areas as the huge Itaipú dam and some areas of high deforestation.
- Ecoregions map produced by WWF.
- Ancient maps in paper formats, as the one of Santiago at 1:250 000 made by the Head Office of Geodesy and Cartography of the German Democratic Republic from 1971.
- Orthophotographies extracted from Google Maps and Microsoft Bing.
- WMS services of the world.
- In-situ GPS information capture.

Most of the vector data available, was previously produced in SHP format and it was transformed when needed to the geographic reference system used in all lessons (the official UTM 21S, except in the cases of exercises of projection transformations).

The software used was MiraMon v7 (Pons, 2004), a GIS and Remote Sensing programme developed since 1994 at CREAF, Catalonia, Spain. It is an almost freely tool with the only cost to maintain the structure of developers who implement applications and innovations in the GI Science and Technology discipline. This software was chosen by the professionals in the UNA for its low cost so they could get several licenses for every computer and student. In cases of developing countries, this kind of software strategy is a very good option as combines the completeness and professional maintenance of costly software but in a really affordable cost.

The lessons were scheduled in 40 hours during 5 days (26th-28th October and 3rd-4th November) and structured according to the following programme, which was carefully thought. We assume it will be clear to other professionals of GIS education, but some cases will be illustrated and explained more in detail in the next section.

1. Introduction (4h)

- Introduction. GIS fundamentals
  - Raster and vector data models. Main formats.
  - Georeferencing. Concept and importance.
  - Databases. Tables, fields, records, relationships.
- MiraMon specifications
  - Operating systems and hardware platforms.
  - Functionality model: main application, modules, etc.

    - MiraMon files.
- Data visualization
    - Layer control.
    - Visualization and cartographic symbolization.
- Queries and selections
    - Queries by location and attributes.
    - Interactive selection of entities.
- More about data
    - Layers. Monolayer and multilayer files. Multirecord datasets.
    - MiraMon Maps: MMM and MMZ.

2. **Database management (2h)**
    - Relational database model
    - MiraDades: MiraMon database manager
        - Table relationships edition.
        - ODBC: Access to huge database managers (Oracle, etc), XLS tables, etc.
3. **Metadata documentation (2h)**
    - Introduction to metadata documentation standards: ISO 19115/19139
    - Metadata documentation with GeMM (MiraMon metadata manager)
4. **Georeferencing and subsequent data acquisition (12h)**
    - Georeferencing of scanned cartographic documents: georeferencing fundamentals and theory; conversion from a map or a scanned orthophotography into a digital georeferenced document; scanning criteria; practical methodology; geodetic calculator and reference system (projection, datum, etc) changes.
    - Georeferencing and generation of orthophotos: conversion from an aerial photograph to an orthophotography.
    - Digitizing new vector information: creation and updating vector information: point, arc, polygon; tools for digitizing and editing vectors; topology fundamentals.
5. **Pre-existing data acquisition (2h)**
    - Data import and export from other common formats: SHP (ArcView), DGN (MicroStation), DXF (AutoCAD), TIF and GeoTIFF (Tagged Image File Format), JPG - JPEG (Joint Photographic Experts Group), JPEG2000, SID (MrSID) and ECW, GPX (GPS), XLS (Microsoft Excel) and TXT (ASCII).
    - Cartography in the Internet: OGC standards and MMZ maps: introduction to the main OGC standards: Web Map Service (WMS), Web Map Tiling Service (WMTS), Web Coverage Service (WCS), Web Feature Service (WFS) and Web Processing Service (WPS)
6. **Printing and presenting results (2h)**
7. **Basic tools (3h)**
    - Raster conversion and compression
    - Changing raster resolution
    - Mosaicking and clipping raster and vectors
    - Raster <--> vector conversions
8. **Spatial Analysis (5h)**
    - Spatial interpolation. Main methods.
    - Terrain analysis. Slope, orientation, visibility, map shadowing, etc.
    - Buffers and distance calculations.
    - Merging layers: temporal dynamics, comparison between thematic maps, etc, entity enrichment with information from another vector or raster layer, etc.

- Map algebra.

9. **GPS navigation** (3h): introduction to real-time navigation and off-line downloading data from the GPS.
10. **Applications in remote sensing** (5h): satellites, planes and sensors applied to Earth Observation, electromagnetic spectrum principles, geometric and radiometric corrections, classification methods to obtain categorical maps, quality assessment (confusion matrices, kappa index, RMS, etc).

SOME PRACTICAL CONSIDERATIONS

As stated before, it is not possible to explain, discuss and illustrate each one of the parts of this 40 h GIS&RS program in this brief paper, so we will focus on some particular cases, interesting from some point of view (thematic, procedural, etc).

Part 1, Introduction, does not require especial comments in the context of this course.

Regarding **Part 2, Database management**, note that we emphasize the possibility of accessing tabular data from a variety of formats, from huge database managers to spreadsheet files.

In **Part 3, Metadata documentation**, we emphasize the interest of using an environment that really relates data and metadata and that serves to define the relationships explained in Part 2 (as the GeMM applications does), and using ISO standards, but we also show their weakness and drawbacks.

Part 4, Georeferencing and subsequent data acquisition, requires a large session, but we think it is usually important, and especially important in developing countries, where digitizing to acquire ancient information (sometimes the only information available) is crucial, and where orthophoto generation gives a very valuable base cartography for visual interpretation. In this case, the practical example was performed using an ancient map of Paraguay in paper format made by the Head Office of Geodesy and Cartography of the German Democratic Republic in 1971, in Conic equidistant projection. This exercise wanted to be a real situation where the students only have the spatial data information in a conventional paper map and in a reference system different than the one most commonly used in their country.

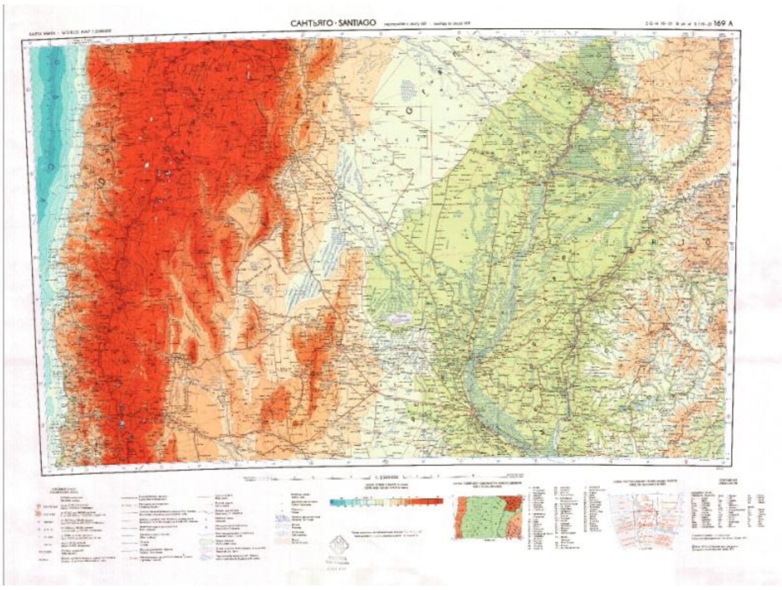

Figure 2: 1971 map of the used to illustrate several aspects: georeferencing, transforming spatial reference systems, analyzing large land cover changes (as the huge Itaipú water reservoir), etc.

This specific geographic reference system had to be created and included in the list of reference systems in MiraMon and so concrete parameters of the projection had to be analysed and incorporated following the specifications in Snyder, 1987.

Parts 5, Pre-existing data acquisition, and 6, Printing and presenting results, do not require especial comments.

When facing **Part 7, Basic tools**, we planned that all students were able to use tools as basic and necessary as mosaicking and clipping raster and vectors.

Part 8, Spatial Analysis, could be covered in a similar length course by itself. Nevertheless we had to select appropriate exercises to illustrate topics as different as spatial interpolation or map algebra. To avoid an excessive dispersion of data, we used for many aspects the ASTER Digital Elevation Model of 30 metres of resolution. Beyond the classical computation of slopes, etc, this DEM was used to perform some terrain analysis in relation to the Itaipú dam (water volume, etc).

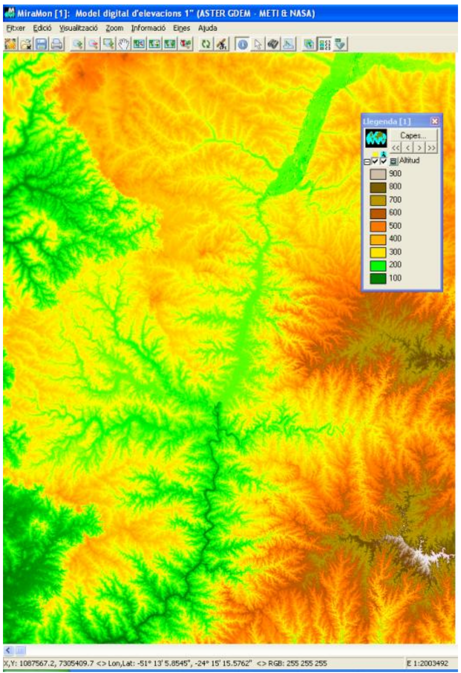

Figure 3: ASTER DEM from the Itaipú dam area

Part 9, GPS navigation, introduced real-time navigation and off-line downloading data from the GPS using three different approaches:

- Navigating from a laptop with a GPS receiver connected to it that merges in the same environment all the GIS power and the real-time navigation. This directly generated the tracks in the GIS thematic and temporal structure.
- Navigating from a GPS receiver. This allowed to download the GPX file created, very common nowadays, and to open, off-line, it in the GIS environment.
- Navigating form a phone application (in this case a version of MiraMon for Windows 6.x Mobile phones). This allows a view of the GIS datasets overlapped in real time with the GPS data, but with a more limited set of functionalities with regard to the first one. Of course in this case GPX files must be used intensively.

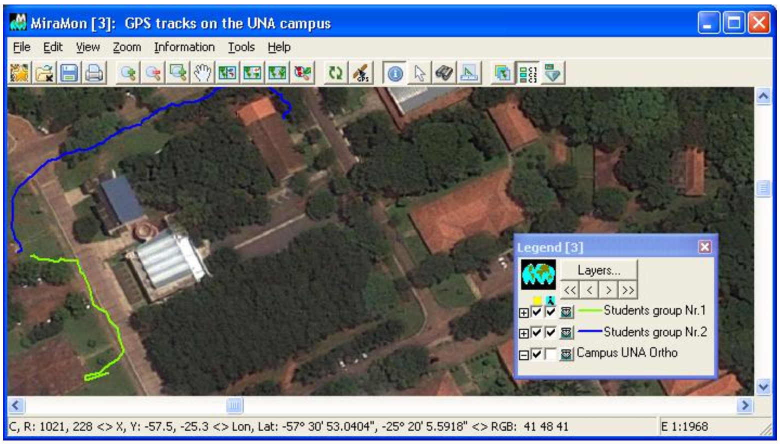

Figure 4: Examples of GPS tracks obtained by the students, overlaid on an orthophoto of the UNA campus.

Finally, **Part 10, Applications in remote sensing**, tries to give an overview of the enormous possibilities of Remote Sensing, and especially in countries where data from plane acquisition is not so usual.

Four Landsat 5-TM scenes were used to examine the changes in the territory, for example due to the construction of the Itaipú hydroelectric dam on the Paraná River located on the border between Brazil and Paraguay on 1970.

The selected scenes were: 20111017 (224-077), 20111017 (224-078), 19730223 (240-077) and 19730223 (240-078). All images were downloaded from the GloVis NASA server and geometrically corrected by UAB following the methods described in Palà and Pons (1995).

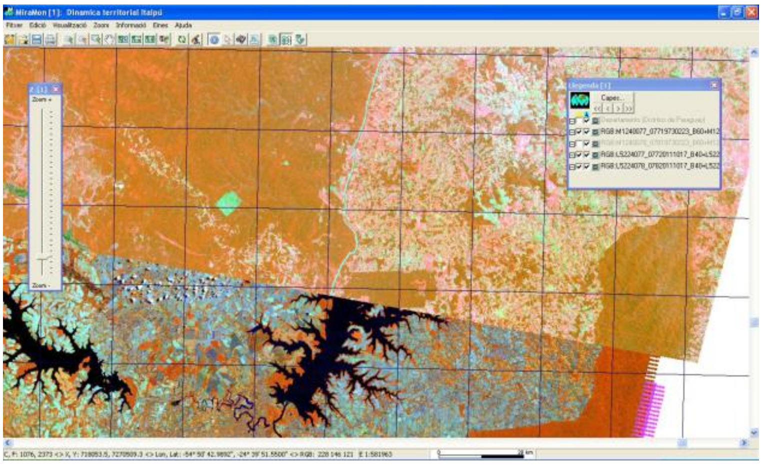
Figure 5: Overlapping of ancient (1973) and current (2011) satellite images. This allowed seeing the huge flooded area and the affected land uses.

Other examples analysed using Landsat imagery were the land use/land cover changes from forest to crops, and the huge deforestation ratios of the forest (according to local agencies, Paraguay is the American country with the highest ratio).

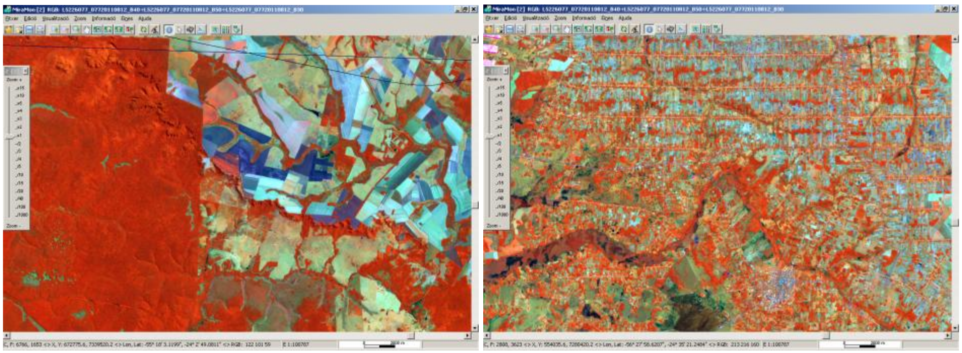

Figure 6: Examples of the very reach and detailed information offered by remote sensing imagery over Paraguay (left: “scissors-like” deforestation; right: parallel roads used for wood extraction).

RESULTS AND CONCLUSIONS

Most of the attendees to the course followed perfectly the lessons given. The most difficult part to follow was the vector digitizing one and the document georeferencing, because of the lack of time for deeply explain all the concepts involved.

Nevertheless, the program presented in this paper can be used to cover a primer in GIS in countries with poor or no digital cartography.

As a practical result of the preparation of the lessons taught, all the materials in terms of reference maps, satellite images and DEMs are free available to anyone interested in. In order to ease the access to the Paraguay cartography, a Collection of Favourite Maps of Paraguay has been developed to all MiraMon users.

