Teaching SDI and OGC

Ingo Simonis and Christoph Brox
Institute for Geoinformatics, University of Münster, Germany
simonis@uni-muenster.de, broxc@uni-muenster.de

Abstract

SDIs from global to local levels rely on standardization and interoperable GI services. In the GI field, factual standards are those from the Open Geospatial Consortium (OGC). Therefore, the use and further development of OGC standards are crucial for the success of SDIs. Despite a lack of qualified personnel in OGC issues, OGC topics are rarely included in current GI curricula. In some GI institutes, OGC becomes part of existing courses, but teachers face many problems. How to teach OGC better was the focus of a workshop at the AGILE 2006 conference, organized by the AGILE Education Working Group and the OGC University Working Group. Based on the workshop results, this paper identifies the impediments for teaching OGC and outlines activities for improvements in

- Know-how about user requirements
- Re-use and sharing of existing resources for e-Learning provision
- Open Source system for provision of OGC services and data for education and training.

Needs for and impediments to teach OGC

Several studies emphasize the economic value of standardization, e.g.: the DIN study (DIN 2000) states that standardization removes trading barriers, provides better cooperation possibilities, and increases the amount of suppliers; the Delphi study (Dephi 2003) concludes that the use of standards improves the return of investment. In the GI field, factual standards are those from the Open Geospatial Consortium (OGC).

A survey of the Institute for Geoinformatics (IfGI) asked GI professionals, what they think an essential know-how that Graduates in Geoinformatics should bring into their future jobs (Brox and Pires 2004): ~ 53 % think SDI essential for their future jobs, ~ 43 % OGC/interoperability. These were the highest values only outmatched by core GI topics like GIS, spatial databases and cartography. However, OGC topics, which form the technical basis for SDIs, are rarely represented in current GI curricula.

Based on the outcome of the aforementioned studies as well as on own experiences and surveys, we forecast an increasing demand for qualified personnel in OGC topics in the near future. OGC should become a key topic of a modern education in GI Science. As GI reality is moving from monolithic to services oriented systems, students have to learn the background. Technical as well as administrational and political aspects of service oriented architectures shall become part of current curricula.

The discussions within the OGC University Working Group show two trends:

- Slowly, the demand for OGC know-how affects an increasing integration of some OGC-related seminars into GI education.
- The positive effect of the few existing OGC courses already results in pro-active transport of ideas from universities towards the industry and public authorities.

At the AGILE 2006 conference, the AGILE Education working group and the OGC University working group jointly organized the workshop “Teaching OGC”. We identified a number of common impediments from the teachers’ perspectives:

Uncertainty regarding teaching content and targeted audience. Despite the fact that the number of universities as members in OGC is continuously growing (currently more than 100), there is still a high amount of uncertainty regarding the "what to teach to whom" question. The target audiences vary from highly skilled GI students being future developers of OGC services to employers, e.g., in ecological planning, requiring training measures for “just” using OGC services.

The fact that OGC related technologies are voted by GI professionals to play an important role in the job market, we have to differentiate between SDI as a concept and OGC as an organization. Spatial Data Infrastructures do work to a certain amount without consensus driven standardization processes as well, as some networks of the leading GI software providers proof right. Other approaches like the Infrastructure for Spatial Information in Europe (INSPIRE) are of particular interest at least in some parts of the world. They are somehow related to OGC but certainly not build on top of it. Should it become part of "teaching OGC"? "Teaching OGC" is often a mix of some SDI concept (including a wide range of issues like technology, models, architecture, politics, organization, etc.), some SDI products, some OGC, some ISO and standardization in general and market related aspects.

Also OGC-experienced teachers will have problems to keep track on rapidly changing OGC contents and discussions. Not being involved into continuous OGC work will result in hardly being able to decide what is important for students and what not.

Accessibility to usable and up-to-date OGC teaching materials. It is still difficult to find appropriate teaching material. The lack of introductory OGC material in combination with the hardly usable entry point at the OGC web site makes is harder for “OGC beginners”.

The few existing (public) OGC teaching materials face two major impediments:

- All teaching materials are designed for a specific purpose. If a teacher wants to adapt external materials for his/her own use, required contents, quality standards, learning requirements, and background know-how of the targeted students, will mostly be very different. So it will end up with a very time-consuming and costly adaptation process.
- Teaching materials are outdated very quickly due to the rapidly changing processes and specifications in OGC.

