Web Mapping and Geospatial Web: An Introductory Course for Geographers and Geoscientists

Emmanuel Stefanakis
Department of Geodesy and Geomatics Engineering
University of New Brunswick
Fredericton, NB, Canada
estef@unb.ca

Abstract

The paper presents the syllabus of a course on web mapping and geospatial web for geographers and geoscientists, developed and delivered in several European and Canadian Institutes, since 2007. The author wishes to share the challenges and opportunities as well as the experiences and perspectives with educators around the globe who either consider the introduction of a relevant course to their institute curriculum or offer relevant courses and seek ideas for revision of content and teaching practices.

1 Introduction

Geographic information science and technology (GIS&T) education has evolved dramatically the last thirty years. The complex and dynamic interaction between technology, the GIS industry and the academia [18] transformed the niche courses in a small number of academic departments, back to the '80s, into the ubiquitous GIS&T courses of today, being offered in almost all geography and environmental studies programs and many other disciplines in social studies, humanities, education, and business [16,10]. The GIS&T Body of Knowledge [3] is one of the most significant achievements in GIS&T education. It provides a systematic thematic catalog with the learning outcomes for the discipline, and can support the development of sound curricula. On the other hand, the great breadth of the GIS&T Body of Knowledge makes it difficult to know what to include in a particular course or module [4].

This paper presents the syllabus of an introductory course to web mapping and geospatial web for geographers and geoscientists. This course has been developed and delivered to geography and geomatics students in European and Canadian institutes since 2007. During a five year period, the content has been evolved dramatically to reflect the technology developments as well as the experience gained from the previous years. The challenge in teaching a web technology course to students with limited skills in programming and computer networks has been alleviated by applying various innovating developments in teaching, such as open educational resources, web-based instructional materials, and active pedagogy techniques [9].

Enthusiasm overwhelms the students, starting from the first couple of weeks in the course, when they realize that building web applications is feasible for them. Upon completion of this course, students recognize its value and declare willing to deepen their technical knowledge into advanced topics of web mapping and geospatial web. As for the educator, it is encouraging to see them building neat web applications, kindly competing each other for the best outcome, and often including new methods and tools, never taught in class, to enhance functionality.

The paper is organized as follows. Section 2 presents the challenges and opportunities in designing and delivering the course. Section 3 describes the course syllabus. Section 4 highlights the experiences from teaching of the course. Finally, Section 5 concludes the discussion.

2 Challenges and Opportunities

The design of a course for Geographers has many challenges and opportunities. Geographers have usually limited programming skills. Although, there are bright exceptions, most geography students have taken at most one introductory course in programming. On the other hand, they are familiar with GIS and Remote Sensing software packages, and pretty advanced internet users. In addition, they are acquainted with the spatial dimension, the spatial reference and projection systems as well as the spatial data sources available on the web.

The development of applications on the web requires some basic knowledge in computer network infrastructures as well as programming skills in script languages. One of the main challenges in introducing Geographers into Geospatial Web is that there is not enough time and space for the teacher to initiate the students into these technologies. On the other hand, web technology, although sophisticated, has some features that ease its understanding by non-experts in computer science.

For instance, XML-based languages are human readable and built on top of few and simple constructs (i.e., element and attribute). In addition, script programming (e.g., JavaScripts) are easy to understand and portable from one application to another. The option to browse the source code behind the web pages also helps non-programmes to catch up on missing knowledge, when trying to build their own web maps. Apparently, the fascinating tutorials and example pages built for developers (e.g., Google Playground and OpenLayers Development Examples) encourage non-programmers to improve their skills in building advanced web mapping applications.

The following assumptions have been made in the development of the course:

- The students have limited or no experience in: programming, markup languages, computer networking and web technologies.
- The course will consist of a dozen of lectures and lab sessions as a regular term-long course.
- The course will be implemented in free and open source tools, so that there is no need for purchasing any software.

The course syllabus, which is presented in the next Section, is the outcome of an evolution from a series of courses, tutorials and seminars on the topic [1,2,15], delivered by the author, since 2007. The most mature version is a technical elective course (addressed to senior undergraduate and graduate students) entitled "Web Mapping and Geospatial Web" in the Department of Geodesy and Geomatics Engineering at the University of New Brunswick, taught in the Fall 2012.