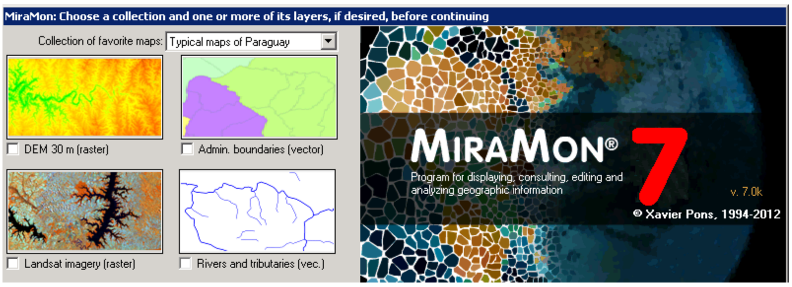

Figure 7: Part of the splash screen of the software showing the rapid access to some of the resources used in the course.

ACKNOWLEDGMENTS

We would like to express our gratitude to our respective institutions and to some colleagues (Cristina Cea, Lluís Pesquer) for helping us in making possible this project. We especially acknowledge UNA for the initiative and for providing all kind of facilities that highly benefited the quality of the course. Xavier Pons is recipient of an ICREA Acadèmia Excellence in Research grant (2011-2015).

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GIS Educational Cooperation: Helping from the North and Learning from the South

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INTRODUCTION

The present paper tells the teaching and learning experience that a group of lecturers, researchers and students from the University of Cantabria in Santander (Spain) have shared with members and students from the University of Kara in Togo for the last three years in relation to accessing and using Geographic Information Technologies (GITs). The paper shows how sharing knowledge through teaching and learning GITs can be an excellent way to start, promote and foster inter-institutional relationships1 between European and African universities.

This article is also focused on showing how cooperation activities based on teaching GITs can be an good mechanism to counteract actively the existing digital divide at the higher education level in the underdeveloped countries.

This experience has offered us the chance to reflect on many different aspects: (1) how important Geographic Information can be in order to promote knowledge society; (2) how technological revolution and digital divide can be a problem or an opportunity to minimize the differences between developed and underdeveloped countries, knowing how subjective the concept development can be (Lacoste,1978); (3) how GITs courses must be designed considering real needs and the environmental and socio-economic contexts of those places where they are taught; (4) how diverse the digital gap can be in two different scenarios such as Africa or Europe.

The article is organized in two different parts. First, it attends to the legal framework of cooperation among African and European universities. Then, some theoretical concepts are also reviewed in relation to the new European Higher Education model and digital divide being presented, at this point, the experience and the contents of the teaching activities in Kara.

The main outcomes of the experience are listed on a qualitative way in the second part of the article where the lessons learnt from the North are also listed. These lessons are used as an input to rethink the concept of digital divide traditionally based on the idea of accessing to technologies. A new theoretical approach is started in this sense showing how relevant concepts such as the level of awareness of the problem and/or personal attitudes can also be to avoid digital divide and to obtain the most advantage from GITs.

[1] This agreement between both universities is the result of a long process and it has been possible thanks to the work developed by Professor Antonio Rodriguez for many years in the field of Enginery and Cooperation at the University of Cantabria.

A CONCEPTUAL FRAMEWORK FOR COOPERATION

Legal and education context

From a legal point of view, cooperation activities have been developed according to the Spanish Law Nº 23/1998, July 7th for International Cooperation and Development and taking into account the millennium goals defined by the United Nations which are fully sustained by the University of Cantabria http://www.un.org/spanish/millenniumgoals. This university is also supporting the *code of conduct of universities in relation to cooperation for development* that was signed at the Provosts Spanish Universities Conference in 2006. Based on this legal background, the University of Cantabria, (Spain) and the University of Kara (Togo) signed a framework agreement on December 2009 which main aim was to promote knowledge and the use of technical applications in those scientific areas characterized by the lack of educational and technological resources. This inter-institutional agreement created the propitious legal structure for the development of two new courses on *Land discovering and water uses* (2009) and *Planning and Enginery* (2010) where Geographic Information Science and Technologies became an important part of the full proposal.

From an educational point of view, any new course design and delivery comprises a theoretical and knowledge background based on models to anticipate needs satisfaction. This paper is conceptually framed on several concepts such as cooperation and development, information society, technology and digital divide (Servon, 2002), (Jeffrey 2003), (Warschauer 2004) Lifelong Learning (Griffin 1999), (Chisholm et al. 2004) or knowledge Society which are creating new bases of education for future societies.

At the European level the new model for higher education proposed by the Bologna Agreement has become the main personal reference in this sense. According to the World Bank Reports (2003), Lifelong Learning model should promote the following characteristics in the education process: • Educators are guides to sources of knowledge. • People learn by doing. • People learn in groups and from each other. • Assessment is used to guide learning strategies and identify pathways for future learning. • Educators develop individualized learning plans. • Educators are lifelong learners. Initial training and ongoing professional development are linked. • People have access to learning opportunities over a lifetime.

Psacharopulos and Patrinos (2002) present in Figure 1 how investment on higher education in low income countries is especially important in relation to private returns.

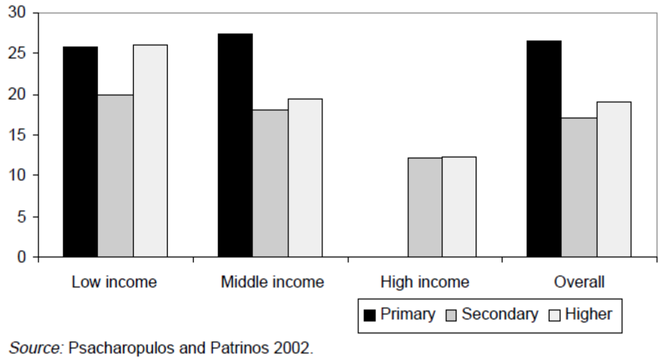


Figure 1: Private return of investment on education by level of education and country income group

ICTs, Geographic Information and Digital Divide

The expansion and growth of digital information and communication technologies have become one of the most relevant issues in the last decades all over the world. This process has been defined by several authors as digital revolution. It is well known that access to digital technologies is related to development. Geographic Information Systems (GIS) as a know-how that is the result of an historical adding of independent technologies, (CAD, DBMS), (Antenucci, 1991) and Knowledge based on spatial science, generate digital divide too. Figure 2.

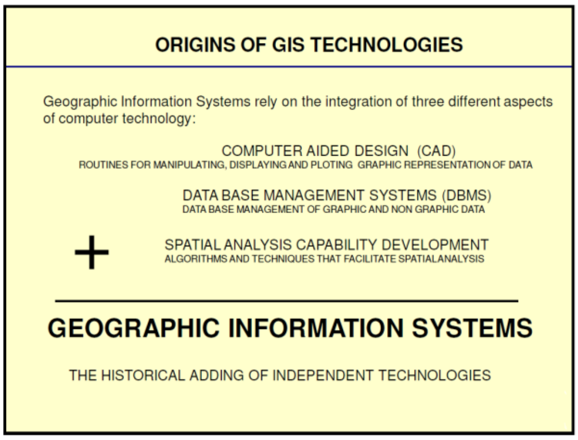


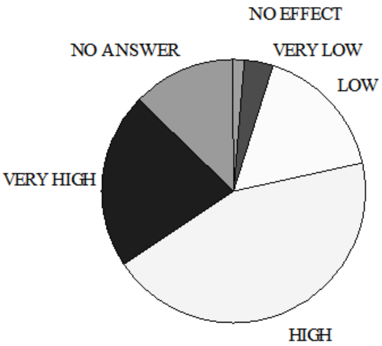
Figure 2: GIS and the historical adding of independent technologies.

The organizational setting of GI has changed very fast in last two decades from personal projects and personal GIS to societal GIS (Bakker, 2011). In this sense WEB-GIS (Google Earth / Google Map) and MOBILE-GIS have highly contributed to the socialization of the use of some technologies based on GI such as GPS-Based navigators or various GIS applied to a wide number of disciplines. The Internet and mobile phones technologies have become two essential platforms for socializing geographic information as never before. Being technologies the *science of means* (Scruton 1982) and being GIT one of the technologies that probably most has being socialized for the last decade, we have to consider the impact that this socializing is producing at all levels. United Nations (Jeffrey, 2003), has announced that in the new digital era, a person who is not able to use a computer can be considered as illiterate.

One of the most known virtual encyclopedia, Wikipedia, describes the term 'digital divide' as "*the discrepancy between people who have access to, and the resources to use, digital information and communication tools* (e.g. Database technology, Geographical Information Systems, the Internet, E-mail) *and people who do not. The expression is also used to express the discrepancy between those who have the skills, knowledge and abilities to use (and profit) from the new technologies and those who do not*.

According to this definition, digital divide is clearly happening between Africa and Europe at all levels. When we focus our attention specifically at the higher education level, GITs seem to be nowadays one important sources of digital divide at universities in both countries.

One of the main outcomes from the study developed by Fdez-Arroyabe (2006) in relation to the use of GITs and digital divide at European Higher Education Area (EHEA) was that more than 65.5 % of people who have ever lectured or worked in relation to geo-information, cartographic edition, GIS, GPS, Remote Sensing, spatial analysis or interpolation techniques considered that the degree in which this particular group of technologies will generate digital divide within the teaching activities in the future is *high* or *very high* (Figure 3, left). The same percentage of respondents considered that digital divide due to GITs will be *high* or *very high* also within the researching activities in the future (Figure 4, right).



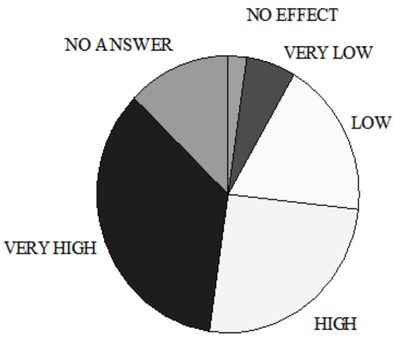
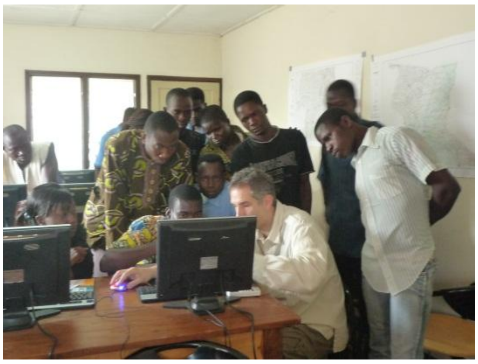


Figure 3 and 4: Future impact of digital divide on lecturing and researching activities at the EHEA

One point seems to be unanimously accepted. Understanding how digital divide is produced in each country and at each level is the first step to be able to counteract it. Teaching and learning seems to be an excellent way to reduce the impact of digital divide. Digital gap related to GITs is producing an increasing gap in both societies at higher education level in different ways. Further education appears to be one of the best methods available to counteract the digital divide.

Teaching and learning at Kara University

The first teaching/learning activities at the University of Kara took place from May to June 2010 and lasted for five weeks. There were four different courses, one per week: (1) Geographic Information Systems; (2) CAD and hydrologic models; (3) Classic topography and digital cartography; (4) Natural hazards management. Last week was dedicated to tutorials and personal work. Courses were attended by professors and a selection of postgraduate students from the degree on Geography that is taught at the University of Kara. It is important to mention that accessing to digital technologies such as a computer or to an Internet connection is very limited in Kara. The agreement between both universities made possible the creation of the first computers room at the University of Kara. While University of Cantabria offered the teaching and learning resources, the University of Kara agreed to create a computers room to run the courses, Figure 4 and 5.

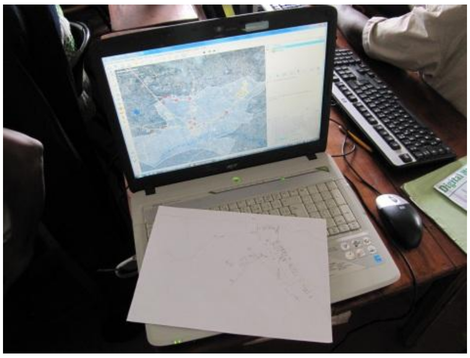


Figures 5 and 6: Teaching activities in Kara (left) and staff members of both universities (right)

This first teaching and learning experience on GIT allowed us to set up the main theoretical concepts that are needed to work with geographic data. At this point, different demos were used such as a Cartalinx (a topological editor from Clark Labs) and Arcview3.2 and ArcGis 9 (ESRI products) in the specific field of Geographic Information Systems. Some staff of the Geography Department of the University of Kara traveled to Santander (Spain) in 2011 in order to collaborate in the design of the second year courses. In this sense, contents were adjusted to their specific needs being the main requirement to create a map of the city of Kara.

The second year courses (2011) were mainly focused on the disciplines of Territorial Planning and having GIT a relevant protagonist on them. They were attended by students from the Geography and from the Physics degrees. There were seven different courses from Applied Energetic Systems; Urban and Rural Development; Rainfall and Hydrologic Models; Urban Planning; Collaborative Mapping and Geodesy; Digital Cartography Applications.

One course focused on creating a cartographic database for the city of Kara (Togo) using an Open Source GIS Platform (Open Street Map) http://www.openstreetmap.es.

Figures 7 and 8: Fieldtrip (left) and labs activity (right) in the edition of Kara´s map

As usual in the OSM community, it was proposed a Mapping Party in which field trip and lab work were complementary. The field trip was based on “Walking Papers” in afternoon sessions and lab activity was developed using JOSM, a free tool to edit information in OpenStreeMap.


Figures 9 and 10: They show how much digital information about the city of Kara there was before the mapping party (left) and after this course (right).

MAIN OUTCOMES

Main feedbacks from the South

According to the opinions of students and lecturers from the University of Kara, positive impacts of courses are numerous.

Indeed, GIS training for teachers and students of the University of Kara have allowed to the University of Kara to strengthen its relations with the municipality of the town of Kara and progress in achieving its ideal of being more present in people's daily lives through the GIS skills (teachers and students) it provides the town of Kara.

The development of a GIS for the city Kara was presented to the municipality of the city of Kara by lecturers of the University of Kara to be subject to the grant application by the institutions involved in urban management. Note that this project has reassured the municipality expects a contribution to the university management and planning of the city.

It has to be considered that the students that joined the courses are a very small sample of the total of the Kara students. Even having several courses per year would not be enough to access most of them. At this point, on line courses can be a way to enlarge the universe of students who attend the courses. For this it is essential to access to a basic technological infrastructure and equipment which are not available in Togo yet.

The starting of an introductory course on GIS for fourth year students of the University of Kara which is given by lecturers of the University of Kara. This course is effective since the 2011-2012 academic years and it would not have been possible if the teachers of the University of Kara had not received training on GIS in the context of cooperation between Universities of Cantabria and Kara.

The development of thematic maps on different researching areas is also a clear outcome. The GIS training made possible to map the risk of water erosion in a catchment area of great public interest but very poor such as Boummong watershed in which is performed the largest water reservoir of northern Togo.