An important aspect of teaching in topics as OGC is to provide practical exercises for students. However, these are time-consuming and costly to implement. Having access to some service installations does not help much in teaching OGC. Concrete exercises require a huge amount of additional time. You have to find data and load the different service repositories, you have to configure clients and import your data into catalogues. All this has to be done manually. If somebody messes up the whole system, you have to start from the beginning. Often, you even have to deal with legal restrictions. Data that is freely available often covers distinct and remote places on the earth. Further on, if you want to show interoperability, you should have at least more than one installation involved, but multiple set up is very labour intensive.

Accessibility to appropriate OGC-compliant software for educational use. Accessibility has three aspects, which in the end can be related with costs:

1. Typically, *commercial OGC-compliant software is not affordable* for academic institutions. This is particularly true for products of smaller software companies that specialized in OGC compliant Web service implementations. Most big GI software vendors run academic programs and provide a broad range of their products at academic prices, but due to longer development cycles and general market strategies, OGC standard compliancy of those products is often poor.

2. The large variety of *open source products* calls itself free, but still: The evaluation of appropriate software for educational use, and its *adaptation* to the own course requirements cost to many financial resources in terms of personnel.

3. Open source software initiatives provide a wide range of products addressing OGC related issues. At least in the field of the core services like web mapping and access to spatial data via Web Feature Services you can choose from a huge number of different implementations. The common problem of most of those *open source products is the lack of maintenance tools*. It might be part of the business model (some products call themselves open source only because you can access the repository anonymously) or lack of time, but tools that support proper configuration of the service are scarce goods.

Based on these impediments, the following three sections suggest improvements on three levels:

- A more detailed knowledge of different users' (OGC learners') requirements will provide a better decision bases about what to teach and what to learn
- A business model for re-using and sharing resources can improve the access to appropriate OGC teaching materials
- A networked approach for implementing an open source OGC servers can improve the access to OGC-compliant software and data for educational use.

How to improve teaching OGC - User requirements analysis

Though first enquiries have shown the need for OGC experts, teaching contents as well as level of abstraction remain vague. The need for OGC experts became even more urgent due to the INSPIRE initiative (Infrastructure for Spatial Information in Europe, an initiative launched by the European Commission), evoking the potential for an increasing number of transnational and national use of geographic information that will lead to the creation of a European SDI. The gap in information about needed experts should be filled by a European analysis of

- the know-how needed for increasing use of OGC standards and techniques, and the implementation of INSPIRE,
- and consequently, what kind of learning offer is needed for professionals and students.

The following sub-sections provide a concept and an implementation model for a user (learners) requirements analysis.

Concept: The basic approach is to analyze the learning requirements in the context of OGC and SDI on a European level. Four major questions have to be addressed:

- Which types of users are important e.g., end users of web services, designers, builders, data manager/provider, system/maintenance managers, project managers, Bachelor and Master students?
- What are "OGC environment and workflows" of these users?

- What contents has to be taught for different user groups? Contents also includes the learning intensity and invested time, appropriate for different user groups.
- How can the extended development and provision of OGC/SDI teaching modules be implemented in education and training, organizationally and financially?

Valuable resources for a start are the results of the GI-INDEED project, see http://www.gisig.it/gi-indeed/. Within this EC-LEONARDO project, the user requirements of "learners" in the SDI context were investigated by partners of four European countries (results to be published soon on the project website). The user requirements analysis forms the basis for the curriculum development of four pre-defined teaching modules in SDI.

Due to the (necessary) focus of this project, it has its limitations regarding the analysis of the all-European education and training needs in the OGC/SDI context:

- Being a LEONARDO project, GI-INDEED rather focuses on training than education.
- The project partners cover some European countries, but not all of Europe.
- The user requirements analysis focused on pre-defined modules, not on the general learning need for OGC/SDI topics and the implementation of the INSPIRE initiative.

We suggest extending the results of GI-INDEED by a European analysis of learning needs in OGC and SDI.

Implementation: The method would be similar as in the GI-INDEED project, basing on questionnaires as well as on personal interviews. Extensions are

- Covering learning needs in education AND training
- Covering more European countries, e.g., addressing the members of the AGILE organization (more than 20 European members)
- Covering general learning needs in the OGC and SDI context, also including the potential and needs of the implementation of INSPIRE.