3 Course Syllabus

3.1 Objectives and Structure

The objectives of the course can be summarized in the following paragraph, which is aligned to the GIS&T BoK learning objectives: "The course focuses on both the theoretical and practical issues related to the dissemination of mapping/geographic content on the web and the development of map mashups and geospatial web services. Students will learn how to design and implement advanced web mapping applications and geospatial web services using free software tools. Special attention will be given to the recent technological developments and research directions."

As for the course structure, it consists of two parts: (a) Lectures: a series of presentations on the basic theoretical issues related to Web Mapping and Geospatial Web Services; and (b) Lab Sessions: a series of exercises focusing on the practical issues related to the dissemination of mapping/geographic content on the web and the implementation of geospatial web services. After each Lecture/Lab Session, students will be receiving an Assignment to get acquainted with the methods and tools taught in the class/labs.

3.2 Hardware, Software and Data Requirements

Regarding the hardware requirements, the educator needs to have access to a computer (preferable a power PC) with internet connection and ability to install free software, including web server software (e.g., Apache) and ftp server software (e.g., Filezilla). On the other hand, the students need to have access to a computer (a regular PC or laptop) with internet connection and ability to install free software.

Table 1 summarizes the software requirements for the educator and the students in the course. All software components are free and most of them open source (OSGeo Projects [6]).

An easy solution for an educator with a windows PC is to install the ms4w (MapServer for windows) available at MapTools [5]. This is a no fuss installer which quickly installs a working environment for Apache (web server), php processor (server-side compiler), and MapServer (map server software). In addition, the educator needs to install Filezilla (FTP server), GeoNetworks (catalog server) and GeoServer (map server; usually installed along with GeoNetworks). Optionally, the educator may also install ProstgreSQL/PostGIS (geographic database server) and download the OpenLayers Javascript library (Map API library).

The students need to install only Quantum GIS and Google Earth (desktop clients), as well as Kernow software (XSLT transformer). Optionally, they can install Filezilla (FTP client), as alternatively they may ftp their files to the server through any file manager. Apparently, a web browser is already available in their computer. If the browser does not support SVG, a free SVG viewer (e.g., from Adobe) needs to be installed as well.

Figure 1 shows the framework of the student's interaction with the course server. Each student has allocated some disk space on the server side. The student is able to upload data and applications on the server through the ftp protocol. The uploaded content can be accessed through the HTTP protocol as well. Hence, all functionality of the server software can be exploited by the students. Figure 2 shows the location of the students' disk space on the course server for an installation with ms4w on windows operating system.

Table 1: Software requirements.

Server side (Educator)		Client side (Students)	
Role	**S/w Name**	**Role**	**S/w Name**
Web Server	Apache	Web Browser	Google Chrome, Mozilla Firefox
Scripting Language Compiler	php processor	Desktop GIS	Quantum GIS
Map Server	MapServer, GeoServer	Desktop KML Visualizer	Google Earth
Map API - JavaScript Library	OpenLayers	XSLT Transformer	Kernow
Catalog Server	GeoNetwork	FTP Client	Filezilla Client
Database Server	PostgreSQL/PostGIS		
FTP Server	Filezilla Server		

Figure 1: Student's interaction with the course server.