Two African students have mentioned they were able to get an internship because they took the training certificate on GIS. The certificate that they have received at the end of the trainings is a piece that gives them more opportunities to be selected when they apply for various positions.

About the use of GIS by students, the real problem is the short time of the training that they received because it does not allow them having a good control of the programs. It can be also cited the case of a student whose application was accepted by the Department of Planning but he rejected the work after the interview because considered that he would not be able to perform the tasks to do.

The lessons learned from the North

The process of teaching/learning GITs in a new social and physical environment has opened us to a new understanding of the concept of digital divide which has traditionally been explained through the idea of access to technology and knowledge to use it. Nevertheless, new factors have become essential to explain this complex issue now. The lessons learned can be summarized in the following "*A cycle*" formed by four concepts: Awareness, Access, Attitudes and Advantages.

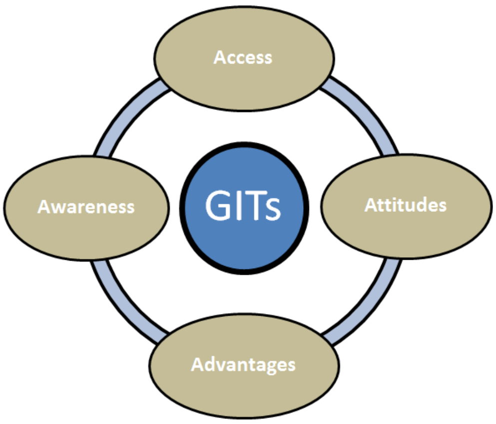


Figure 11: The new cycle for digital divide based on levels of awareness and attitudes

Awareness

- Being aware of the real situation of Kara University has been relevant for action. At a theoretical level, sharing this experience has allowed us rethinking the concept of digital divide defining different levels of impact. At an institutional level, we have learned that buying GITs does not mean avoiding digital divide. The worst type of digital divide is that in which you are not aware about that digital divide is taking place. Moreover, knowing how to use a technology, it does not mean being aware of how the technology is affecting us personally in a positive and also in a negative way.

Access

- Access to technologies is vital to stop digital divide but it is not enough. We have become aware that money can also be wasted when technology is bought and none one is able to use it. Access to digital technology and the offer of courses to avoid digital gap is very low in Togo where surviving is the main priority being the economy mainly based on traditional agriculture.

Attitudes

- Nevertheless, access to digital technology and the offer of courses to minimize the digital gap is very high in Europe where personal attitudes do not fit to the offered opportunities. The number of students and professors willing to attend a new course in relation to GITs in Africa is higher than in Europe where having free courses, they can even be cancelled because of few attendances. This is also a lesson we have learned that shows that attitudes to learn must be together in the process of avoiding digital divide at all levels.

Advantages

- In this sense personal behavior is the main advantage to avoid digital divide. This must be understood in the A cycle as a result of joining the other three parameters. When awareness, access and attitude are combined, the digital gap is reduced.

Another important lessons learned from this experience is that, generally speaking, the service offered by a technology in Europe seems to be more important than the knowledge of how it works. The consumption of technological services has become more important than the knowledge of the technological tool. In Togo, the need to learn how a technology tool works is more relevant than in Europe because substitution is more difficult.

CONCLUSIONS

Educational cooperation can be an excellent way to reduce the existing gap produced by digital divide between those countries with access to and knowledge of new digital technologies based on geographic information. Access to the technological instrument, information and software is today much easier than few years ago. In this context, educational cooperation can show how to use the GITs applied to specific problems that happen in the countries were the teaching and learning experience takes place.

Transferring of knowledge in the field of applied GITs can make digital divide smaller at different temporal and spatial scales. The main social outcome of reducing the digital gap should also follow a reduction of inequalities among living conditions in African countries and European ones. At the same time, the A cycle is defined as a reference to the European countries in order to remain how important other factors such personal awareness and attitudes can be in this process of avoiding digital divide at the EHEA.

In this sense, through educational cooperation, learning becomes a wider concept than something related to technologies in general or to GITs in particular being and instrument to acquire knowledge, to develop new skills and competences.

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Session 5: Effectiveness and quality of GI S&T-education

Software-independent tutorials and their effectiveness for supervised self-study of GIS&T

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ABSTRACT

The learning effectiveness of a software-independent "conceptual" tutorial for a bachelor-course on Geographic Information Science and Technology (GI S&T) was assessed by comparing the performance of 11 students that followed the software-independent tutorial with the performance of 8 students working through a similar tutorial developed specifically for Quantum GIS 1.7 Wroclaw software. The knowledge and insight of both groups of students were tested by means of a practical exam dealing with a vector-based multi-criteria location problem. The exam had to be solved using the ArcGIS-software which was at that time new for all students. Moreover, the learning experience of the members of each group was investigated by enquiring about the perceived preparedness for the practical exam and by comparing the total number of hours spent in the tutorial and exam. The results revealed no significant differences, neither regarding the effectiveness nor regarding the perceived preparedness. This suggests the equivalence of the software-independent and software-dependent approaches. The time spent by the software-independent group was lower though pointing to a possible higher efficiency. More in depth analysis and larger sample sizes are necessary to possibly confirm these findings. Also student and staff satisfaction must be examined before widespread promotion and generalised introduction of the otherwise promising concept of software-independent tutorials of GI S&T.

INTRODUCTION

At the University of Leuven (KU Leuven), various study programmes include one or more courses about the science, technology and applications of Geographic Information Systems. Typically, these courses encompass a practical part in which students consolidate their theoretical knowledge and acquire practical skills in solving geospatial questions. Until 2009, students were exposed mainly to Commercial and Closed Source Software (CCSS) such as MapInfo, pcArcInfo, IDRISI and ArcView-GIS. However, the use of CCSS is not in line with KU Leuven's educational vision, i.e. to prepare students for lifelong learning through supervised self-study. Supervised self-study (SSS) is a teaching approach emphasising student's independent work while having access to thorough advice and feedback. Obviously, the cost price of CCSS is counterproductive for SSS.

From 2009 onwards, the increased availability and reliability of Free and Open Source Software (FOSS) allowed us to elaborate GI S&T-tutorials for FOSS which is believed to be more compatible with the SSS-approach. To this end, we opted for QuantumGIS (QGIS)-software in combination with GRASS, R and PostgreSQL/PostGIS. Previous research indicated that the combination of FOSS and web-based SSS is well accepted by both students and tutors and that the performance level and skills acquired was equal to what is achieved in more traditional in class GIS-courses (Van Orshoven et al., 2010, Hubeau et al., 2011a, Hubeau et al., in preparation). This result is substantiated by other studies which indicated no significant difference between student's performances in web-based learning on the one hand and in-class learning on the other hand for the same course (e.g. Detwiler, 2008, Brown & Kulikowich, 2004, Caywood & Duckett, 2003).

All these earlier tutorials were developed for dedicated CCSS- or FOSS-software and contained exercises with stepwise guidance and illustrated solution pathways. Obviously, such tutorials demand an update as soon as a new software version comes along. Moreover, the prescriptive nature of the exercises enables students to solve them without necessarily acquiring in-depth knowledge of the GIS-concepts behind the software functionalities. Therefore, it can be questioned whether such approach is most effective for the learning process of the students and for promoting a lifelong learning attitude in particular.

To date, GIS-software both of the commercial, closed-source and the free, open source types have become relatively standardised regarding interface, terminology, functionality, toolbox, etc. This standardisation was the basis for the idea to develop tutorials without reference to any particular GIS-software, containing so-called 'conceptual exercises'. Conceptual GIS-exercises present a geospatial problem and a generic approach towards its solution. The students are expected to identify and select appropriate software, typically from the FOSS-domain, encompassing all the required functionality for the problem at hand. Students need to download and install the software, convert the distributed or acquired data into the appropriate formats prior to starting the actual problem solving for which neither a stepwise nor an illustrated solution pathway is available. Hence, a rich palette of learning activities is at stake, making these tutorials fully compatible with education of the supervised self-study type. We developed such a software-independent tutorial and used it in the fall semester of 2011 in a Bachelor level course on GI S&T of which the theoretical part was taught in a traditional way through interactive lectures.

This paper addresses the learning effectiveness of conceptual exercises in GI S&T-courses. To this end, the performance of two groups of students with regard to the practical and theoretical part of the GI S&T-course was compared. In line with Sloan Consortium (2002), the hypothesis was that the quality of SSS of GI S&T with software-independent tutorials is at least equivalent to learning through software-oriented exercises. Also, the students' perspective concerning the knowledge and skills they acquired was measured. In particular it was investigated how they felt about how well the type of tutorial taken prepared for the practical exam. The methods section of the paper describes the nature of the conceptual exercises, presents the virtual learning environment in which these exercises were offered and describes the set-up used to investigate the learning effectiveness. In the subsequent sections, the results of this investigation are presented and discussed.

METHODS

Conceptual exercises versus software-oriented exercises

Software-oriented GIS-exercises are exercises developed for a specific GIS-software. For every exercise a stepwise and illustrated solution is available and all the GIS-functionalities are illustrated according to the software-specific procedure. Students need to download and install the specific software in line with the described installation procedure and solve the exercises following the solution pathways. We developed such exercises for Quantum GIS 1.7 Wroclaw software (http://www.qgis.org/).

On the other hand, conceptual exercises are software-independent exercises which can be solved with any GIS-software containing the necessary functionalities. The objectives of conceptual exercises are (i) to enhance acquisition of in-depth knowledge about GIS-concepts by stimulating students to explore GIS-functionalities without step-by-step explained exercises (i.e. no screenshots, no illustration of buttons etc.), (ii) to force students to choose and select a GIS-software which encourages them to work with internet-based software user communities and to differentiate between different GIS-desktop software solutions, and (iii) to develop long-living tutorials requiring limited maintenance as they are software- and software version-independent.

The standard structure of a conceptual exercise is shown in Figure 1. First, the objectives of the exercise are given in terms of the skills to be acquired. Next, the required GIS-functionalities to solve the exercise are listed which allows students to verify whether the GIS-software they intend to use includes the necessary functionalities. Subsequently, the thematic context of the exercise is given, and a generic solution scheme is demonstrated. At the end, a demo-movie is available illustrating the workflow of the exercise using an arbitrary GIS-software (CCSS or FOSS). This movie illustrates and visualises all the different GIS-concepts and functionalities so that the students can assess and improve their own solution approach. After having worked through a set of exercises, an assignment is proposed whereby no reference solution is available and for which students receive individual and personalised feedback (Hubeau et al., 2011b).

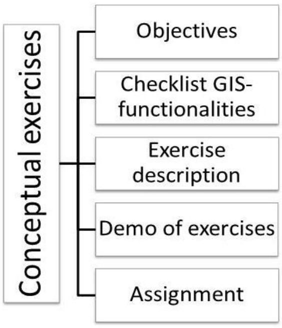

Figure 1: Structure of a conceptual exercise

Virtual learning environment

Web-based learning is usually embedded in a virtual learning environment, i.e. a software system designed to help tutors to organize learning activities facilitating communication, assessment and document sharing (De Lange et al., 2003). The virtual learning environment of KU Leuven is Toledo (http://toledo.kuleuven.be), a blackboard software application. Toledo provides a framework and a set of tools that support and enhance the organisational processes of content creation, storage, transfer, delivery, interaction and application (Coates et al., 2005). It allows tutors to create an active learning environment by providing learning materials, instructions, assignments, evaluation tests, surveys, and by having the opportunity to give personalised feedback to students. Moreover, students can submit assignments, share documents, and interact with peer students or the tutor through a discussion board. Both the conceptual and the QGIS-tutorial were offered through Toledo.

Learning effectiveness

In order to assess the relative learning effectiveness of the conceptual versus the software-specific approach, 21 students taking the introductory GI S&T-course in the fall semester of the academic year 2011-2012 at KU Leuven, were randomly assigned to one of two groups. The first group of 11 students was offered the conceptual exercises tutorial (the ‘test group’) while the second group (10 students) worked through a similar tutorial developed specifically for QGIS 1.7 Wroclaw software (the ‘control group’). The participating students were in the final phase of the Bachelor programme of either biology or bioscience engineering at KU Leuven. Whereas the control group worked in a rather blended learning environment (in addition to Toledo, they had the possibility to interact with the tutor in class), the test group only had online access to the tutor and hence strictly adhered to distance learning. The effectiveness was tested through two different take-home assignments, a practical exam and a theoretical exam. The first assignment consisted of a multi-criteria location analysis problem while the second assignment aimed at the assessment of the thematic quality of two geodatasets. The practical exam was also about a multi-criteria location analysis problem. It was organised in class and all students were required to make use of the desktop ArcGIS-software (ArcMap10) which was at that time new for all of them. Also the results of the written -theoretical- exam accomplished in January 2012 were compared between the two groups.

The differences between the mean scores of the test group and the control group for the two assignments and the two exams were tested for statistical significance using a Student’s t-test. Only students that completed both the exams and assignments were taken into account, i.e. all 11 for the test group and 8 (out of 10) for the control group.

Learning experience

To allow further interpretation of the effectiveness of the students’ learning process, as well as the contribution of the course to a lifelong learning attitude, the learning experience was measured through a web-based survey hosted by Toledo. Students were asked to self-evaluate their learning process. A questionnaire was compiled based on the ones developed for previous surveys (Abu el Nasr et al., 2008, Van Orshoven et al., 2010, Hubeau et al., 2011a) and offered to the students in December 2011 immediately after the practical exam but before the theoretical exam. In addition to questions pertaining to their learning experience (Table 2), the survey also included questions regarding the students’ attitude towards the teaching approach and tutorial format. The answers to the latter questions will be analysed and discussed in a forthcoming publication (Hubeau et al., in preparation).

Student responses were compared between the two groups using the non-parametric Mann-Whitney U test. This study assumed that a statistically significant difference between rating distributions associated with the two different tutorials point to a difference (positive or negative) in the students’ learning experience. On the other hand, distributions that did not differ significantly were assumed to reflect similar learning perspectives.

RESULTS

Learning effectiveness

Table 1 summarises the results obtained regarding the learning effectiveness. The data indicate that no significant difference exists between the average learning outcomes of the test group on the one hand and the control group on the other hand. Whereas the test group scores slightly better on assignment 1 and the theoretical exam, the control group scores slightly higher on assignment 2 and the practical exam.

Table 1: Comparison of mean scores for the practical and theoretical part of the GI S&T-course

	Control group Supervised Self Study with QGIS/GRASS (8 students)	Test group Supervised Self Study with conceptual exercises (11 students)	p-value
Assignment 1	18.52/25	19.59/25	0.432
Assignment 2	19.25/25	18.09/25	0.591
Practical exam	16.93/25	15.86/25	0.611
Theoretical exam	20.45/40	22.90/40	0.522

Learning experience

Table 2 presents the results of the survey. A significant difference was found regarding the number of hours students spent on the practical part of the GI S&T-course. This number can be interpreted as an indicator of learning efficiency, i.e. how time-efficient students work through the exercises and assignments. Students of the test group worked fewer hours to complete the conceptual tutorial and assignments in comparison to the control group working with QGIS-software. The reported number of hours includes all the time spent for the practical part of the course, i.e. the choice, selection (test group only) and installation of the GIS-software, the exercise work, the assignments and reporting and - for the control group only- the attendance to the feedback sessions.

