INTRODUCING GEOGRAPHERS TO WEB MAPPING AND GEOSPATIAL WEB

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ABSTRACT:

The paper starts with a brief overview of an introductory course on web mapping and geospatial web for geography and geomatics students, developed and delivered in several European and Canadian Institutes, since 2007. Then it presents the syllabus of a follow-up course for graduate students, first taught in the Winter-term 2013. The author wishes to share the challenges and experiences with educators in Canada and elsewhere, 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. INTORDUCTION

Geographic information science and technology (GIS&T) education has evolved drastically the last thirty years. The complex and dynamic interaction between technology, the GIS industry and the academia (Unwin et al., 2012) 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 (Tate and Unwin, 2009; Sinton, 2012). The GIS&T Body of Knowledge (DiBiase et al., 2006) is one of the most significant achievements in GIS&T education. It provides a systematic thematic catalogue 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 (Foote, 2012).

The author has been developing and offering web mapping courses to senior undergraduate and graduate geography and geomatics students in European and Canadian institutes (in both class-based and online mode) since 2007. During a six year period, the content has been evolved 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 (Schultz, 2012; Balram Dragicevic,2008).

Recently, the author has shared the content and experiences of the introductory course on web mapping and geospatial web in AGILE, the annual conference of the European Geographic Information Laboratories (Stefanakis, 2013). The present paper goes a step further and presents the content of a follow-up graduate course first taught in the Winter-term 2013, in the Department of Geodesy and Geomatics Engineering at the University of New Brunswick.

The paper is organized as follows. Section 2 offers an overview of the introductory course. Section 3 describes the follow-up course syllabus. Section 4 highlights the experiences gained from teaching the two courses. Finally, Section 5 concludes the discussion and presents the author's future plans.

2. THE INTRODUCTORY COURSE

The objectives of the introductory 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."

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

1. Senior undergraduate and graduate geography or geomatics students take the course.
2. The students have limited or no experience in: programming, markup languages, computer networking and web technologies.
3. The course consists of a dozen of lectures and lab sessions as a regular term-long course.
4. The course is implemented in free and open source tools, so that there is no need for purchasing any software.

As for the course structure, it consists of two parts: (a) Lectures: a series of presentations on the basic concepts and technologies of 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 receive an Assignment to get themselves acquainted with the methods and tools taught in the class and labs.

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.

An easy solution for an educator with a windows PC is to install the ms4w (MapServer for windows) available at MapTools (MapTools, 2013). 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 locally 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.

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 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).

The course content as of its most recent offering (Fall 2012) is summarized in Table 1. The topics have been organized in a block of 11 sessions, which fits well in a regular term and gives room for a couple of sessions (a term usually has up to 13 sessions) for course overview, midterm, review, and tutoring, 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 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. 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). More details about both the course content and settings can be found in Stefanakis, 2013.

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.

Table 1. Lecture/Lab Sessions and Assignments of the Introductory Course (UNB, Fall-term 2012).

3. THE ADVANCED COURSE

In the Winter-term 2013, a follow-up course has been delivered by the author to the graduate students in the Department of Geodesy and Geomatics Engineering at the University of New Brunswick. The course was designed with the assumption that the introductory course (Section 2) was a prerequisite. Hence, students taking the advanced course have a good background on web mapping and geospatial web as of Table 1.

As summarized in Table 2, the content of the advanced course is focused on the key methods and technologies that turn the traditional web into an interoperable framework, easily interpreted by machines and software components. In addition, students get a deeper understanding of the web mapping services and tools that comprise the geospatial web.

The settings of the course are similar to those of the introductory one. Each session (week) includes: (a) a Lecture on the technical foundations, enabling technologies and research directions of geospatial web; (b) a Lab focussing on the practical aspects of the corresponding lecture; and (c) an Assignment to the students on the session (Lecture and Lab) content.

All software components used are free or even open source tools. In addition to those used in the introductory course, students need to install into their computer the following packages: Protégé Ontology Editor and Knowledge Acquisition System, the SketchUp by Trimble, and a CityGML plugin for SketchUp. A series of web accessible tools are also used in the course such as W3C RDF validator, KONA GeoSPARQL editor, XPATH Editor, etc. Students' deliverables are uploaded through the ftp protocol to the course server and are accessible from the educator and all course students through the web.