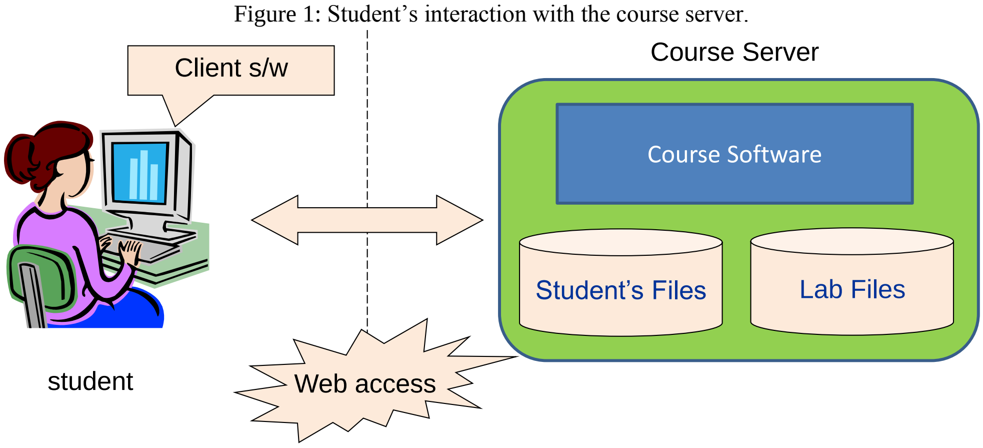
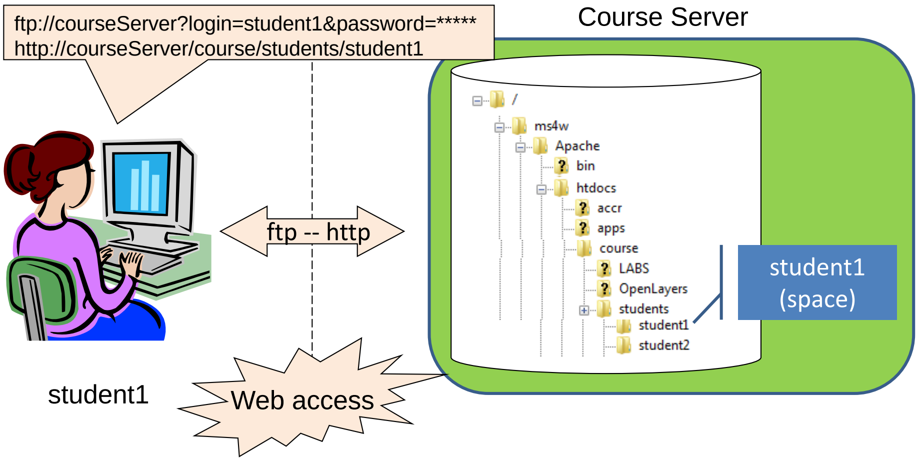


Figure 2: The student has access to the allocated space on server disk through both ftp and http protocols.



As regards to the data requirements, the students need a few shapefiles of the same region (e.g., road network, towns and counties of a Province) in order to complete their assignments. Similarly, the educator also needs a few shapefiles for running the labs. If shapefiles are not available, they can be downloaded from some public servers. Optionally, the educator may have some layers available in a PostgreSQL/PostGIS database and show the students how various methods in web mapping and web mapping services can retrieve and disseminate content that resides in a geographic database. Most of the lab sessions and assignments make use of data available in Earth browsers (e.g., Google Maps, OSM) or raster image providers (e.g., GeoBase Landsat images repository).

3.3 Course Content

The course content is summarized in Table 2. The topics have been organized in a block of 11 sessions, which fits well in a regular term and gives space for a couple of sessions (a term usually has up to 13 sessions) for course overview, midterm, review, and tutoring sessions, if needed. Each session consists of a lecture and a lab. The session concludes with an assignment to the students, which is due to the next session.

The most recent offering of the course (Fall-term 2012) was combining a session lecture and lab in a 3 hour meeting once a week. Each meeting was setting off with the presentation of the students' work on the assignment of the previous session, followed by the lecture and lab of the week. Table 2 highlights the topics of an 11 week block. The sessions may be grouped into two Parts.

The scope of the first part (Part I: Weeks 1-6) is to get the students acquainted with the basic technologies involved in web mapping applications. A series of methods and tools are explained to the students in simple terms and through a series of examples.

After the first six sessions (Table 2), the students have already built-up a good knowledge on client and server-side processing, on languages and protocols used in web mapping as well as on web services. Hence, they can proceed to more advanced topics on Geospatial Web, including Spatial Data Infrastructures and Web Services for Mapping.

The scope of the second part of the course (Part II: Weeks 7-11) is to make the students acquainted with the technological aspects of an SDI (basically, disseminate geographic content on the web using widely accepted standards) through the development of a framework with an architecture similar to the one shown in Figure 3.

Table 2. Lecture/Lab Sessions and Assignments (Fall-term 2012 at UNB).