The question concerning the readiness for the practical exam, i.e. an assignment with ArcGIS-software, did also not yield significantly different response between the groups. However, all students of the control group found the concept of the practical exam to be challenging, but also frightening. In contrast, the opinion of the test group of students regarding their experience to work with an unknown GIS-software varied from 'difficult' (27%), 'rather difficult' (9%) and 'challenging' (45%), to 'great experience' (9%). One of the test-students reported that the conceptual-tutorial was not a good preparation for the practical exam. In contrast, all students of the control group answered that the tutorial prepared well for the practical exam.

Table 2: Learning experience of the test group and the control group

<table>
<tr><th>Questions</th><th colspan="4">Control group
Supervised Self Study with QGIS/GRASS
(8 students)</th><th colspan="4">Test group
Supervised Self Study with conceptual exercises
(11 students)</th><th>p-value</th></tr>
<tr><td rowspan="2">Number of hours worked</td><td><20h</td><td>20-40h</td><td>40-60h</td><td>>60h</td><td><20h</td><td>20-40h</td><td>40-60h</td><td>>60h</td><td rowspan="2">0.021*</td></tr>
<tr><td>0%</td><td>25%</td><td>25%</td><td>50%</td><td>38%</td><td>18%</td><td>36%</td><td>9%</td></tr>
<tr><td rowspan="4">What was your experience to work with an unknown GIS-software?</td><td colspan="2">Difficult</td><td colspan="2">0%</td><td colspan="2">Difficult</td><td colspan="2">27%</td><td rowspan="4">0.108</td></tr>
<tr><td colspan="2">Rather difficult</td><td colspan="2">0%</td><td colspan="2">Rather difficult</td><td colspan="2">9%</td></tr>
<tr><td colspan="2">At the beginning a little bit frightening but a challenge</td><td colspan="2">100%</td><td colspan="2">At the beginning a little bit frightening but a challenge</td><td colspan="2">45%</td></tr>
<tr><td colspan="2">Great experience</td><td colspan="2">0%</td><td colspan="2">Great experience</td><td colspan="2">9%</td></tr>
<tr><td rowspan="3">How good did the Supervised Self Study - tutorial prepare for the practical exam?</td><td colspan="2">Not so good</td><td colspan="2">0%</td><td colspan="2">Not so good</td><td colspan="2">9%</td><td rowspan="3">1</td></tr>
<tr><td colspan="2">Good</td><td colspan="2">50%</td><td colspan="2">Good</td><td colspan="2">36%</td></tr>
<tr><td colspan="2">Very good</td><td colspan="2">50%</td><td colspan="2">Very good</td><td colspan="2">55%</td></tr>
</table>

* Significant result

DISCUSSION

One of the arguments underpinning the development of conceptual tutorials is the expectation that students will acquire more in-depth knowledge about GIS-concepts. Therefore, our hypothesis was that the test group would more easily adjust to a new GIS-software and would perform better on the practical and theoretical exam. This hypothesis was not confirmed since the learning outcomes from the practical exam of the software-independent and software-dependent approaches were statistically equivalent.

However, whereas effectiveness was equal, time efficiency was higher for the test group. The survey did indeed reveal a significant difference in number of hours worked between the two groups. Students of the test group have spent significantly fewer hours to complete the conceptual tutorial and assignments, including the choice and selection of a GIS-software. Students of the control group had the possibility to attend four non-compulsory feedback sessions of two hours which may contribute to the observed differences. But it seems that the students working with the conceptual exercises used the time more efficiently than the other students. Since only rather inexperienced bachelor students participated in this course, it was expected that students of the test group would more easily drop out. This did not happen, probably because there was enough possibility to interact online with the tutor and peers through Toledo.

No significant differences were found between the two groups regarding their perceived readiness to work with an unknown GIS-software. The initial hypothesis that students of the test group solving the conceptual tutorial would more easily adapt to using a new GIS-software was not confirmed by the survey results. Students of the test group seem to have more mixed feelings though and felt more precarious in comparison to students of the control group. An explanation may be that some students learn better the concepts rather than the functionalities of a particular GIS-software while other students are more attached to a particular GIS-software because they had to seek and search for all the GIS-functionalities on their own and therefore, felt lost when having to tackle an assignment with an unknown GIS-software.

It was the first time that the conceptual exercises were implemented within a GI S&T-course in a regular study program at KU Leuven. The reported learning effectiveness, learning experience and efficiency are encouraging for further development, implementation and fine-tuning of the conceptual tutorials. This is even more true since we believe that the conceptual approach also has secondary benefits. Students are forced to choose and select a GIS-software which encourages them to differentiate between different candidate softwares and to worsk with internet-based communities. Moreover, conceptual tutorials are long-living tutorials with limited needs maintenance since they are independent of software and software version.

The geodata required by both tutorials were provided through Toledo in a generic format, i.e. shapefiles for vector-structured data and ASCII-grids for raster data. It is clear that in line with the concept of software-independent tutorials, also data-independency can be envisaged. This would imply that students have to make use of facilities provided by available public spatial data infrastructures to discover, explore and exploit geodata sources. Whereas we expect that this data-independency will add to the learning effectiveness and experience, we also suspect that this kind of all-encompassing tutorials are more fit for advanced students, rather than for inexperienced undergraduate students.

CONCLUSION

The effectiveness of a software-independent GI S&T-tutorial was assessed in a supervised self-study context by comparing the performance of a randomly composed group of 11 Bachelor students taking this software-independent tutorial (the 'test group') with the performance of a control group of 8 students working through a similar tutorial specifically developed for Quantum GIS 1.7 Wroclaw software. The performance was expressed in terms of the learning outcomes obtained for a theoretical exam, two practical assignments and a practical exam. Whereas the assignments were of the take-home type, the practical exam was organised in class and consisted of solving a multi-criteria location analysis problem using the ArcGIS-software which was at that time new for all participants. The results revealed no significant differences in the performance of the two groups of students suggesting the didactic equivalence of the software-independent and software-dependent approaches.

The learning experience of both teaching approaches was measured through a web-based survey. Students of the test group reported to have used significantly less time to complete all different tasks of the practical part of the GI S&T-course indicating a higher time efficiency. The perceived preparedness for the practical exam was similar although the range of the responses of the students of the test group was larger. Although all these results need confirmation through examination of larger sample sizes, it can be stated that the concept of software-independent tutorials is sufficiently promising for further development, fine-tuning and implementation.

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Measuring Learning Effectiveness of GIS Repetition Units - the GRAPE project

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Within the project GRAPE (GIS-Repetition using audio-visual repetition units and its learning effectiveness), the learning effectiveness of newly created multi-media, audio-visual Repetition Units will be investigated. These Repetition Units have been developed for the geo-information science (GIS) courses at the Department of Environmental Systems Science at ETH Zurich, Switzerland. Each Repetition Unit consists of a recorded and spoken slide show (max. 5 min.), one or two relevant exercises, and solutions for the exercises.

We will investigate the learning effectiveness of the Repetition Units over a period of 5 years (2009 – 2013) and focus on the following two aspects:

Regarding our main GIS bachelor course, we want to investigate whether the Repeating Units helps to consolidate the basic GIS knowledge and thus improve the results in the final exam. B) Regarding our master course, we will analyze whether the Repetition Units help to better refresh the basic knowledge in comparison to, a quick group repetition within the first two hours of the master course. A repetition is necessary as there is usually a time gap of at least 14 months, and in some cases up to three years between the bachelor and masters course. Subsequently we have observed a low and heterogeneous level of GIS knowledge at the beginning of our master course.

For the learning effectiveness study, we have chosen the statistical approach of longitudinal studies. For all tests, we have divided the students into two statistically independent and unbiased groups; a test group and a control group. The test group has access to the Repetition Units while the control group has to use the conventional materials, such as lecture notes or workbooks.

Aspect A has been investigated by carrying out a test one week before the final exam. The test results from 2010 and 2011 have statistically been analyzed using a Wilcoxon two-sample test. The results show that in both years the test group scored significantly higher ($p=0.0013$ resp. $p=0.0121$) than the control group. These results are very encouraging and suggest that the Repetition Units help to improve test results.

To answer Aspect B, two tests were given to the master students during the first two weeks of the master course in 2011. Within the first test, we analyzed if there is a significant difference between the test and the control group before repetition, using a Wilcoxon Two-Sample test (two-sided). The p-value of 0.5566 indicates that there is no significant difference between these two groups. The second test shows that the scores were better for all students and we could not measure a significant difference ($p=0.1169$, Wilcoxon Two, Sample test (two-sided)). However, when using the one-sided Wilcoxon Two Sample test, the results indicate that there may be a slight improvement in the test scores of the test group ($p=0.0586$) compared to the control group. It must be noted that the sample size is rather small and that the repetition for the students is optional, these aspects must be taken into consideration when interpreting the results of these statistical tests.

We will repeat the tests with our bachelor and master students in 2012 and 2013; this will enable us to compare results for the three years, and hopefully a final conclusion may be drawn, regarding the learning effectiveness of our new medium and its possibility to measure it.

Personal Learning Styles of Students in GIS Distance Education as a Success Factor

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ABSTRACT

Learning GIS in an e-learning environment is quite common, because there is some evidence that it can be as successful as learning in the traditional on-campus environment. The identified boundaries for the successful participation in a distance course are determined by a good course design and supportive course instruction. On the side of a course participant, his or her personal learning style is one of the success factors next to relevant professional background, strong motivation and e-learning competences.

The personal learning style may either correspond with the course design and instruction, strengthening the learning outcomes or it can be in opposition to both mentioned above, leading to weak performance. Some neutral or in-between effects are possible as well. From this perspective it seems quite useful to know personal learning styles of the target student group. It allows to evaluate how well they are suited to a given course design and instruction, enabling to provide effective support in cases where the styles are not relevant enough.

The research was carried out in 2011 on a group of more than forty students taking part in the Postgraduate Studies in Geographic Information Systems UNIGIS offered via the distance mode at the Jagiellonian University in Kraków (Poland) in cooperation with the Paris Lodron University in Salzburg (Austria). To identify students' personal learning styles the Kolb's questionnaire was used. The results showed that the identified dominant basic styles were: theorists and pragmatists. These styles seem to suite quite well to the following course design characteristics: focus on GIScience (in case of theorists) and GIS projects implementation (in case of pragmatists). Taking into account the UNIGIS course instruction, theorists benefit mainly from the systematized learning path and quite well prepared learning content, while the pragmatists may follow the course instruction at home independently from the group.

Possible ways of more effective support could include providing the theorists with additional systematized data and the pragmatists with more GIS software-based exercises, which solve the problems of practice. Theorist-friendly instruction may consider more direction of instructor, while pragmatist-friendly instruction may focus on discussion in several small (instead of one big) groups within the discussion board forum. However, further research is needed to find out what is the exact relationship of the support proposed above and the given learning style of a student and its impact on the learning effectiveness.

KEYWORDS: GIS, e-learning, learning styles

INTRODUCTION

Learning GIS in an e-learning environment is quite common, because there is some evidence that it can be as successful as learning in the traditional on-campus environment (Clark et al., 2007; Mooney and Martin, 2003). The identified boundaries for the successful participation in a distance course are determined by a good course design (Brown and Voltz, 2005) and supportive course instruction (Swan, 2003; Kanuka, 2007; Buchanan et al., 2005). On the side of a course participant well known success factors are: relevant professional background (Detwiler, 2008), strong motivation (Lynch and Dembo, 2004) and e-learning competences (Peters, 2000; Berge, 2007; Tallent-Runnels et al., 2005).

Student's personal learning style is another factor, which may either correspond with the course design and instruction, strengthening the learning outcomes or it can be in opposition to both mentioned above, leading to weak performance (Sadler-Smith, 1996; Healey and Jenkins, 2000). From this perspective it seems quite useful to know personal learning styles of the target student group and to know which learning style the course is aimed at. It allows to evaluate how well the identified learning styles are suited to a given course design and instruction, enabling to provide effective support in cases where the styles are not relevant enough.

LEARNING STYLES

One of the well-know learning styles classification is the Kolb's learning style inventory (LSI), which was modified by Honey and Mumford (Learning and Teaching, 2011). On the basis of their classification it is possible to identify four different learning styles: activists, reflectors, theorists and pragmatists.

Activists engage totally and without any prejudice in every new situation. They enjoy the current moments and direct experiences, are open-minded, not skeptical, people who enthusiastically welcome any news. Their live motto is "Try everything at least once". Activists love to act and in case of crisis situation temporary extinguish fire. They solve the problems by use of "brain storming" method, what means spontaneous finding many possible solutions. When they are not any more enthusiastic with one task, they are looking for another one. That is why they work best when challenged by new experiences and are rather not interested in process of implementation and consolidation of solutions. The constant engagement in solving problems of others people is for them the opportunity to be in the centre of attention. Being the soul of the company they try to concentrate the action around themselves.

Reflectors are analytical people who like to think about the events on distance and observe them from every possible perspective. They collect data, directly and indirectly and want to analyze them carefully before making any conclusion. The process of data collection and analysis of phenomenon and events is very important for them, that is why they put the conclusion to the very last moment. Their live philosophy is sense and methodical approach , their motto: "Check the basis" and "Put the decision until the morning". Reflectors are very sensible people, who like to think of every possible aspect and consequences before they decide. During the meetings they keep at side, as they are interested in observing others in action. They just hear and try to observe the general direction of discussion, before they stand to speak. Tending to stay in the background, reflectors make an impression of distant, tolerant and unmoved people. Their action is planned within the frame of general vision, which consolidates past, current and future events, own and others results of observation.

Theorists acquire and integrate results of observations and build complex but logic and indisputable theories. They solve problems on the way of logic and step by step approach by linking seemingly divergent facts and building cohesive theories. Theoretically oriented people tend to be perfectionists, who work as long as every element is classified. They like to analyze and synthesize facts, are interested in basic concepts, principles, theories and models. Their live philosophy is based on rational and logic assumptions, so their motto is: "If something is rational has to be good". They often ask: "Does it make sense?", "What is the relation of…?, „What are the basic assumptions?". Being rather rational objectivist than subjective thinkers and solving problems on the way of consistent logical thinking are their main characteristics. They prefer to maximize the level of certainty, that is why they feel unsteadily in face of subjective statements and nonchalant approach to problem solving.

Pragmatists like to try up theories and techniques and test how they work in practice. They are looking for new ideas and take first possibility to experiment with them. Pragmatists are this kind of people who return from training and workshops full of new concepts and want to test them immediately. They like to act without any unnecessary delay and use in practice the ideas they perceive as good. Pure talk and long disputes which are not leading to concrete solutions are not interesting for them, as they are practical and like to make practical decisions and solve problems. Being challenged by problems and opportunities, they believe that: „There is always a better solution" and "Everything what works has to be good".