Based on the elaborated user profiles, results would be "ideal curricula" for each user group. The next step is to development of a business model for the implementation of OGC/SDI teaching. As for education, a feasible business model will be presented in the following section. An additional challenge is to explore business models for OGC/SDI training modules for professionals – possibly derived from educational modules and exploited by educational GI institutions.

How to improve teaching OGC - Re-use and sharing of existing resources

Resources for teaching OGC already exist in single GI institutions, e.g., digital teaching materials, OGC-compliant software, and even complete (face-to-face) OGC courses. These resources should be exploited. Due to the impediments described above, e.g., high cost for adapting and/or updating teaching materials, few single GI institutions will be able to provide high-quality OGC courses on its own. Not only re-using resources is required, but also sharing resources.

"Therefore it is crucial to foment European educational projects. They can establish partnerships, coordination of resources and actions in the GI sector, as well as improve the effectiveness of public resources" (Wachowicz, Brox and Reinhardt 2005). This section will provide i. a concept and b. an implementation model for a networked provision of OGC modules by re-using and sharing resources.

Concept: Sharing resources evokes the challenges of a distributed environment: How can international partners cooperate in developing and teaching OGC courses?

Teaching by distance learning is the most obvious solution. However, the times of extensively funded e-Learning projects are over. New e-Learning activities have to be performed with very limited resources. As good e-Learning is expensive, this challenge can hardly be managed by a single institute, but only in networked cooperation.

Approaches in the projects eduGI.LA2 (www.eduGI.net/eduGI.LA2) and eduGI (www.eduGI.net/eduGI) are currently testing the exchange of complete e-Learning courses (Brox, Riedemann and Kuhn 2006). Key features of the business model of the projects' approach are:

- Each partner contributes a module, which is in the core expertise and core interest of the providing institution.
- The provision of modules includes teachers (which is the core idea, preventing costly adaptation of external teaching materials. Ideally, the reception of modules affects no effort for the receiving institution except providing a list of students and receiving a list with students' grades).
- The partners agree on common standards for contents and course organization.
- Partners do not charge fees to each other, but cooperation bases on a balanced exchange.

The above mentioned projects revealed promising results, proving the feasibility of the business model. Therefore, we suggest transferring this business model to a networked provision of OGC modules.

However, e-Learning has its limitations – the above mentioned project results revealed the main impediment of pure distance learning: the restricted interaction between students and teachers, and students among each other. The "classroom provides the organizational framework and motivation, and enables people to learn through their peers' experiences. The aspects of learning can be simulated online", but classroom teaching "is the best place to deal with subtle organizational differences in practice, as well as exceptions to the rules" (Gray 2006).

Blended learning combines e-Learning technologies with traditional classroom teaching (Simonis 2004). Thus, it combines the advantages of e-Learning (individual learning in terms of time, location, and learning progress) with the advantages of face-to-face teaching, i.e., interaction.

Therefore, our approach is to extend the business model of an exchange of e-Learning courses in the eduGI.LA and eduGI projects to a networked provision of blended learning OGC modules. But how can blended learning be performed in a partner network? The following sub-section provides an exemplary implementation model.

Implementation: This implementation model outlines a model based on the input of the AGILE workshop participants. A real-world implementation requires a detailed analysis and matching of

- user requirements (see above), and
- existing resources of the partner network.

In this example, we target the development of a common 6 ECTS credit points OGC module. A consortium of four international partners commonly develops and provides the following sub-modules:

- “Introduction to OGC and SDI”, e-Learning, 1 credit point, partner A
- “Introduction to web services”, e-Learning, 1 credit point, partner B
- “Application of OGC specifications I”, e-Learning, 1 credit point, partner C
- “Application of OGC specifications II”, e-Learning, 1 credit point, partner D
- “Practical: Web services”, classroom teaching, 1 credit point, partners A and B
- “Practical: OGC specifications”, classroom teaching, 1 credit point, partners C and D.

The four e-Learning sub-modules can be performed in the same way as in the projects eduGI and eduGI.LA: non-fee business model and exchange of courses including teachers.

