The use of open source GI software in teachings

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Abstract

The use of geographic information systems in universities, colleges, in advanced or further training has become common standard in the last years. In most of the cases desktop GIS of the main software producers - like ArcGIS or MapInfo are used. With their well adapted and easy to use windows-like user interfaces, the numerous extensions and functions and the in many cases easy and cheap price structures and licensing models for educational institutions, they seem to offer exactly what is needed or wanted.

So why should open source GI software be used in teaching?

This issue was addressed in a research study that started in 2007 as part of a project at the University of Applied Sciences in Eberswalde, Germany. It includes the evaluation of interviews that followed different GIS courses in universities and other educational institutions.

The evaluation of use and potential for open source GI software initially demanded the definition of requirements from an organizational perspective (administration, software administrators) and a user perspective (lecturers, tutors and students). Each perspective was evaluated to understand possible barriers in using open source GI software. The functional complexity of different software applications were also examined according to environmental analysis, as this often includes very complex tasks and questions. The common requirements, however, can be easily assigned to other applications.

The use of open source GI software in teaching has proven to be sufficient for the initially defined requirements and problems in environmental applications. Even complex tasks can be handled whether sometimes by using more than one software solution or by combining functionalities.

Introduction

The project for the evaluation of open source GI software in teaching was significantly influenced by two factors, the restructuring of degree courses in forest information technology (FIT) and its content and the restricted budget for implementing new software at the University of Applied Sciences in Eberswalde, Germany. On the one hand, free and open source software had to be found for teaching, on the other, a survey should evaluate its suitability for the required environmental analysis.

The following results will present parts of the study that also include surveys from other academic institutions and advanced training facilities in Germany.

Requirements concerning GIS in education

The evaluation of application areas and potentials for free GI software within the study need the definition of requirements concerning GIS in education from the student's as well as the instructor's perspective (lecturers, software management, administration).

Due to the various application areas of geographic information systems the requirements of environmental analysis were selected as a reference as they totally differ from other application areas concerning the common complexity of the tasks. And its general tasks and requirements can be transferred very well to other application areas.

The following will give a summary of the main requirements from the perspective of different users. The view of the 'providers' – the lecturers, educational institutions, the IT administrators - will be shown in contrast to the student's view.

The importance and relevance of using geographic information systems for training in different application areas and the increasing importance for occupational activities can be taken for granted. Many examples for these developments can be found in current publications and will not be discussed at this point. A review can also be found in the discussed survey (Dresen, Elisabeth et al. 2008).

From the view of the provider, the training or further training institutions, the main requirements arise from expenses for the purchase, implementation and maintenance of a GIS. The respective costs may differ greatly; low prices for purchasing a system may result in high costs for implementation and maintenance, just as high costs for purchase may result in low maintenance expenses.

According to acquisition costs free software has an enormous advantage as the expenses are restricted to the download costs for the software, a fact that should not be underestimated in times of restricted funds for universities, departments or training institutions. Especially small universities or technical colleges decide on the basis of acquisition costs about buying software solutions and the number of licenses. In addition to the acquisition costs, the follow-up costs for maintenance and updates must be mentioned, costs not incurred for free software, except for the already mentioned costs for downloading updates etc.

In contrast there are the implementation costs for free software, which are assumed to be much higher than for proprietary software, as pointed out in the survey. The confirmation of this assumption could not be made within the scope of this survey, especially because of varying costs according to the implemented system and its functional requirements. Nevertheless the assumption demonstrates the existing barriers for the adoption of free GI software because of prejudices. Without going into details, many of them seem to be a result of the early developments of open source software that were equated with the need for adaptation and development in connection with poor or missing documentation. Within the present survey it could pointed out that none of the evaluated solutions were missing a documentation. Additional features and functions will be discussed in the following section.

Apart from such barriers the adjustment of the lecturer and the preparation of materials and exercises are relevant factors for the adoption of a software solution. As these services normally are

not compensated separately, no conclusions can be drawn if this changes or influences the implementation costs for a software.

Another main factor is the existing IT structure of the training facilities. Every new system integration poses challenges to the IT administrators of an educational facility. Frequently, the complex licensing requirements of proprietary systems with software or hardware protection (dongle) cause additional work and expense, which is very close to the frequently needed step-by-step installation of different libraries and software modules for open source solutions.

But the selection of the operating system should be mentioned specifically from the point of view of the IT administrators. In none of the courses an open source operating system (Linux) could be installed on the desktop PCs as they could not bear the additionally required IT administration. It is not possible to discuss this subject matter here and also not necessary, as only Microsoft Windows-based software solutions have been selected for the survey.

After discussing the cost factors for the implementation of a software solution, the second main part from the view of the institutions will be discussed, that is the functional complexity of each software. This involves the problem to which extent the functional complexity is sufficient for solving the general and more complex tasks within the different application areas.

As for the examined environmental field, this contains, for example, complex spatial analyses with manifold intersection and geoprocessing operations, the processing and interpretation of remote sensing images, the visualization and further processing of digital terrain models or the integration of models and simulations. It must be mentioned that such comprehensive functions are also limited in proprietary software, where sometimes additional extensions are only available with additional costs. This problem will be discussed later on as it is also very important from the viewpoint of the students.