UNIGIS STUDIES IN KRAKÓW (POLAND)

The research was carried out on a group of 44 students of Postgraduate Studies in Geographic Information Systems UNIGIS (Studia Podyplomowe UNIGIS, 2011) at the Jagiellonian University in Kraków (Poland). The studies have been organized each year since 2004 by the Institute of Geography and Spatial Management in close cooperation with the Centre of Geoinformatics of the University of Salzburg (Austria). Both institutions belong to the UNIGIS International Association (UNIGIS International Association, 2012), which aims to educate GIS professionals all around the word in Geographic Information Science and Technology on distance.

Students in the UNIGIS centre in Kraków take part in the two-year blended learning program, however the majority of classes is on distance and only twice a year they meet on campus during two-day workshops. The online part is supported by an e-learning platform, where the course content is delivered and the social process of the studies is taking place. The course content is divided into nine obligatory modules (Table 1), which are accessed by students sequentially after completing the previous ones, and some additional activities, which cover the main themes of the „GIS&T Body of Knowledge" (University Consortium for Geographic Information Science, 2006). The idea of such a composition is to give the students as broad view of GIScience as possible and to equip them with some skills useful in case of taking management positions. The emphasis is put rather on the theoretical knowledge including understanding of concepts and ideas behind GIS than on the training in using given GIS software. The communication tools of the e-learning platform support the social needs of the learning group, what include the possibility to communicate with other students and instructor by use of discussion forums and e-mail and to cooperate with each other by use of blogs and wiki tools. To compete successfully the postgraduate studies, students are obliged to prepare assignments for each module, send them to the course instructor and gain a positive grade.

The group of students which took part in the research started the studies in February 2010 and in comparison with other intakes was the biggest one and selected in a special way due to the requirements of the "UNIGIS 2010" project supported by the European Union within the European Social Fund (PO KL/2.1.1/S - WND-POKL.02.01.01-00-650/09). Students of 2010 intake were the employees of Polish enterprises working on the positions where the GIS skills and knowledge were required. That is why on the beginning of their studies they were experienced professionals, who wanted to broaden their knowledge and acquire some additional skills.

Table 1: Obligatory modules in the UNIGIS curriculum

No	Title of the module
Module 1	Introduction to Geographical Information Science
Module 2	Data Modelling and Data Structures
Module 3	Data Sources and Data Acquisition
Module 4	GeoDBMS
Module 5	Spatial Statistics
Module 6	OpenGIS and Distributed GI Infrastructures
Module 7	Geographical Analysis
Module 8	Visualisation and Cartography
Module 9	GIS Organisation and Project Management

IDENTIFICATION OF LEARNING STYLES: APPROACH AND RESULTS

The research was carried out in December 2011 during the last on-campus workshop. Students filled in the Kolb's questionnaire, which was based on 10 multi-choice questions. The sum of given answers indicated the dominant learning style of each person who took part in the research (Figure 1). The results showed that the identified dominant basic styles were: pragmatists (57% of students), theorists (36%) and reflectors (7%). Activists were not identified. As the results of style identification showed, the group of 2010 intake was dominated by students with the pragmatic learning style. This dominance may be caused by the selection procedure which allowed admission to the studies only for enterprises' employees, who had practical experience with GIS. Students with such professional background may be more likely to represent pragmatic learning style.

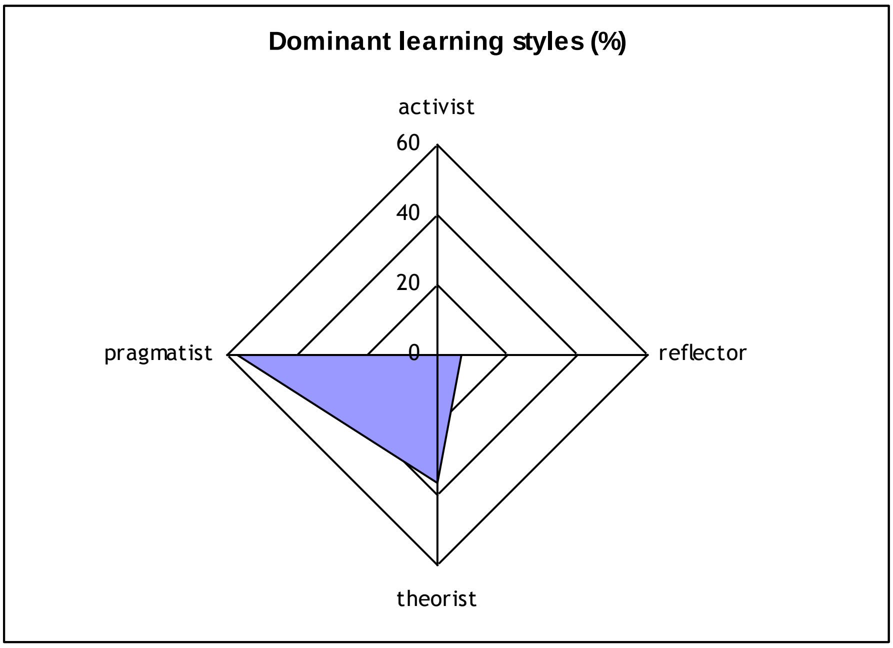

Figure 1: Dominant learning styles of UNIGIS students –2010 intake

To identify impact of identified learning styles on students' performance further analysis was carried out with the use of information regarding modules completion rates. This measure of performance was identified as more diverse than quality of results, therefore was chosen for the analysis. In December 2011 students of 2010 intake took part in nine obligatory and at least in one optional modules. Some of them have completed every module, some of them some of modules. There were a few students who have made no progress in these terms (Figure 2).

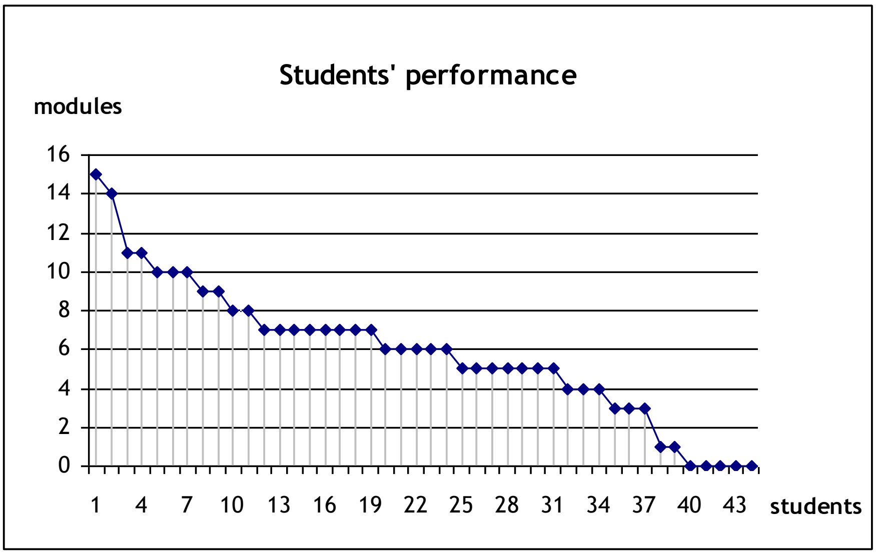

Figure 2: Students' performance

Depending on their perseverance (number of completed modules) the group of students was divided into four categories: excellent, good, satisfactory and weak performance (Table 2). Both in terms of number of modules completed and number of students the categories were equal size.

Table 2: Performance categories

performance	*excellent*	*good*	*satisfactory*	***weak***
modules completed	> = 8	6 - 7	4 - 5	< = 3
number of students	11	13	10	10

Then the learning styles of students falling into each category were analyzed. In each category except for satisfactory, each of identified dominant learning styles were represented (Figure 3). Students, who manifested the excellent performance were mainly these who were identified as theorists (55% of students in this category). Following categories with good, satisfactory and weak performance were dominated by students with pragmatic learning style (respectively 54%, 70% and 70% of students in these categories). As the reflectors were represented only by three students in the group being researched it was decided not to analyze their presence in the performance categories. Due to a very small number of cases, their appearing in a given performance category could be rather accidental.

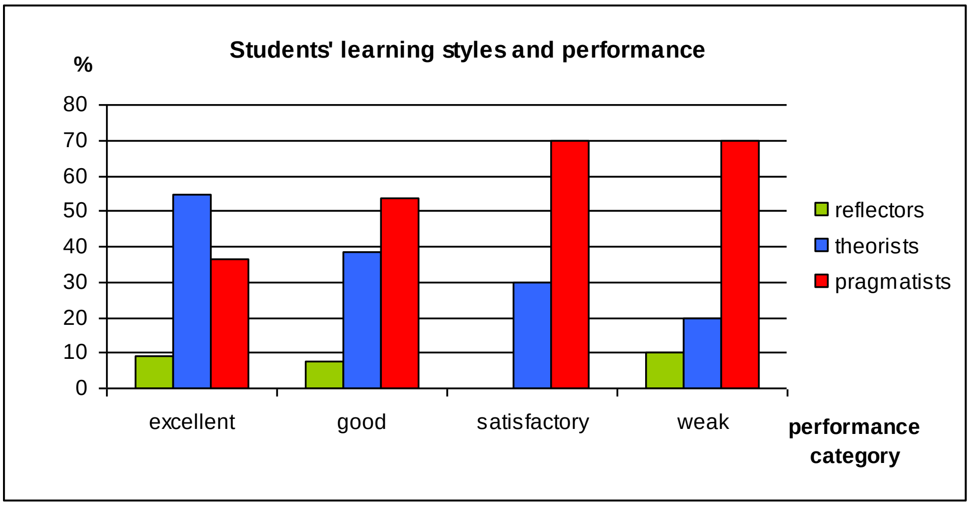

Figure 3: Students' learning style and his/her performance

It is evident that the number of students with a given identified learning style in a given performance category is not as important as the change of their percentage between categories, which could be observed (Figure 3). The highest number of pragmatists in three categories can be the result of the dominance of this type of students in the researched group (Figure 1). Differently, the distribution of pragmatists percentage among the categories can be the result of the UNIGIS course and instruction relevance for this style of learning. The percentage of pragmatists is the lowest in excellent category (36%), higher in good category (54%) and the highest in satisfactory and weak category (70% in both). Contrary, the percentage of theorists in the following categories decreases: the highest is the percentage of theorists between students with excellent performance (55%), lower in category of good performance (38%), and the lowest in categories of satisfactory (30%) and weak performance (20%).

STYLES RELEVANCE AND POSSIBLE SUPPORT

The results of the research presented above give some basis to state that learning style may serve as a success factor in learning GIS on distance. The learning style of a student may correspond more or less with the course mode of delivery, course design, course focus and instruction or be even in opposition to mentioned above. This relation may give a positive or negative impact on the students performance. In case of 2010 intake taking part in the UNIGIS studies in Kraków it was rather evident that students with theoretical learning style presented generally better performance than students with pragmatic learning style. The performance of students with reflecting learning style was not analyzed due to the low number of cases. Activists were not identified. Taking into account the e-learning mode used in majority during the course and the characteristics of the GIScience and Systems discipline as well as the course focus it was possible to assess the benefits, which could be gained during the studies by students representing each of the identified learning styles, together with some difficulties which in future may require some instructional (or organizational) support.

Pragmatists, who choose the e-learning form of the studies benefit mainly from the possibility to work independently at home, what gives them the chance to test some ideas and implement learnt solutions. They could be deeply interested in GIS project management topic, which is discussed in one of the obligatory modules. Another possible advantage of choosing e-learning in their case is the opportunity to talk to other GIS professionals and to compare practical experiences. Such communities of practice should be rather small and thematic oriented, what in case of this intake was not officially practiced. Due to the course focus on GIS theoretical background, the practical side of the course is in the minority. For the pragmatists this proportion may cause lower engagement in studies and worst (than in case of theorists) performance. Possible support should be oriented on providing pragmatists with the opportunity to build rather smaller than bigger communities of practice and giving them often a chance to implement GIS solutions.

Theorists, as mentioned above, pay much attention to the GI theory, which in case of UNIGIS course is on the first place. Students, who represent this learning style demand an ordered and well-structured approach to the course material, both in the relation to the learning path and e-learning content design and quality. This requirements are rather fulfilled in the UNIGIS course. Additionally, theorists need constant guidance from the course instructor. They could be less likely to ask their colleagues for help and hints, when working on assignments. This may result in their absence in the discussion forums and in overloading the instructor or lack of progress in case, when instructor is not easily accessible (Morgan, 2003). In most cases instructors are easy accessible and helpful during UNIGIS studies, what satisfies theorists needs, but in case these needs are on the high level it is recommended to engage, especially for big groups, a course moderator or mentor, who could provide additional support to the learners.

Reflectors, in contrary to theorists rather often visit the discussion forums, but not like pragmatists to share experiences. They would prefer to observe the discussion threads and to construct their own opinion taking into account information found on forums. Access to many sources of different information is the main advantage, which may encourage students with this style of learning to take part in the e-learning studies. The UNIGIS content perfectly fulfills that need. Every lesson in each course module is based on many internet sources. As the course is focused on GIS theory, it does not offer many examples of GIS applications in form of case studies. This is the main disadvantage, which is often highlighted by students with reflecting learning style. Supporting them in this part of learning could be beneficial for the their learning performance. Even, easy intervention in form of GIS case studies repository should give some positive results.

Activists, although they were not identified in the researched group, can also benefit from some UNIGIS studies characteristics. First of all the possibility to share experiences on discussion forums, offered during the whole period of the course and in case of every module learnt, are most probably in the centre of their interests. Secondly, communication with teacher, who demonstrates some student-centered approach, which in majority of modules takes place, is very valuable for them. They are looking for the news from the GIS discipline and for a lot of practical but rather easy exercises with the use of GIS software. These two activities are not extensively practiced during the UNIGIS course, so eventual support for activists could be based on taking into account these needs and providing students with news and exercises.

Recognition of the learning style may bring some benefits to students, instructors and organizers of the e-learning course in GIS (Bach et al., 2007). From the student perspective it is useful to know his or her strong and weak sides in the context of the learning mode and the course focus. This awareness may help in using the opportunities connected with a given organization of the GIS e-learning course. The learning style awareness helps as well to minimize threats of eventual irrelevance with the course concept. From the instructor and organization perspective it is useful to know which learning style the given course is the most friendly and which styles are represented in a given group of students. In case of less-favored learning styles some support policies could be prepared and implemented, if necessary. Such approach addresses the learner-centered paradigm in GIS learning, which requires to prepare different learning, organizational and business models for different group of learners (Strobl, 2008).

CONCLUSIONS

The results of the research related to personal learning styles of UNIGIS students in Kraków (Poland) showed that three out of four dominant learning styles were identified in the group. The majority of students was classified as pragmatic learners, then theoretical and reflecting learners. Most likely, it was the specific recruitment procedure that influenced the distribution of styles. The analysis of the relation between the learning style and the students performance proved that students who represented the theoretical learning style presented better performance than students with the pragmatic learning style. Although course content and delivery can be useful for students of each learning style, it seems that theorist take more benefits from the course than learners with other learning styles. According to this finding, some solutions which could help students with other than theoretical learning style to improve their performance were proposed. These solutions may be provided either by organizers or course instructors. However, further research is needed to find out the relationship between the support proposed, given learning styles of students and their joint impact on the learning effectiveness.