Week	Lecture/Lab Topics	Assignments
1	Course Overview – Computer Networks & Web Concepts. Introduction to HTML and HTML Scripts. Clickable Areas in HTML.	Create an HTML page with hyperlinks, tables, bullets, images, buttons/actions, etc. Include a map as image with clickable areas (hyperlinks).
2	Introduction to XML (Language & Technologies). Geo-XML languages (GML, SVG, KML). XSL Transformations (XML2XML & XML2HTML).	Enrich the page in Ass.1 with an SVG script/map (vector graphics & animation). Convert a SHP to KML using QGIS. Show on Google Earth.
3	Introduction to Web Feeds (RSS and Atom). Geographically tagged Feeds (GeoRSS: Simple & GML). Introduction to Mashups (Categories & Applications).	Compose a GeoRSS feed and visualize it using OpenLayers RSS Visualizer Example. Convert RSS to KML using XSLT. Show on Google Earth.
4	Map Mashups (Web-based & Server-based). Google Maps API – Google Code (Maps) Playground. Introduction to JavaScripts (client-side processing).	Create a Visualizer (in HTML+JavaScripts) for KML & GeoRSS files on top of Google Maps using Google Maps API. Visualize the files of Ass.3.
5	Introduction to php (server-side processing). Combination of php with JavaScripts. php & Google Maps API.	Create an HTML form which accepts values (eg., KML file name or location X,Y). Post values to a php script to generate an HTML page with Google Maps API JS.
6	Introduction to Web Services & Example Services (GeoNames). Implementation of Web Services using php. Web Services for Data Management (Google Fusion Tables).	Create a service in php to respond to unclear URL requests (similar to GeoNames services). Create your Fusion Tables and visualize content using GMaps API.
7	Web Services for Mapping & Example Services (GeoBase). OGC Services: WMS, WFS and WCS. Introduction to MapServer and the mapfile.	Create the WMS, WFS and WCS Services for a set of shapefiles using MapServer (compose the corresponding mapfiles). Visualize content in QGIS.
8	Thin and thick (desktop) Web Clients. Examples. Introduction to OpenLayers JavaScript Library. Development of a thin client for Web Services in OpenLayers.	Create a thin Web in OpenLayers. Activate and visualize the web services in Ass.7 using this client. Create various base maps and overlays on the client.
9	Introduction to Spatial Data Infrastructures (SDI). Catalog Servers, Geoportals & Gateways. Metadata Standards (DC, ISO19139, FGDC) & Services (CSW).	Create the metadata items (ISO19139) of two data sets in GeoNetwork server. Search them with various constraints. Access the items through CSW requests.
10	Geospatial Processing Services (OGC Web Processing Service). JavaScript Object Notation (JSON & GeoJSON). AJAX (Asynchronous JavaScript & XML/JSON) Model.	Create a WPS Service in GeoServer. Use the WPS Request Builder. Simulate an Ajax model with php, HTML and GMAP API JavaScripts.
11	Introduction to ArcGIS Online. Google Maps API Web Services (Distance, Geocoding, etc.). Bing Map App SDK. OpenStreetMap Collaborative Project.	Publish your data on ArcGIS Online. Create an HTML page with GMAP JS to implement two GMAP API Web Services. Create an OSM visualizer in OpenLayers.

This architecture is compatible with the proposal for GeoFOSS SDI [17], and it has been adopted in the development of SDIs in the past [13,14]. At the bottom layer, reside the SDI repositories. The geospatial layers can be available in shapefiles, geotiff images or Postgresql/PostGIS tables. In the middle layer (middleware) reside all the services that assist the accessibility to the data repositories. The SDI has two main servers, i.e., the Map Server and the Catalog Server. These two servers provide (serve) the geospatial content on the web, based on standard interfaces (e.g., WMS, WFS, WCS, CSW–ISO19115/139). At the top layer (the client) reside the users and applications. The access to the SDI geospatial content is possible through either a desktop (thick) or a web (thin) client. These clients and the corresponding visualization capabilities are accessible by the SDI users.