The extension is the additional provision of two sub-modules via face-to-face teaching. For each of these two sub-modules, two partners commonly develop a concept and teaching materials. Consequently, partners A and B are able to teach the first classroom sub-module “Practical: Web services” at home on their own. In addition, partner A will teach this sub-module at partner C’s institution and partner B at D’s. The other way around, partners C and D provide classroom teaching at partners A and B. This requires physical teachers’ mobility measures of one week each.

As desribed above, the exchange of e-Learning modules in this way has proven to be feasible in the projects eduGI and eduGI.LA. We also think the exchange of classroom teaching would be feasible:

The following table compares the return of investment of the development and provision of the OGC module by a single partner with the provision by a consortium, basing on a course with 30 students per partner:

Investment – single institution	**Investment - consortium**	**Return of investment (single institution and consortium)**
Development of sub-modules – 6 credit points	Development of 1 e-Learning sub-module + 0,5 face-to-face sub-module = 1.5 credit points	Six sub-modules developed = 6 credit points
Teaching 4 ***different*** e-Learning sub-modules to students at home	Teaching four times the ***same*** e-Learning sub-module at home and for partners’ students	4 e-Learning sub-modules taught
Teaching 2 ***different*** face-to-face sub-modules to students at home	Teaching two times the ***same*** face-to-face sub-module at home and at the partner’s institution	2 face-to-face sub-modules taught
Updating 6 sub-modules in the following years - 6 credit points	Updating 1 e-Learning sub-module + 0,5 face-to-face sub-module in the following years = 1.5 credit points	6 sub-modules updated

The main benefit of a networked cooperation is in saving resources in development and updating sub-modules: Instead of developing/updating 6 credit points, each partner only has to invest 1.5

credit points. Although the same amount of hours have to be taught, also teaching the SAME sub-module twice or four times saves resources vs. teaching different sub-modules.

The most crucial issue is the physical performance of teachers' mobility measures. However, our experience in mobility measures within the network eduGI.net (www.eduGI.net) revealed that

- visiting a partner for one week is feasible for almost all teachers
- teachers mobility measures can also be performed by PhD students and result a valuable international teaching experience
- at least within the EC countries, ERASMUS (European Community Action Scheme for the Mobility of University Students) provides an appropriate funding opportunity
- teaching ~ 8-10 hours in a week leaves sufficient time for other purposes, e.g., research discussions and project acquisition.

How to improve teaching OGC - Open Source system for provision of services and data

Practical exercises play an important role in modern didactical approaches. However, it is very time-consuming and hardly manageable for single teachers to develop and provide OGC-compliant software and exercises to their students. To manage the splits between exercise units that illustrate real world problems to the students on the one side and keeping the work load for the lecturer within reasonable limits, we present the new "ad-hoc SDI" concept: The dynamic and automated setup of a Spatial Data Infrastructure; publicly accessible for GI teachers all across Europe.

The core idea is to have a one-click SDI setup that can be launched and configured by teachers as required. Teachers can choose what kind of services will be deployed and what kind of problems or errors the students will be confronted with. Data will be loaded to the ad-hoc SDI automatically. The services do run on various machines at different places. The number of participating organizations is arbitrary.

First we will present the concept behind the ad-hoc SDI. After having "Introduction to SDI" as a permanent item on GI curricula for some years now, we will shortly discuss what it means to provide practical examples to students. Afterwards we will sketch a possible implementation. This can only be a first approach as the realization of the intended ad-hoc SDI would require a larger, multi-years project.

Concept: Although the implementation of the different services, the service setup process and the registration of service instances at registries is worth several credit points itself, we will focus on the use of SDI. Using individual services, playing around with data from multiple service instances and put them into complex chains, making experiences with technical and semantic interoperability are certainly important aspects while learning the art of Spatial Data Infrastructures. Here, we will focus on the aspect of how to provide a playing field for those being new to SDI and making their own experiences. Though a number of SDIs are currently installed and still growing in numbers, those SDI often are not suitable for beginners to start with. One important aspect here is that SDIs are slowly but steadily leaving the phase of active testing and prototype status. This development comes along with access restrictions and rising costs. Alternatively, an educational SDI might be installed and used. The problem here, as experiences in former projects has shown, are maintenance costs and data availability (Simonis 2004). Single institutions at Universities often do not have the possibility to maintain a SDI on their own. Additionally, running a bunch of services within a LAN does not

provide students with real world scenarios where misunderstandings, firewall settings, configuration problems etc. appear and have to be handled.