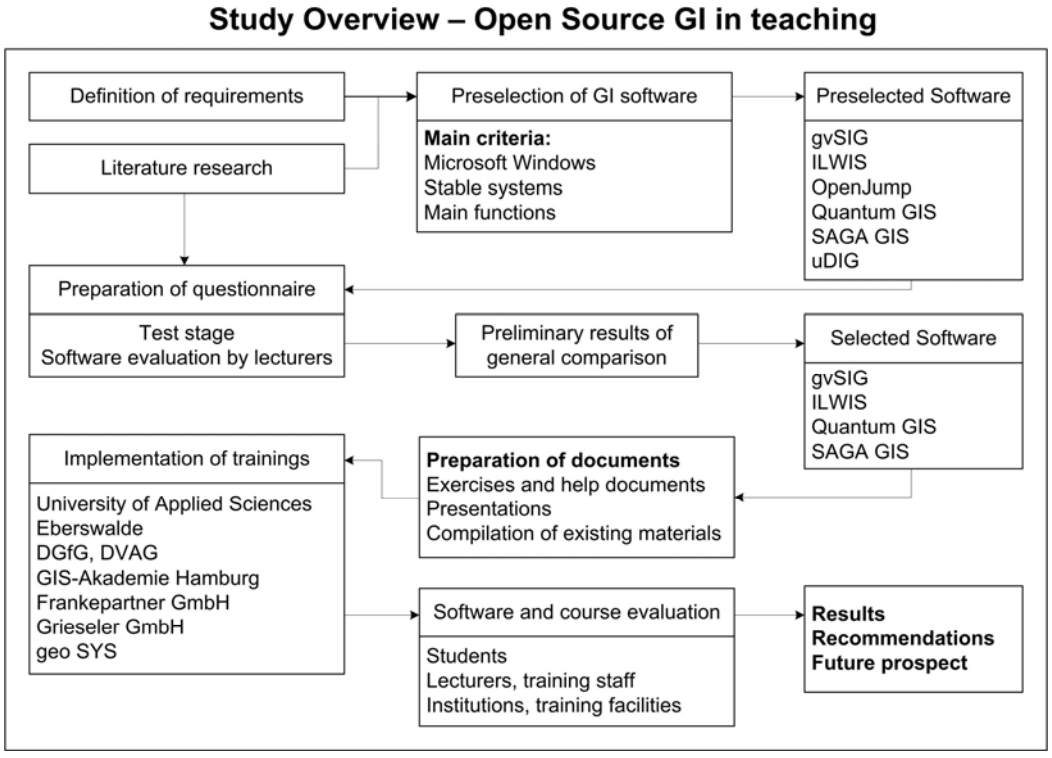

Figure 1. Study overview

From the view of the lecturer the analyzed open source GI solutions have an overall functional deficiency compared to proprietary GIS, which can be compensated or even expanded by using different open source solutions for one task. This is a remarkable fact as it was assumed in the run-up to the survey that open source solutions would not have such a functional complexity. Especially with regard to complex modeling and simulations open source solutions are on a par with or even superior to proprietary systems. An overview about the tested solutions will be given in the next section.

From the perspective of the lecturer there are more relevant features that become more important for complex problems and tasks. With regard to the common limited resources of software licenses and existing hardware in the computer pools there is a great advantage of free GI software in the possibility of using any number of licenses; in addition, the lecturers may assign exercises that can be solved by the students independently at home without overstraining the resources of the training facility. This not only increases the possible exercise time for learning the software but also compensates structural deficits within the teaching services.

The use of multiple GI solutions – as sometimes necessary to answer complex questions with free applications - has the particular advantage that the students are concerned with different user interfaces, geo-data structures and functions. This will lead to a much better overview of GIS and the required methods and will facilitate the preparation time for learning new systems, a factor that is important for the students as well as for the lecturers.

Furthermore there are advantages concerning the possibilities to adapt and enhance a system because of the accessible source code in free GI software, which should be mentioned although this is normally not part of the general teaching. A step-by-step adaptation of the software according to the student's standard of knowledge might be a possible and interesting education method.

The availability of material, documents, sample data, web forums and even exercises for the use in education are additional questions that come up while implementing new software. This is also important for the students, especially for independent training. It can be stated that all of the analyzed solutions met the given demands. An explanation about that will be given in the next section.

If we turn to the student's requirements that certainly correspond with some of the facilities' requirements, we also find aspects of particular concern for students. This includes all problems concerning the different application areas but also the wish to learn about a software that can be used in one's future career. This is a logical wish although it contains some risks. The majority of GI software solutions in companies and authorities are proprietary solutions of the main producers. This corresponds with the GI knowledge of applicants required by companies, as different studies have revealed. In this regard the knowledge of these systems seems to be quite useful. The existing risk here is that the students in this way learn and use only a single GI solution without having any overview of other systems. A reorientation seems to be much more difficult for these students than for those who have worked with different systems in order to be able to use all required functions.