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POSTER

LeGIO Tutorial in Cultural Heritage of Monuments and Sites: open GIS e-learning

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INTRODUCTION

Courses dealing with Geographic Information Systems (GIS) have been available to the students at the KULeuven since more than 20 years (Hubeau et al. 2011). However, it was not until last year that due to the increasing demand from the students of the Master of Conservation of Monuments and Sites (MCMS) to become familiar with GIS, the Raymond Lemaire International Centre for Conservation (RLICC) has been exploring the ability to teach GIS in a conservation heritage environment through the use of an online learning platform. Supported by the KU Leuven office for educational affairs and together with the LSUE-members (Leuven Sustainable Earth Research Centre), i.e. SADL (Spatial Applications Division Leuven) and the FNL (Division of Forest, Nature and Landscape) under the LeGIO (Leuven Geographic Information Distance Education) project, the RLICC offered a non compulsory tutorial to graduate students of the MCMS to gain a better understanding of the applicability of GIS within the heritage field. The tutorial 'Introduction to GIS in Cultural Heritage' is hosted by Toledo, a blackboard software and the educational online platform of the KU Leuven. Students can get familiar at their own pace with both the most important GIS-concepts and the application in Build Cultural Heritage (CH) in a relatively short period of time. Moreover, they are able to use GIS-software to support their study projects and thesis. This paper presents the scope of the tutorial and an example of its results is illustrated by the application of GIS to map the values of the Petra Archaeological Park in Jordan developed by a MCMS student, who has followed the course in 2011. Until now the course has not been integrated into the university credit system nor is there any evaluation of the students. However, during the first year 40% of the students completed the course and evaluated it as successful (Vileikis et al. 2011). This year the course is open again and a higher number of students is expected.

GIS IN A BUILT CULTURAL ENVIRONMENT

GIS is not a new tool in CH management, but it is a tool with a gallery of applications to be further explored. Nowadays, GIS is part of the dynamics of our daily lives helping to take decisions, e.g. to find the nearest location of a restaurant by using a smart phone, or to look for the fastest and shortest way to go to work avoiding traffic jam by using a real-time feed GPS. Moreover, GIS is also answering scientific questions and operations to better protect, manage and understand heritage sites by the support in many decision-making processes (Longley et al. 2011). As an example of the latter application, World Heritage cities such as the colonial city of Cuenca in Ecuador or the Ancyra Project in Turkey, already count with a GIS system as a data repository. In Cuenca the GIS aims to visualize typologies or perform data analysis that can e.g. inform stakeholders where additional conservation-based investigations are necessary (Heras et al. 2010). In Ancyra, metadata, data structure and content were designed allowing accurate querying, maps visualization and the location of damages of different heritage monuments (Gabrielli & Malinverni 2007). Other common applications of GIS in CH can be found in the management of archaeological sites, e.g. in field work to record data of excavations, in modelling to create surface models to locate archaeological remains, or in data management to prepare data for future field survey. Further approaches less frequently used are the integration of intangible heritage and participatory mapping. For instance, the Troina GIS project shows the integration of spatial knowledge of the local communities and diverse forms of oral information in a GIS in order to represent and interpret the various significations of Troina, a small town in Sicily (Fitzjohn 2009). GIS is an important and useful tool in cultural heritage because the characteristics and differences of each cultural heritage site could be linked with the explicit spatial location and therefore supporting to define site conservation strategies and protection.

THE LEGIO PLATFORM

The LeGIO educational platform is linked to Toledo, the e-learning platform of the KU Leuven. Therefore, students and external registered participants have the opportunity to access this supervised self-study distance course. Toledo gives the opportunity to exchange information, personalized feedback, assignments and documents between tutors and students. 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 or thesis in the field of cultural heritage. Due to the multidisciplinary and international group of the MCMS students this GIS&T course potentiates the use of GIS in different research fields with different perspectives, requirements and user needs.

The course contains a specific tutorial on cultural heritage. This tutorial aims to work inline with the practical use of GIS and the activities of the MCMS. Figure 1 shows an example of the structure of the modules on the Toledo platform.

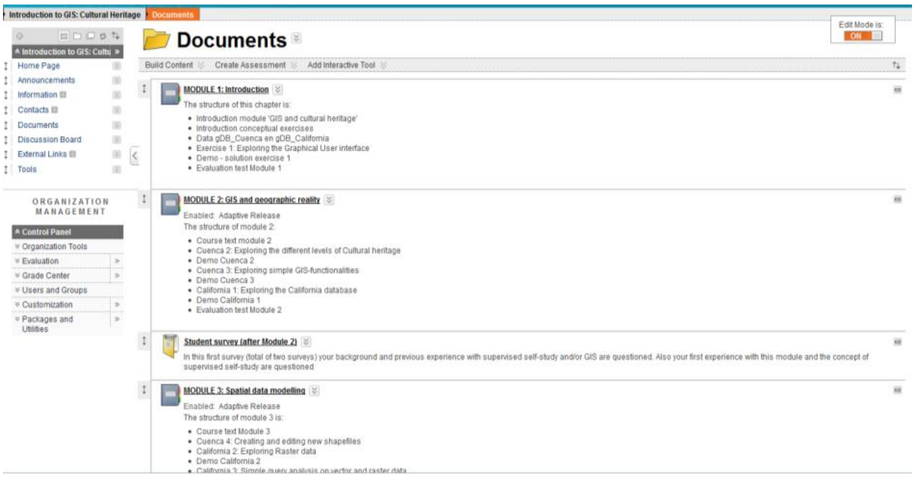

Figure 1. Toledo Platform. Introduction to GIS: Cultural Heritage.

At the beginning of each module there is a theoretical introduction on GIS common to other introductory GIS tutorials. This is followed by seven exercises and two assignments specifically created for the Cultural Heritage tutorial with the geographic datasets of the city of Cuenca (Heras et al. 2010) and California (Plant n.d.). For example, after collecting cultural heritage data, e.g. about historical buildings, and heritage elements, the students are able to explore its content and structure allowing them to carry out further and more complex analysis.

TEST RESULTS

The e-learning GIS&T course was voluntarily tested in 2011 and is tested in 2012 by first and second year MCMS students achieving good but different results regarding the participation. In 2011, the course was recommended as preparation for the work carried out during the study trip and Risk Mapping project in Petra in Jordan. 22 students registered for 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. (2) For planning: Knowing the places and their location could assist the authorities, e.g. to decide on the location of visitor's facilities or detect areas at risk. This will lead later to determine protection areas and management zones. (3) For Value Mapping: Illustrated in the example below. In 2012, 21 students showed interest, 8 students started the course and 5 students already finished the course while at this moment it is not closed yet. However, the first result reveals a higher dropout rate, probably because no specific aim such as Petra fieldwork was given.

Value Mapping

As part of the Risk Mapping project in Petra, a value mapping methodology was foreseen. Its outcome could benefit the management of the Petra World Heritage Property, in relation to preservation priorities and the required level of integrity to preserve this outstanding site. In order to show the risks identified and relate them to the values of the site, a GIS project was designed where the information will be easily visualized and analysed. Therefore, it was opted to revert to the e-learning GI S&T course. Given that the course is designed for learning with non specified software, the digitization of the fieldwork results was implemented by using a FOSS, the Quantum GIS version 1.7.2, an Open Source GIS-software as depicted in Figure 2.

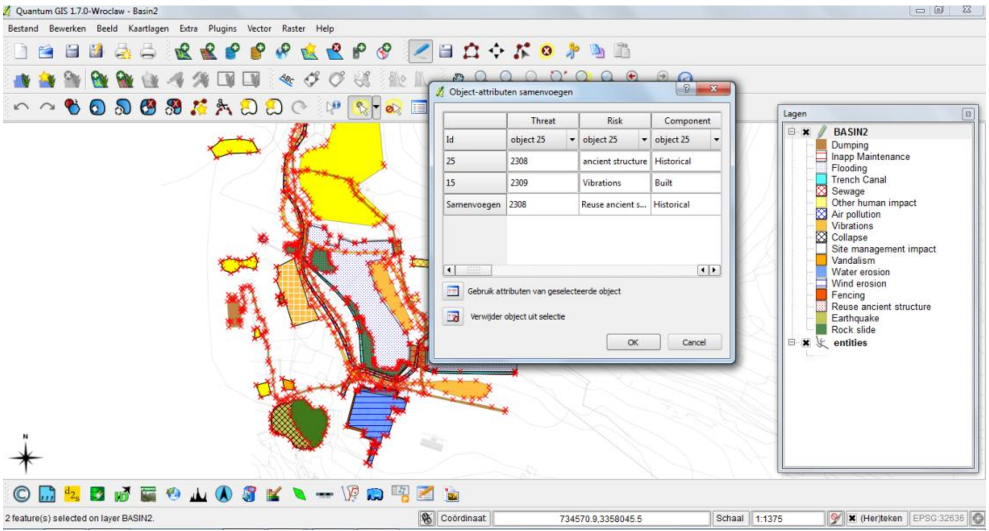

Figure 2: the preliminary risk assessment project was created in Quantum GIS version 1.7.2

CONCLUSION

The application of GIS in Cultural Heritage has been most of the time related to land use analysis, land evaluation, spatial distribution of survey data, and its visualization. However, other applications such as value mapping and risk assessment have proved the enormous potential of GIS in this field, opening new channels to protect as well as communicate to the public the values of the heritage sites. Moreover, applications illustrating intangible values displayed by, for instance, multimedia, could be further explored.

In the example of the LeGIO platform, the opportunity of the graduate students to learn GIS as part of their training in Conservation of Monuments and Sites with an specific course where they could easily relate to their field of work, has moved the students to see the application of GIS far more than just as a tool for documentation of cultural heritage but also, for instance, to encourage stakeholders to actively participate at different levels in the management and monitoring processes of the heritage sites or as the Petra Case Study showed, how to capture the values of the site linked to their specific location. The nature of the LeGIO as a software-independent learning platform, allows the students to work with commercial as well as license free software according to the needs of the students and the capability offered by the different systems. An advanced GIS encompassing 3D build heritage is underdevelopment. Regardless the scope of the GIS technology development and its widespread use in other fields such as in environmental analysis, both GIS and GIS e-learning, is becoming a successful and necessary tool in the field of cultural heritage.

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AMENDMENT

Structured or non-structured doctoral programmes? A bottom-up approach for third-cycle Bologna implementation

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ABSTRACT

In 2003, doctoral education was included in the Bologna Process as the third cycle. Recommendations, but no binding regulations, for "Bologna-conformant" doctoral programmes have emerged. However, in parallel to the political processes we already have de facto standards: European and national funding organisations pay millions of Euros for structured doctoral programmes with sets of rules, which they think achieve excellent doctoral education. This paper evaluates the state-of-the-art of structured doctoral programmes in the context of the Bologna process. It asks how a single research institute can deal with these developments and maintain excellence in research. The Institute for Geoinformatics, University of Münster, Germany, runs both models in parallel, the traditional German non-structured PhD and a structured PhD programme funded by the national science foundation. Against this background, we highlight advantages and disadvantages and discuss the feasibility of the two models. Our preliminary conclusion and recommendation is to give up the traditional German model and to switch entirely to Bologna-conformant structured doctoral programmes.

KEY WORDS

Doctoral programme, structured doctoral programme, PhD, third cycle, Bologna process

INTRODUCTION

With (Berlin_Communiqué, 2003), the Bologna Process began to focus on doctoral education as the third cycle. Since then, many improvements and concretizations have been made at the EU level. The European Joint Doctorate Programmes within the Erasmus Mundus Programme of the European Commission (European_Commission, 2010) can be considered an implementation of the current state-of-the-art of structured doctoral programmes at the EU level.

Structured doctoral programmes emerged in many European countries, even before the Bologna Process, e.g., in the UK twenty years ago (Denicolo, 2010). Also in Germany, the "Graduiertenkolleg" (Research Training Groups) came up at that time (Schmidtmann, 2010) and was subsequently extended with an international version. The traditional doctoral education in Germany was – and is still, for most universities – following an "apprenticeship model": The responsibility for the PhD student is exclusively a matter of the supervising professor, called "doctor father" (or "doctor mother") due to the close relation between doctoral candidate and professor (Greisler, 2007).

Although German PhD students studying in structured programmes are still a minority of 15% (Greisler and Hendriks, 2008), the number is increasing. Furthermore, the pressure to introduce structured doctoral programmes is increasing:

- After implementing the Bologna Process for the first and second cycle in most European countries (with a deadline to finalise the implementation in 2020), the third cycle is the logical next step. Yet, one should not expect regulations for the third cycle as detailed as for the reform of the Bachelors and Masters programmes. The (London_Coummuniqué,

2007) states that "we recognize the value of developing and maintaining a wide variety of doctoral programmes". On the other hand, "Ministers consider it necessary to go beyond the present focus on two main cycles of higher education to include the doctoral level as the third cycle in the Bologna Process" (Berlin_Communiqué, 2003).

- At the European level, as well as in many EU member states, structured doctoral programmes can be considered de facto standards for excellence in doctoral education. In Germany, "Graduiertenkollegs" (Research Training Groups) and "Graduiertenschulen" (Graduate Schools) attract excellent students and provide attractive scholarships.

How can research institutes handle this situation? An easy top-down approach would be to wait for new regulations and implement them gradually when they are established. Our bottom-up approach, instead, is to ask: What is the better model for the doctoral candidates and the institute? We currently run both models, a traditional German doctoral education (with ad hoc funding from projects) and a funded structured doctoral programme. The goal of this paper is to evaluate strengths and weaknesses of both models and to come to a preliminary conclusion from the perspective of a modern research institute whether to

- go back to the traditional German "apprenticeship model",
- switch entirely to a structured doctoral programme,
- run both modes in parallel after the end of the funding period of the structured doctoral programme.

The following section describes the developments and the current status in the European Bologna Process. The next section will compare key features of structured vs. non-structured doctoral programmes and will discuss pros and cons – in general and from the perspective of our research institute based on experiences with both models. The paper will conclude with a summary of the results as well as a preliminary conclusion on which model will be appropriate for the future of research institutes.

"BOLOGNA-CONFORMANT" DOCTORAL EDUCATION

Most Bologna Process member countries have adopted new higher education legislation to introduce and regulate elements of the Bologna Process, although there are different speeds in the implementation of the Bologna Process action areas. In 2010, 90 % of students in 30 higher education systems were in two cycle degree structures. Percentages lower than 100 either reflect ongoing transition to the new structure or the fact that certain study fields are exempted from the two-cycle model, e.g., medicine, dentistry, pharmacy, and architecture (Westerheijden et al., 2010).