To solve the maintenance problems and to provide a Spatial Data Infrastructure that supports learning SDI in an optimal way, we propose the concept of the "ad-hoc SDI". The ad-hoc SDI is a software collection that consists of any number of service implementations, data, configuration tools and installation scripts. Multiple institutions can participate by simply providing a machine within their local network that the ad-hoc SDI may connect to. It allows GI teachers to set up a fully functional Spatial Data Infrastructure with a few mouse clicks only. Further on, this SDI will be fully distributed across multiple institutions to demonstrate possible communication and administration problems. The predefinition of typical SDI related problems, e.g. counterproductive data integration due to semantic incompliancy.

Implementation: A possible scenario for the implementation of the "ad-hoc SDI" is as follows: In a consortium, each of the partners provides one to many machines with ad-hoc SDI host adapters. There is no SDI in place. Just a small software package in idle mode is listening on every machine. Now one institution wants to make use of the SDI. Using the configuration tool, the lecturer defines how many and the sort of services to be installed, what kind of data will be available and hits run. The installation scripts will now contact the ad-hoc SDI clients on the connected machines. Data packages will be transferred and services installed. After the installation is finished, the lecturer will receive the initial SDI URLs to make use of the fresh SDI. By either using a catalogue or by exploring the configuration tool, the lecturer as well as the students will learn about the different services in place with corresponding bindings. Now students are free to explore the SDI and run whatever command on it without interfering commercial SDIs. In case something breaks, the installation of a fresh SDI is only mouse clicks away. More sophisticated configuration tools and installation scripts may allow the configuration of pre set problems and errors. By easy definition of specific errors, users will be able to explore typical SDI problems in a labor like environment. Bug tracking becomes available and less frustrating.

The realization of the ad-hoc SDI is a task that certainly requires a number of resources. Individual service instances, provision of data, configuration and management tools as well as installation scripts sum up to a considerable amount of work. Though, a number of service installations are already available as open source software under GPL license. Making use of those packages would reduce the amount of work to be done but would still require a substantially funded project, possibly on international scale.

Summary and conclusions

Improved education in OGC topics is crucial for the success of local, national, and international SDIs. As the number of SDIs is continuously growing, the market will require an increased number of SDI experts.

Though first studies identifying the concrete need have been performed, there is still lack of knowledge about the specific know-how students and professionals should acquire. The same applies for the level of abstraction. "Introduction into SDI" and similar courses become common part of GI curricula, but contents vary enormously among Universities. Inherently this is not a bad fact, but

adjusting course contents on SDI user requirements in industry and the public sector would further improve job opportunities as well as market development.

Facing many problems in teaching OGC, improvements can be achieved by a careful analysis of what is needed, an international cooperation by re-using and sharing resources, and tools supporting teachers in the setup of educational SDIs. The development e-learning material in conjunction with business models for an active GI education market provides a solid base to optimize the education at the individual institutes. To facilitate practical experiences in SDI, the concept of the ad-hoc SDI was introduced. Though probably developed by a small number of institutions, it would fit perfectly into the developing GI-education and training market.

To solve typical problems SDI lecturers are faced with (e.g. SDI availability, data, etc.), we described a concept and implementation plan of an ad-hoc SDI. The aim of the ad-hoc SDI is to provide a fully functional SDI upon request by requiring only minimum input from the lecturer. The cooperative development would even allow keeping pace with the ongoing standardization work in OGC. New specifications or modifications to the existing standards can be integrated and are available to all ad-hoc SDI users instantly.

This paper shows concepts and implementation models for an improved teaching by concrete activities to be initiated by international projects and initiatives. Further discussion of project ideas and initiation of activities are very welcome.

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Ideas about re-use and sharing existing e-Learning resources base on the results of the following projects:

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- eduGI, EC eLearning Programme, project reference eduGI EAC/23/05 DE 011, www.eduGI.net/eduGI/.
- GI-INDEED, EC Leonardo Programme, project reference 2005- S/05/B/F/PP -161012, http://www.gisig.it/gi-indeed/
- BEGIN (Barents Educational Geoinformation Network), EC TEMPUS Program, project reference Project N° 24231-2003

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