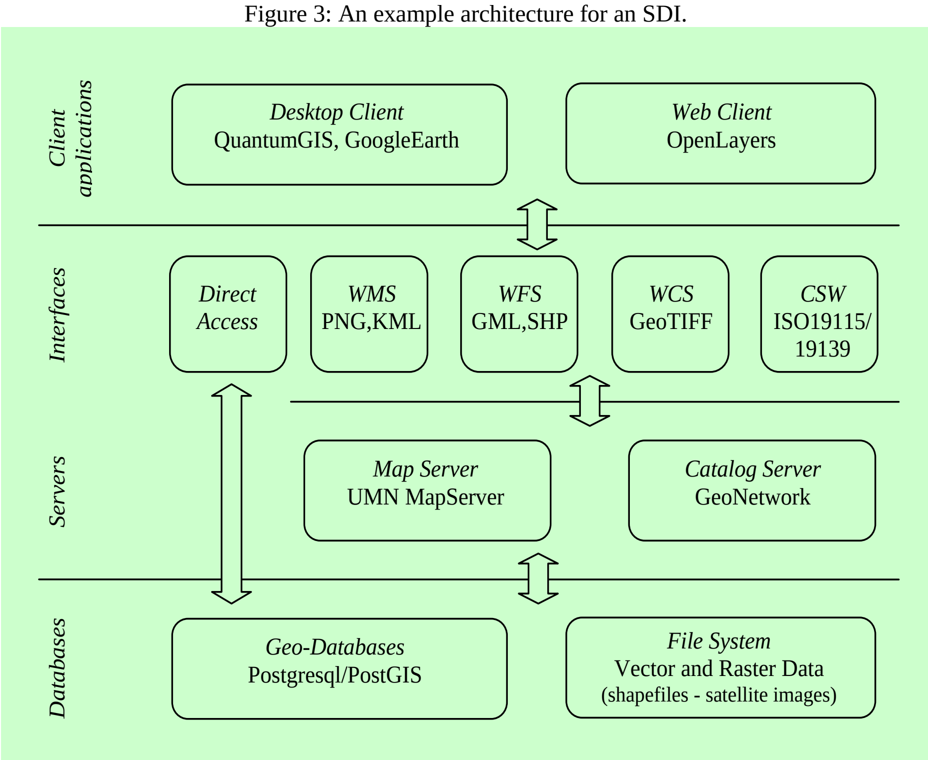
4 Experiences

As explained in Section 2, the main challenge of the course syllabus is to cover the relevant topics and make the students acquainted with the technology and the tools, while at the same time avoid spending time in teaching them fundamentals in informatics, such as programming techniques, computer networking, communication protocols, etc. There are some contradictory facts to achieve that. On one hand, the students have limited background in informatics, which seemingly is a barrier in teaching them such a course. On the other hand, the course content must cover the basics in web mapping and geospatial web, which although are pretty wide, they should fit in a term course, consisting of a limited number of sessions.

Although, it sounds unattainable, the approach followed in this syllabus turns out to be rather successful. The lectures focus on the concepts and objectives of each method or tool taught, while the labs highlight these through examples. Then the students are encouraged, through assignments to experiment and learn through an active training. In addition, the innovative open educational resources and web-based instructional materials are used to assist the students in the learning process.

Some practices applied in the course were proven very effective. For example, the posting of the students work on the assignments to the server, in a space which is visible by all course participants, as well as the students' work presentation in a weekly basis, help them to empower their skills and confidence in web application development. It is awesome for the educator to realize that in a couple of weeks after the course sets off, a significant number of students (in an average

Figure 3: An example architecture for an SDI.



of 30% each year) produce deliverables of quality much higher than any expectation and kindly compete each other for the best outcome.

A total of 150 students (80 senior undergraduate and 70 graduate students) have taken the regular term course as taught at Harokopio University of Athens and the University of New Brunswick (Section 2), since 2007. With minor exceptions, the students assessed the course with a top mark for all aspects. Many of them stated that they really enjoyed the course, mainly because it helped them to get introduced into the web mapping technology and build-up their skills in web mapping programming. The educator has taken care of collecting their comments for improvements systematically, throughout of the last five years. The student comments were considered carefully and helped the educator to evolve both the course content and delivery practices. The current course syllabus, as presented in Section 3, incorporates most of these comments.

Another challenge in running the course is fast changes in technology, which should be reflected in the syllabus as soon as possible. As mentioned in Section 3.3.2, two sessions (Weeks 10 and 11) have been reserved to accommodate new developments and tools. In addition to this, there is need to check out the availability of web resources used in the course, in a regular basis, as their provider might decide to cancel them at any time. This has happened quite a few times since 2007 for the material used in this course. Two of the most representative examples were (a) the NASA JPL WMS service, which was not supported for a period, while currently it provides limited functionality, and (b) the Integrated CEOS European Data Server (ICEDS), which was suddenly ceased in the Summer 2012. It is interesting to mention that this happened while a course session on web sevices for mapping was running and the author was forced to change a series of examples built on top of ICEDS server to another server (GeoBase).

5 Conclusion

The syllabus of a course entitled “Web Mapping and Geospatial Web” has been developed over a five year period. The course has been taught in several European and Canadian institutes and was addressed mostly to geographers and geoscientists at both a senior undergraduate and graduate level (Section 2). At the same time the author had an active research in the area (e.g., [13,11,7]) and a clear understanding of the technology as well as the learning objectives of such a course. The most recent syllabus of the course (as of the Fall-term 2012) is presented in this paper. The assessments (student opinion surveys) of over 150 students throughout a 5-year period were very positive and the experiences of the author very encouraging.