The Bologna Process also has a global effect, positive or negative, e.g., in the USA, more and more prestigious universities recognize European three-year Bachelor programs for accessing postgraduate programs; China is looking at the Bologna Process due to its interest in student mobility to Europe; and Australia is said to have perceived the Bologna Process as a threat to their market shares of international students (Westerheijden et al., 2010).

After the "official" start of the Bologna Process with the Bologna Declaration in 1999, focusing on Bachelor and Master programmes, and the inclusion of the third cycle in (Berlin_Communiqué, 2003), (Bergen_Communiqué, 2005) declared in more concrete terms:

- Doctoral level qualifications need to be fully aligned with the European Higher Education Area (EHEA) overarching framework for qualifications using the outcomes-based approach.
- The core component of doctoral training is the advancement of knowledge through original research.
- The normal workload of the third cycle in most countries would correspond to 3-4 years full time.
- Universities are urged to ensure that their doctoral programmes promote interdisciplinary training and the development of transferable skills, thus meeting the needs of the wider employment market.
- Overregulation of doctoral programmes must be avoided.

Also in 2005, the European Commission provided a further consolidation regarding the role of doctoral candidates in its "European Charter for Researchers" and "The Code of Conduct for the Recruitment of Researchers" (European_Commission, 2005). "All researchers engaged in a research career should be recognised as professionals and be treated accordingly. This should commence at the beginning of their careers, namely at the postgraduate level…" and provide adequate salaries including social security provisions as well as appropriate conditions during their training phase, e.g., structured and multi-faceted supervision, career advice and career development opportunities, and mobility measures.

The (London_Coummuniqué, 2007) emphasised the overall goal to strengthen Europe's research capacity. Again, one can observe the balancing act between regulation and flexibility: "We recognize the value of developing and maintaining a wide variety of doctoral programs linked to the overarching qualifications framework for the EHEA, whilst avoiding overregulation." New specific objectives were to focus on learning outcomes, including "transferable skills", and ways to enhance employability.

The (Leuven_Communiqué, 2009) focused on overall topics such as social dimensions, life-long learning, mobility, employability, and organizational structure of the future Bologna Process.

The next high-level Bologna meeting took place in Vienna and Budapest in 2010. Although the introduction of Bologna-conformant Bachelors and Masters programmes is now daily business all over Europe, third-cycle education is comparably little affected by the Bologna Process. "Variety in doctoral studies continues to exist, as intended by ministers" (Westerheijden et al., 2010). However, doctoral degrees have become more structured than before the Bologna Declaration in many countries (Westerheijden et al., 2010). A diversity of models continues to exist as agreed, and a length of 3-4 years is the most common duration. In 16 countries, a PhD has duration of 3 years, in 9 countries, 3-4 years, and in 6 countries 4 years. In 6 countries, there is a duration of 3-5 years, and some countries are out of this range, e.g., Cyprus (3-8 years), Lithuania (2-6 years), and Russia (3+3 years) (Westerheijden et al., 2010). For comparison, note that top research universities in the US, which typically has no structured PhD programmes, but substantial course requirements, often have median thesis completion times of 5 or more years.

At the most recent European Higher Education Area Ministry Conference at Bucharest, few progress was made regarding the third-cycle education, rather "Taking into account the "Salzburg II recommendations" and the "Principles for Innovative Doctoral Training" (Bucharest_Communiqué, 2012). These principles published by the European Commission (European_Commission, 2011) rather focus on economic needs and that "it is important to focus on doctoral training as this is the qualification that should enable researchers to move into a wide range of employment sectors". Furthermore, general principles (recommendations) for improving the quality of doctoral programs (still basing on the Salzburg II recommendations) are provided. The report clearly votes for "doctoral schools" with structured doctoral programmes and "collaborative research with other institutions (joint programmes, which may lead to joint or double degrees)".

In the context of the Bologna Process, there are no official regulations so far. Therefore, the term "Bologna-conformant doctoral education" does not refer to a fixed set of rules, but to the state-of-the-art of an on-going discussion, which is driven by European stakeholders such as the (Conference of the) European Ministers for Education and the European University Association (EUA).

Key features of a Bologna-conformant third cycle can be summarized as follows:

Value of excellent doctoral education: The European Charter for Researchers identified a potential shortage of researchers, which "will pose a serious threat to EU's innovative strength, knowledge capacity and productivity growth in the near future" (European_Commission, 2005). "Within this context, particular priority should be given to the organisation of working and training conditions in the early stage of the researchers' careers, as it contributes to the future choices and attractiveness of a career in R&D" (European_Commission, 2005).

Learning outcomes: The core component of the third cycle is the advancement of knowledge through original research (EUA, 2007), (EUA-CDE, 2010). According to the European Qualifications Framework, the "learning outcomes relevant to Level 8 are knowledge at the most advanced frontier of a field of work or study and at the interface between fields" (EU, 2008). The "most advanced and specialised skills and techniques" will be acquired as well as competences in terms of "responsibility and autonomy" (EU, 2008).

Structured programmes: The (Bergen_Communiqué, 2005) considered the need for structured doctoral programmes and installed a follow-up group for the further development of their basic principles. According to the EUA (European University Association), 30% of European higher education institutions surveyed say that they have established some kind of doctoral, graduate or research school (Crosier et al., 2007). "Some kind of" should be highlighted, because it shows a dilemma: Not having official regulations or not even a clear definition of a Bologna-conformant structured doctoral programme makes it hard to evaluate how many fulfil these criteria.

Duration: "Doctoral programmes should operate within appropriate time duration (three to four years fulltime as a rule)" (EUA, 2005). Another quality aspect of doctoral education are acceptable completion rates (Sursock and Smidt, 2010).

Status as professionals and funding: The statements are ambiguous. On the one hand: "We consider participants in third cycle programmes both as students and as early stage researchers" (Bergen_Communiqué, 2005), on the other hand, the European Charter for Researchers (European_Commission, 2005) sees it a bit differently: "All researchers engaged in a research career should be recognised as professionals and be treated accordingly. This should commence at the beginning of their careers, namely at postgraduate level". "This includes fair and attractive conditions of funding and/or salaries with adequate and equitable social security provisions (including sickness and parental benefits, pension rights and unemployment benefits) according to national laws" (European_Commission, 2005), which is implemented in the Erasmus Mundus programme for Joint

Doctorate Programmes (European_Commission, 2010). Also in reality, there are different perspectives: In 2007, 22 of 37 participating Bologna countries considered the status of doctoral candidates as “mixed” (students and employees), 10 countries only as students, and 3 countries only as employees (EUA, 2007). Another aspect of a professional attitude is “documented responsibilities and duties”. In the Erasmus Mundus programme, the EC requires a “Doctoral Candidate Agreement”, which amongst others requires a definition of “the nature of the supervisory/monitoring/assessment procedures and the criteria used to assess the candidate’s performance” (European_Commission, 2010).

Recruitment and selection: In a non-structured doctoral education the “process is more like this: A professor knows a good student from her university and asks her if she wants to write a PhD thesis” (Thaller, 2006). According to the Conduct for the Recruitment of Researchers (European_Commission, 2005), “employers and/or funders should establish recruitment procedures which are open, efficient, transparent, supportive and internationally comparable”. The advantage is that “broader channels of advertisement are used” (Baschung, 2010); consequently more potential PhD students apply, so the choice is bigger. A selection committee (vs. a single professor) is supposed to make more substantial selection decisions, and the process is more transparent, being structured in a better way and publicly documented. US universities, again for comparison, have had such selection processes for a long time, with ambiguous results. A broader participation in the selection can reduce the weight of the scientific potential of candidates.

Multiple supervision complements the traditional one-to-one apprenticeship model (Sursock and Smidt, 2010). “Supervision must be a collective effort with clearly defined and written responsibilities of the main supervisor, supervisory team, doctoral candidate, doctoral school, research group and the institution, leaving room for the individual development of the doctoral candidate” (EUA-CDE, 2010). The most important aspect is that of supervision by a group of supervisors vs. a single professor. Another aspect is informal supervision, leading to the next issue of ***research environment.*** The (Bergen_Communiqué, 2005) urges universities to ensure that their doctoral programmes promote interdisciplinary training. The Erasmus Mundus programme for Joint Doctorate Programmes requires inter-sectorial and inter-organisational collaboration (EACEA, 2010). All of these aspects are fulfilled, almost by definition, in structured doctoral programmes. The environment of a structured programme is interdisciplinary, inter-sectorial, and inter-organisational per se and fosters informal supervision through the feedback of PhD colleagues, other professors in the programme, and feedback on presentations and publications. As such, a research environment is supposed to be stimulating and evoke the best-possible results from the PhD students. The “environment” also includes student services (Sursock and Smidt, 2010), e.g., accommodation, visa information, and organization of administrative issues.

Employability is a key concern of structured doctoral programmes. It is stressed quite often that more than half of PhD earners do not choose careers in academia (Huisman and Naidoo, 2006). So it makes sense for the European Ministers for Education to “invite our HEIs to reinforce their efforts to embed doctoral programmes in institutional strategies and policies, and to develop appropriate career paths and opportunities for doctoral candidates and early stage researchers” (London_Coummuniqué, 2007). A first approach is to teach soft skills (transferable skills) such as time management, project proposing and management, writing and communication skills, copyright regulations, risk management, and research ethics (Peers, 2010). This helps doctoral candidates targeting both, academic or non-academic careers. Nevertheless, “if the non-academic labour market becomes the destination of an increasing number of Doctoral candidates, are the generic skills sufficient to meet employers' expectations?" (Sursock and Smidt, 2010). A radical answer to this question is Professional Doctorates, particularly found in the UK. "Collaborative doctoral programmes, with their exposure to non-university environments, are seen as an excellent way to improve candidates' ability to relate abstract thinking to practical applications and vice versa, as required for the development of new knowledge, products or services" (Borell-Damian, 2009). The European Commission, in its Erasmus Mundus Programme for Joint Doctorate Programmes, requires the participation of associated industrial and government partners (EACEA, 2010). It exceeds the scope of this paper to further discuss advantages and disadvantages and whether these developments shift doctoral education towards an industry-oriented third cycle or new emerging alternatives.

Internationalisation and mobility: "International students, especially at the graduate level represent a huge part of the knowledge creation workforce in many universities of industrialized nations" (de la Fuente, 2010). "Doctoral programmes are a key component of the discussion on European higher education in a global context, while at institutional level, attracting the best doctoral candidates from all over the world, encouraging mobility within doctoral programmes and supporting European and international joint doctoral programmes and co-tutelle arrangements, are central to the development of any international strategy" (EUA, 2007).

STRUCTURED VS. NON-STRUCTURED DOCTORAL PROGRAMMES – PROS AND CONS

This section picks up the key features of Bologna-conformant doctoral education and examines pros and cons of structured and non-structured doctoral programmes – theoretically as well as from the point of view of a research and teaching institute with experience in both models.

Value: At the European level, (doctoral) education is considered as a valuable economic and societal resource. There is no contradiction to this in Germany. Doctoral education is highly appreciated – as Germany has one of the "highest proportions of doctorates in relation to the number of graduates worldwide" (Kehm, 2007). There is also no contradiction between structured and non-structured doctoral programmes. Both models target excellent doctoral education and there is no need to ask a research institute about the value of either.

***Learning outcomes*:** The German and the European Qualifications Frameworks are compatible (Greisler and Hendriks, 2008). However, they are so abstract that they are hardly usable as guidelines for an institute. Probably most professors would agree that graduates with doctorates must have acquired the "most advanced and specialised skills and techniques, including synthesis and evaluation, required to solve critical problems in research" (EU, 2008) or "can be expected to be able to promote, within academic and professional contexts, technological, social or cultural advancement in a knowledge based society" (Greisler and Hendriks, 2008). At this abstract level, there are hardly any differences between structured and non-structured doctoral programmes.

If we are looking at learning outcomes in terms of knowledge, skills, and competences in more detail, we can observe differences between structured and non-structured doctoral programmes: Bologna-conformant doctoral education provides transferable skills (soft skills) and supports career development. Both, "research skills for the discipline and career management skills have their place in a doctoral training programme" (Schäffner, 2008).

Already in the traditional doctoral education, doctoral candidates presented their research at conferences, attended courses in scientific writing or career building, organized international events, taught classes, and cooperated with international partners, thus acquiring transferable skills such as communication skills, English language proficiency, writing and presentation skills, multi-cultural competencies, and building up professional networks. The difference is: the structured doctoral programme reliably conveys *all* these skills to *all* doctoral candidates due to a mandatory course programme of 30 ECTS credit points, mandatory milestones such as journal and conference publications, and a mandatory external semester in the USA.

A second aspect is the mediation of interdisciplinary knowledge. Especially "German doctoral candidates are known for being schooled in great depth in their specific fields, but often lack a broader orientation" (Baftiri, 2010). In order to avoid such an "over-specialisation", the mandatory course program of our structured doctoral programme contains field-specific and interdisciplinary courses.

***Structured programmes*:** This key feature will be discussed in the following section summarising the results.

***Duration*:** Bologna-conformant doctoral education should last 3 to 4 years (EUA, 2005). In Germany, an average duration of 5 years is estimated overall (Gerhardt et al., 2005), with structured doctoral programmes achieving 3 to 4 years (Greisler and Hendriks, 2008). Another aspect of duration is completion rates. Estimates show that only a third of German candidates starting a PhD complete it (Baftiri, 2010).

At our institute, we estimate an average duration of 4 to 5 years for the traditional doctorates and drop-out rates of markedly below one third. The structured doctoral programme started at the end of 2009, so it is too early to evaluate duration and completion rates, though at this time they look very strong. So far, we have one drop out amongst 18 doctoral candidates (with no further drop-out in sight). One can estimate that the duration for fully funded doctoral candidates will be 3 to 3.5 years, for candidates with partly or no scholarships closer to 4 to 4.5 years.

It would be too early and too easy to claim this as a success of the structured doctoral program. First, we are talking about a group of selected students with high motivation and excellent backgrounds. Second, many students of the programme receive a scholarship. Nevertheless, there are strong arguments that the structured doctoral programme supports shorter duration, higher completion rates, and better outcomes:

- Doctoral candidates started in cohorts. Instead of "working alone (if not lonely)" (Huisman and Naidoo, 2006), candidates are in a group, which not only provides support in research issues, but creates a motivating and personal environment.
- Schedule and milestones provide a structure. Instead of facing a huge endeavour, doctoral candidates have clear and achievable goals and, step by step, feelings of success.
- Improved supervision facilitates quicker progress (see respective sub-section below).

***Status as professionals and funding*:** As described above, there is an ambiguous attitude in the European context whether to see doctoral candidates as students or as professionals. However, the most important factor in this regard is the situation a single doctoral candidate is in:

- Doctoral candidates should be well prepared for the professional life *after* the PhD, which will be discussed in the sub-section "employability".
- "Having fair and attractive conditions of funding and/or salaries with adequate and equitable social security provisions" as stated in the European Charter for Researchers (European_Commission, 2005).