The course content consists of three parts (Table 2). Part I (Weeks 1-3) offers a deep understanding on interoperability issues, the role of standards, and the work undertaken by the Open Geospatial Consortium (OGC) and the International Organization for Standardization (ISO). Geography Markup Language (GML) and OGC Web Services, discussed already in the introductory course, are revisited and examined closely. The lab sessions include the WMS-time service, CSV to GML conversion, GML validation, CityGML application schema, and a two-way conversion among all three SketchUp files, KMZ, and CityGML.

Part II (Weeks 4-7) introduces the semantic web concepts and technologies and their geospatial web dimension. Students get familiar with the basic semantic web languages, i.e., RDF and OWL, as well as some well-established vocabularies and ontologies such as FOAF, DublinCore, and GeoNames. The lab sessions include the compilation, validation and visualization of RDF files in triples and graphs, the extension of existing vocabularies to describe the semantics of a geospatial domain on the web, the definition and extension of ontologies in Protégé as well as the inference of knowledge by applying appropriate reasoners. In addition the XPATH (for XML files) and SPARQL/GeoSPARQL (for RDF files) languages are examined closely.

Part III (Weeks 8-10) covers some advanced topics on geospatial web. Among them are geolocation services, crowd maps and services, and WebGL graphics library. A series of labs have been developed to get the students acquainted with these topics and the representative systems (Ushahidi) and services (Swift River). Obviously, there are much more that

Week	Lecture/Lab Topics	Assignments
1	Course Overview – Open Geospatial Consortium (OGC). OGC and ISO Standards. OGC Abstract Specification and OGC Reference Model.	Develop a WMS-Time Service on MapServer to disseminate the content of an ST shapefile. Extend the service with the GetFeatureInfo functionality.
2	Geography Markup Language (GML). ISO19100 Series and GML. GML 3.2 and 3.3 Specifications. GML Schema, Profiles and Application Schema. GML Validation.	Create a prototype CSV2GML converter in php for point features. Test the prototype using the csv file of a point shp. Validate the gml/xsd files in Kernow.
3	CityGML application schema. Advanced Web Mapping Services: Transactional Web Feature Service (WFS-T). Web Services technologies (SOAP/USDL/UDDI) vs RESTful services.	Create the 3D Model of a UNB Building in SketchUp. Use plugin to (a) export the model into CityGML; and (b) visualize (import) the CityGML in SketchUp & GE.
4	Introduction to Semantic Web. Limitations of traditional web. Introduction to Semantic Web impact and technologies. Search XML documents using XPATH.	Use XPATH to extract data from the response of Google Map API Web Services. Create a navigation tool using GMAP JS, GMAP WS and XPATH.
5	Describing web resources in RDF. Drawbacks of XML. Resources, properties, values (statements). RDF and RDF Schema. RDF in XML and RDF graphs. Common vocabularies.	Write an RDF file to link a unit (a person) to places on earth with descriptions in GeoNames database. Validate. Make use of geoRDF and other vocabularies.
6	Query language for RDF: SPARQL. SPARQL Specification. SPARQL query tools and example queries. GeoSPARQL Specification: vocabulary, operations and examples.	Extract information from the RDF file of Assignment 5 using SPARQL queries. Experiment with GeoSPARQL using an online tool.
7	Ontology languages. Introduction to Web ontology language (OWL). Limitations of RDF Schema. Reasoning support for OWL. OWL DL and RDF. Introduction to Protégé and reasoning.	Using protégé s/w browse the ontologies in Protégé Wiki. Choose one and present the classes, properties and individuals as defined or inferred by the reasoner.
8	Introduction to WebGL: Web Graphics Library. Advanced Geospatial Services: GeoClustering. Linked Open Geodata. LOD datasets, components and agents.	Using protégé s/w re-write the rdf file of Ass.5. Import ontologies, add your own classes, properties and individuals. Save the ontology in rdf. Validate.
9	Geolocation. IP addresses and IP locating. Databases and APIs. Geotagging, GeoSMS, and GeoURI. Standards for Gazetteers. Geospatial Metadata Standards.	Create an app for mobile devices using W3C Geolocation API and Google Static Maps API. It will report/visualize the location and distance from 3 POIs
10	Collaborative GIS and VGI. DBPedia and DBPedia Mobile. Crowdsourcing and Crowdmaps. Introduction to Ushahidi and services for validating and filtering real-time information.	Create a crowdmap in Ushahidi. Define the appropriate map settings, categories, and theme. Post reports and manage statistics.