The short-term goals for the future include: (a) a continuous improvement and update of the content and teaching practices; (b) the development of a follow up course entitled “Research directions in Geospatial Web” (to be first delivered in Winter-term 2013 at UNB); and (c) the compilation of the teaching materials, lab exercises and assignments in a form that can be released to others as a sound educational resource. The long-term goals include: (a) the authoring of an up-to-date text book in the topic [12,15]; and (b) the compilation and delivery of the course and the corresponding teaching materials as an online module (e.g., [8]).

References

[1] eduGI 2007. Reuse and Sharing of e-Learning Courses in GI Science Education (2006-07). [Accessed Nov.14, 2012: http://edugi.uni-muenster.de/eduGI/]

[2] eduGI Network, 2003. International Network for Education in Geographic Information Science [Accessed Nov.14, 2012: http://edugi.uni-muenster.de/]

[3] DiBiase, D., DeMers, M., Johnson, A., Kemp, K., Luck, A.T., Plewe, B., and Wentz, E. (Eds) 2006. Geographic Information Science and Technology (GIS&T) Body of Knowledge. AAG and UCGIS.

[4] Foote, K.E., 2012. Issues in curriculum and course design: discussion and prospect. In Unwin et al., 2012., pp. 159-164.

[5] MapTools, 2012. Resource of Open Source Mapping [Accessed: Nov.14, 2012: http://www.maptools.org/]

[6] OSGeo, 2012. The Open Source Geospatial Consortium. [Accessed: Nov.14, 2012: http://www.osgeo.org/]

[7] Pelekis, N., Stefanakis, E., Kopanakis, I., Zotali, C., Vodas, M., and Theodoridis, Y., 2011. choroChronos.org: A GeoPortal for Movement Data and Processes. Conference on Spatial Information Theory (COSIT 2011), Belfast, Maine,USA, Sept.12-16, 2011.

[8] PennState, 2012. GEOG 863: Mashups. Online Course. PennState University. Department of Geography. [Accessed Nov.14, 2012: https://gis.e-education.psu.edu/ gis/geog863_overview]

[9] Schultz, R.B., 2012. Active pedagogy leading to deeper learning: fostering metagognition and infusing active learning into the GIS&T classroom. In Unwin et al., 2012., pp. 133-145.

[10] Sinton, D.S., 2012. Making the case for GIS&T in higher education. In Unwin et al., 2012., pp. 17-36.

[11] Stefanakis, E., 2012. Map Mashups and APIs in Education. In: Peterson, M. (Ed.). Online Maps with APIs and Map Services. Springer.

[12] Stefanakis, E., 2009. Web Mapping and Web Mapping Services. New Technologies Publ., pp. 220 [In Greek].

[13] Stefanakis, E., and Prastacos, P., 2008a. Development of an Open Source Based Spatial Data Infrastructure. Applied GIS Journal, ISSN 1832-5505, Vol. 4, No. 4, pp. 1-26. [Accessed Nov.14, 2012: http://arrow.monash.edu. au/vital/access/manager/Repository/monash:7759]

[14] Stefanakis, E., and Prastacos, P., 2008b. Development of a coastal SDI using GeoFOSS. In the Proceedings of the 11th AGILE Conference, Girona, Spain, May 5-8, 2008.

[15] Stefanakis, E., 2008. Web Services for Mapping. Tutorial. The 3rd International Conference on Internet and Web Applications and Services (ICIW 2008). Athens, Greece.

[16] Tate, N.J., and Unwin, D.J., 2009. Teaching GIS&T. Journal of Geography in Higher Education. 25(1), pp. 37-52.

[17] Ticheler, J., 2007. What are SDI, OpenSDI and GeoFOSS? GeoNetwork OpenSource Community Website. [Accessed in Nov. 1, 2007: http://geonetwork-opensource.org/documentation/faq/foss-sdi-and-opensdi]

[18] Unwin, D.J., Foote, K.E., Tate, N.J., and DiBiase, D. (Eds.), 2012. Teaching Geographic Information Science and Technology in Higher Education. Willey-Blackwell.

[19] Unwin, D.J., Foote, K.E., Tate, N.J., and DiBiase, D., 2012. GIS&T in higher education: challenges for educators, opportunities for education. In Unwin et al., 2011., pp. 3-15.