The European Commission is implementing this approach in its Erasmus Mundus Programme for Joint Doctoral Programmes, requiring working contracts vs. regular scholarships wherever possible according to national regulations (EACEA, 2010). Also in Germany, the German Research Foundation (DFG) switched to granting scholarships *or* working contracts (DFG, 2010a).

Apart from "what is best", there is also the question of financial realities. In the above-mentioned Erasmus Mundus Programme, the funding for a working contract of a doctoral candidate is twice as expensive as for a regular scholarship. Twice as many doctoral candidates could be funded, if all candidates would "only" receive regular scholarships (which are not taxed!). Furthermore, many doctoral candidates do not even profit by working contracts. If, for example, a Brazilian or Nigerian candidate has a working contract in Germany for a 3-year doctoral programme and afterwards goes back in his/her home country or to the USA, payments for pension or social security are essentially lost (although one might argue that the payments remain in the German social system).

The German Federal Ministry of Education and Research (BMBF) increased the number of doctoral scholarships from 2.300 to 3.000 within the past eight years; further scholarships are provided by the "Pact for research and innovation" and the "Excellence Initiative" of the German and Federal State Governments (Greisler, 2007). Nevertheless, the majority of doctoral candidates are working, either within institutional positions at the universities (51,4 %) or in third-party funded projects (28,2 %) (Gerhardt et al., 2005).

Being just one research institute, our influence is obviously limited. We try hard to acquire research projects with the goal (amongst others) of securing salaries for doctoral candidates. We try equally hard to acquire funded doctoral programmes and to provide information about individual funding opportunities to have scholarships for doctoral candidates. Although being quite successful with both, we are far from having full scholarships in terms of working contracts with full social security for all doctoral candidates. It would not even be ideal to have funded doctoral candidates only. A research institute should not only do research in funded graduate schools. It is dependent on running research projects as well in order to ground its research to relevant and real-world challenges and to develop teaching materials for the first and second cycles. The scope of research institutes like ours is rather pragmatic, trying to achieve the best possible situation for the doctoral candidates, which is trying to assure secure financing for the duration of the PhDs in some way, either by scholarships or by secure working contracts in on-going research projects.

Considering the question of structured vs. non-structured doctoral programmes in terms of funding, there are no advantages for structured programmes per-se. There is rather a potential advantage, because structured programmes often go along with scholarships.

But apart from the question of working contract vs. regular scholarship, one can observe a clear advantage of a Bologna-conformant doctoral programme: a contractual basis between doctoral candidate and university. Assuming this as an effect of a "more professional attitude" (of both, students and advisors!) within structured doctoral programmes, one can regard the regulation of rights and duties as a substantial advantage – for both parties.

Recruitment and selection: An ethical, fully supported requirement within the Bologna process is the conduction of fair and transparent recruitment and selection procedures, e.g., see Code of Conduct for the Recruitment of Researchers (European_Commission, 2005). Our experiences show that the Bologna-conformant procedures also have practical advantages, for the research institute as well as for the doctoral candidates.

Due to the central role of the "doctor father" or "doctor mother", in the traditional model recruitment and selection are bilateral, based on personal contacts, very often within the same institution. The biggest advantage of our recruitment and selection procedures in the structured doctoral programme was to find the best-possible candidates:

- By a public call for applications, we could reach a much higher number of applicants.
- The percentage of international applicants (and also selected doctoral candidates) was significantly higher.
- Many applicants were not only external in terms of institution or nationality, but also in terms of research fields. Applicants with different (although of course linked) research background have been selected, thus contributing to the interdisciplinarity of the doctoral group and finally of the institute.
- Single professors can make mistakes. A selection committee instead provides a broader view of an applicant, thus avoiding the selection of less-qualified applicants.

Also, for doctoral candidates applying to a programme (vs. applying to a single professor) there are several advantages:

- By public calls for applications, he/she becomes aware of specific research fields and opportunities he/she has never heard of before.
- A structured doctoral programme is typically well described. Due to publicly available programme information, the applicant can get a much better picture if his/her expectations are matched and by knowing what his/her personal PhD could look like.
- An application procedure requires some effort, thus forcing the applicant to think about the advantages and disadvantages of the doctoral programme and to re-think his/her motivation.

***Multiple supervision and research environment*:** Traditional doctoral education in Germany relies "more on self-organization of the doctoral candidates and peer supervision than of defined responsibilities for supervision by senior researchers or research teams as for example, "graduate schools"" (Merkt, 2008). Key words are senior researchers (plural!) / teams and defined responsibilities.

In the context of supervision, it is important to emphasise that the duties of the supervisors are also documented - so a controlling concept also includes the control of the supervisors (Osterwalder, 2007).

In our traditional doctoral programme, we have already conducted elements of multiple supervision. The difference is once again *more* (supervision) reliably provided to *all* doctoral candidates. In our structured doctoral programme, supervision consists of a set of formal and informal procedures and tools. Rather formal are:

- The main supervisor plays a key role in the formal assessment by evaluating and discussing quarterly progress reports and other milestones.
- The co-supervisor ideally has different background than the supervisor and is from the USA, where the doctoral candidates go abroad for an external semester.
- In the structured doctoral programme we could engage a postdoctoral researcher, who is the ideal contact point and consulter on a day-to-day basis.
- In public defences of advanced thesis proposals, doctoral candidates receive feedback from the research institute members.
- The first mandatory publication has to be presented at an international conference in order to get feedback from international experts.

Informal supervision procedures and tools are created by the research environment:

- Research is organized in so called research initiatives. In this way, a doctoral candidate has access to a group of professors involved.
- The structured doctoral programme is group-based rather than based on the individual approach in the traditional model. For example, the doctoral candidates organized a research retreat, they presented results in an online seminar with colleagues from other universities, they came up with a joint case study covering all theses topics – so there are many opportunities to talk to and to receive feedback by other doctoral candidates.
- Doctoral candidates are encouraged (and funded) for attending international conferences, workshops, research visits or summer schools, where they get external feedback.

Maybe most important is the idea of an "environment". Within an "environment" (vs. single entry points in the traditional model), doctoral candidates can build up personal networks and have access to many other researchers, who might be of interest to them. High numbers of cross-thesis publications are just one example of the significant benefits. Another aspect of "environment" is services for doctoral candidates. Through the introduction of the structured doctoral programme, we achieved the critical mass for better organised and standardised services such as German language courses, accommodation, visa support, pre-arrival information, etc.

***Employability*:** Today, on average two thirds of the doctors in developed countries must find a professional position in commerce and industry (Bonnaud and Hoffmann, 2009). These numbers made employability a major topic in the Bologna Process. One solution is to re-think the general concepts and contents of doctoral education. Another solution is to teach additional transferable skills and competences in order to support career development.

As for the concepts of doctoral education, there is a consensus that the core component of the third cycle is the advancement of knowledge through original research (EUA, 2007), (Bergen_Communiqué, 2005), (Sursock and Smidt, 2010). However, we can observe specialisations of doctoral programmes, e.g., in the UK "The *professional doctorate (PD)*: is a taught doctorate but the field of study is a professional discipline, rather than the academic discipline…. Although research-based, the focus is normally more (or also) on application within the student's professional practice (reflexive practitioner)" (Huisman and Naidoo, 2006). This approach is only briefly discussed here, because for an institute clearly committed to research, it is not attractive. One could claim that the on-going discussion has neglected that academia is still a big market for doctoral candidates and each institute has to position itself in an increasingly competitive market.

As for mediation of additional transferable skills and competences to support career development, the need can be claimed for both, research-oriented and professional doctorates. "The European tradition of the Doctorate – as the production of a piece of original research under the supervision of one professor, with very little emphasis on taught courses – has been increasingly questioned in recent years. Discussions have focused on the need to make Doctoral degree holders more competitive internationally" (Sursock and Smidt, 2010).

At our institute, the structured doctoral programme improved transferable skills among graduates. The international research environment alone increases English language proficiency and multicultural competences. Doctoral candidates communicate, present and write more than in the traditional model. The course program includes courses in project management, proposal writing, and scientific writing as well as a mandatory organization of an international research event. The programme includes a one-semester mobility measure to the USA. There are more opportunities to create professional networks.

Again, one can come to the same conclusion as before: We have already done similar things in the traditional model, but the structured programme provides *more* (transferable skills) reliably to *all* doctoral candidates.

***Internationalisation and mobility*:** By a higher percentage of international doctoral candidates,we achieved the critical mass to move from "well, we can speak English and we have five international staff members, most of them speak German" to a truly international research environment, where English is the working and teaching language. In addition, improved mobility at all levels is a substantial advantage of our structured doctoral programme:

- On the German side, the structured programme is a cooperation of the Universities of Münster and Bremen. There is constant short-term exchange between these groups.
- All German doctoral candidates go for a one-semester period to the University at Buffalo, USA.
- US doctoral students visit Germany. The programme also attracted doctoral candidates from other countries, in South America, Africa, and China, for example.
- The programme includes funding for international guest researchers giving classes and discussing with the doctoral candidates.
- Doctoral candidates conduct short-term mobility measures such as visits to research groups at other universities and attending workshops, conferences, and summer schools.

STRUCTURED VS: NON-STRUCTURED DOCTORAL PROGRAMMES – SUMMARY AND CONCLUSIONS

The evaluation of key features of Bologna-conformant doctoral programmes against the background of our parallel experiences with both models, structured and non-structured, can be summarized as follows:

Table 1: Evaluation of structured vs. non-structured doctoral programmes

Key features of doctoral programmes	**Evaluation***
Value	+/-
Learning outcomes	+
Duration	+
Status as professionals and funding	+
Recruitment and selection	+
Multiple supervision and research environment	+
Employability	+
Internationalisation and mobility	+

* + = pro structured doctoral programmes; +/- = no advantages for one of the models; - = contra

Seven of eight key features of doctoral programmes show significant advantages of the structured doctoral programme compared to the traditional German PhD. One can consider multiple supervision and research environment as the most important improvements, because they affect the daily life of the doctoral candidates and significantly contribute to research excellence.

At our research institute, most elements of a structured doctoral programme had already been implemented in the traditional non-structured doctoral education. However, the difference is: *more* (supervision, soft skills, internationalisation, etc.) is reliably provided to *all* doctoral candidates. In the case of our research institute, conducting a structured programme is not necessarily a different concept, but a more successful way of implementation.

Maybe the "secret" behind the improvements can be seen in the term "stronger institutional responsibility" (Baftiri, 2010). Doctoral education should not only be the responsibility of a single professor but should also be seen as a task of a faculty community (Greisler, 2007). A structured programme provides for the critical mass in order to be able to fulfil such an institutional responsibility (EUA, 2005).

Although the evaluation shows clear advantages for structured doctoral programmes, two issues have to be discussed before coming to a conclusion: change of concepts in doctoral education and feasibility.

Change of concepts in doctoral education: There is an on-going discussion of depth vs. breadth orientation in doctoral education. It is obvious that one cannot expect both, depth as claimed for the German system (Baftiri, 2010) and breadth as claimed for the US system (Osterwalder, 2007), without extending doctoral education to five or six years. Taking into account the experiences of our structured programme, a mandatory course programme of 25-30 ECTS credit points, handled in a flexible and individual way so that the doctoral candidates substantially profit from it, and a mobility measure abroad seem to be an appropriate compromise between depth and breadth within an acceptable duration.

Feasibility: Our current structured doctoral programme is funded, but even in this "comfortable" position, the research institute invests additional resources into the programme, e.g., for more organisation, more supervision, and additional courses for the course program. So there will be a problem after the end of the funding period.

On the level of a research institute, we have no influence on the provision of funding programmes in general, and limited influence on writing successful proposals. Internal resources are also limited and dependent on external funding. The only reasonable strategy seems to be to run a structured doctoral programme with limited resources – with lower quality than in a funded programme, but with higher quality than in the traditional doctoral education. For example, with internal resources, we would not be able to hire a postdoctoral researcher to support supervision of doctoral candidates, but other features such as recruitment procedures, services for doctoral candidates, course program, and multiple supervision could be maintained. The approach of a research institute can only be: to try to implement as many Bologna-conformant features of doctoral programmes as possible.

Feasibility is not restricted to institutes, but affects doctoral candidates as well. Despite an institute's attempts to acquire institutional funding with scholarships and doctoral candidates' attempts to acquire individual funding, there will always be a high percentage of doctoral candidates, who will need to earn money for living expenses. Consequently, quite often the question arises: How can I write a PhD thesis *and* attend a one-semester course programme *and* work in a project at the same time? The answers might be as follows:

- The institute has to accept a change of concepts as described above. Supervisors cannot expect doctoral candidates to broaden their horizons in a course program in the same depth as in traditional German doctoral theses.
- Project work does not equal project work. Research institutes should target research projects, where doctoral candidates can work primarily on their thesis topic. Sadly, EU projects are putting more and more emphasis on deliverables for shelves and software development, rather than scientific insights. A doctoral student in an EU project today is kept busy with project meetings, software development, and deliverable writing, which makes it hard to focus on research.
- Different financial situations already existed in the traditional model – some doctoral candidates had scholarships, others did not. The consequence is “only” a matter of time. In a structured doctoral programme, the duration of fully funded doctorates should be limited to 3 years. According to a German survey among 10.000 doctoral candidates, grant-holders spend 71.9 % of their working time on their dissertation, working doctoral candidates 51.7 % (Gerhardt et al., 2005). Mathematically, the working commitment extends the doctorate from 3 to 4.17 years. In a structured doctoral programme, working doctoral candidates should have a flexible duration of 4-5 years.

Coming back to the introductory question, we can conclude the following: The evaluation of key features of doctoral programmes clearly shows advantages for Bologna-conformant structured doctoral programmes. Conducting a structured doctoral programme after the end of the funding period is – with some restrictions – feasible for both parties, the institute and the doctoral candidates.

Running both models in parallel is not feasible for an institute of our size. We would not achieve critical mass at all levels (students, teachers, organisation, and resources). Therefore, a preliminary recommendation had been to switch entirely to a structured doctoral programme.

OUTLOOK

A continuing discussion at the European and national levels regarding the Bologna-conformant third cycle education suggests that, despite some lack of clarity of the outcomes, structured doctoral programs will become more common, but a high degree of flexibility will remain. For the discussion it is not too important whether or not a research institute is in the field of GI S&T/GeoInformatics. One of the driving forces for structured doctoral education will be funding programmes such as Erasmus Mundus in Europe, DFG research training groups in Germany, or the recently published goal of the German Academic Exchange Service (DAAD) to focus individual PhD funding on applicants in structured programmes.

After a substantial discussion of the results and suggestions described in this paper within the department and the university, the Institute for Geoinformatics entirely switched its doctoral education to the structured program. The most important motivation has been to increase the quality of the doctoral education, because doctoral researchers are the main “capital” of a research institute. In April 2012, the “Graduate School for Geoinformatics” has been founded (http://gradschool.ifgi.de/), and the first doctoral candidates have started. It will be an ongoing task to monitor the progress of the new Graduate School and to improve its concepts according to internal evaluations and to new developments in the third-cycle Bologna process.

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