Table 2. Lecture/Lab Sessions and Assignments of the Advanced Course (UNB, Winter-term 2013).

could be included into Part III, such as geosensor web standards, as well as new technologies that keep showing up in this rapidly evolved area. All these, will be considered in future versions of the course.

4. PRACTICES AND EXPERIENCES

The design of a course for geography and geomatics students has many challenges and opportunities. Firstly, although there are bright exceptions, most students have usually limited programming skills as they have taken at most one introductory course in programming. On the other hand, they are familiar with GIS and Remote Sensing software packages, and advanced internet users. In addition, they are acquainted with the spatial dimension, 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 room for the teacher to initiate the students into these technologies. Nevertheless, web technology, although sophisticated, has some features that ease its understanding by non-experts in computer science (Balram and Dragicevic, 2008).

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.

Although, it sounds unattainable, the approach followed in the syllabus of both courses 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 based on 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 deliverables to the course server, in a space which is visible by all course participants, followed by a presentation in the class (in a weekly basis), helps 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 of 30% each year) produce deliverables of quality and kindly compete each other for the best outcome.

A total of 150 students (80 senior undergraduate and 70 graduate students) have taken the introductory course as taught at Harokopio University of Athens, UN Lisbon, BW Munich, 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 six years. The students' comments were considered carefully and helped the educator to evolve both the course content and teaching practices. The most recent course syllabus, as summarized in Table 1, incorporates most of these comments.

The advanced course was taught for the first time in the Winter-term 2013 and the student opinion surveys are not available yet. The course has been taken by 11 graduate students (course and research-based Masters) from the Department of Geodesy and Geomatics Engineering. The educator has received (verbally) very positive comments for this course from the majority of the students. Students expressed clearly that the advanced course offered them a better understanding of the geospatial web concepts and technology, while after completion they felt more confident about their web programming skills.

Another challenge in running both courses is the fast changes in technology, which should be reflected in the syllabus as soon as possible. In the introductory course, two sessions (Weeks 10 and 11) have been reserved to accommodate new developments and tools. In the advanced course, a similar approach applies for the last three sessions (Weeks 8 to 10).

Apparently, there is need for the educator to check out the availability of web resources used in the courses, in a regular basis, as their providers might decide to cancel them at any time. This has happened quite a few times since 2007 for the material used in the introductory 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 services for mapping was running and the author was then forced to urgently change a series of examples built on top of ICEDS server to an alternative one (GeoBase).

5. CONCLUSION

The syllabus of two courses, an introductory and an advanced, on web mapping and geospatial web have been developed over a six year period. The courses have been taught in several European and Canadian institutes and were addressed mostly to geography and geomatics students at both a senior undergraduate and graduate level. At the same time the author had an active research in the area (e.g., Stefanakis and Prastacos, 2008; Stefanakis, 2012; Pelekis et al. 2012) and a clear understanding of the technology as well as the learning objectives of such type of courses. The most recent syllabuses of the courses (as of the academic year 2012-13) are presented in this paper. The assessments (verbal and/or those of student opinion surveys) of over 160 students over the last six years have been very positive and the experiences gained by the author very encouraging.

The short-term goals for the future include: (a) a continuous improvement and update of the content and teaching practices; and (b) 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 (Stefanakis, 2009; Stefanakis 2008); and (b) the compilation and delivery of the course and the corresponding teaching materials as online modules (e.g., PennState, 2012). Towards this direction, a set of educational videos have been already created to cover the first three sessions of the introductory course (Table 1).

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