Especially in the environmental field with its complex problems this factor cannot be denied as in many cases even proprietary systems need to purchase extensions to solve complex problems. Universities or training facilities may often provide all extensions of a proprietary software because of sometimes easy and cheap licensing structures for academic institutions. This is in marked contrast to companies and authorities, where high costs for additional extensions can be eliminated. In this case other possibilities have to be found to solve such complex problems. This is a main advantage of free GI solutions and has been confirmed by almost every interviewed student.
From an occupational perspective the students would prefer a combination or mixture of proprietary and free GI software. Because of an increasing flexibility the main focus might be placed on free GI software with the benefit of reducing initial skill adaptation training, as every student can install and use the software everywhere.

Training Facilities / IT administrators
acquisition costs
implementation expenses and maintenance of the software
licensing structures, copyright
systems installation and integration, compatibility
Lecturers / Training Staff
functional range and extensibility of functions
necessary effort for learning of software, skill enhancement
documentation, test data
creation of documents, exercises, presentations etc.
Students
necessary effort for learning of software, skill enhancement
documentation, test data
complexity, deviation from standard software
orientation to employment market

Figure 2: Software requirements from different perspectives

In view of the results of these interviews, carried out after a 2- to 10-day open source GI training, it appears amazing that none of the academic institutions or training facilities had worked with free software before. But most of the students had had experience with proprietary solutions.
Finally there is the demand for a comprehensive documentation and help from the perspective of the students, particularly in regard to an independent learning of a software. All of the evaluated open source GI solutions were found entirely sufficient according to materials or online help, web forums or mailing lists, although they often did not have the same complexity as comparable proprietary solutions.
To sum up, different perspectives lead to manifold requirements for the use of open source GI software for education. All solutions are perceived as having a high potential for education especially for the combined use of functions. Specific fields will gain advantages by using free systems instead of using proprietary software solutions exclusively.

Free GI software – functions and features

Within the scope of evaluation of the possible use of free GI software for education all suitable software solutions were selected by comparing their different functions and features and evaluated on the basis of a list of questions. The suitable desktop GI solutions had to be executable with Microsoft Windows, as this was the only operating system used in all educational facilities. Besides that the solutions had to have a minimum number of basic GIS functions such as digitizing, editing, geoprocessing and layout or map functions respectively.

The functional requirements for the lecturers and their different specializations were defined afterwards in a survey that also included an evaluation of the software solutions concerning their suitability for particular problems. The analysis was based on numerous training courses in open source GI solutions at universities, colleges and further education facilities.

An extract of the list of criteria e.g. contained:

- robustness with regard to user errors / handling
- easy installation
- good documentation / activity of forums
- development cycles
- availability of basic functions

Furthermore, the additional functionalities were evaluated in their usage with regard to complex questions. These included raster analysis, 3D modeling and other specific functions such as hydrological or geomorphological analyses.

By means of these criteria a selection of systems with basic functions and such with additional functions could be selected rapidly.

Because of their development potential, their wide distribution, very active forums and especially because of their functional volume the software solutions Quantum GIS, gvSIG, SAGA GIS and ILWIS were selected and examined concerning their applicability and the already mentioned requirements for educational use. According to the additional functionalities further solutions were used.

Especially for complex questions the individual software solutions were not sufficient on their own. Instead of this, complex questions could be solved by combining different systems. The two last mentioned solutions could be highlighted because of their comprehensive raster functionalities. The use of ESRI-Shapefiles for vector data was supported in almost every analyzed system, and most of the systems supported different raster formats, so that the conversion effort for the combined usage of different systems could be minimized.

Noteworthy and therefore very positive was the availability of extensive interfaces to databases and OGC web services, an availability that was contrasted clearly against the restricted possibilities of proprietary GI software.

Without going into details it can be pointed out that all of the evaluated solutions could emphasize their applicability for educational use. This could be affirmed in the final evaluation by all of the lecturers and students. For further particulars please refer to the already mentioned survey.

Conclusion

The use of free GI software in education was proven to be sufficient to solve the preliminarily defined requirements and questions in the ecological field, as pointed out in the presented survey. Even extensive and complex tasks could be handled, although, in some cases, this could not be done with a single software solution but through the interaction of different applications. In this regard the proprietary software that was used in the educational and further training facilities could be avoided completely.

In terms of its various functions the selection of a particular system should be dependent on the areas of usage and therefore on the expected complexity of the requirements. The students are advised to use free and open source GI software to obtain a general idea about different systems and the comprehensive methods that are used in research and scientific projects. The students will obtain much more flexibility for their professional careers by using OS software - as its use can be also assured beyond the academic institutions.

Free software has been established within the past years and has also become a trendsetting option in the GI market. Its enormous potential for education and teaching need only be used in training institutions to a greater extent. In times of decreasing public funds for educational institutions and universities and the transition to flexible regional and global working conditions, the use of free and open source software is an excellent way to look ahead for educational institutions and for students.

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