Real Experience in GIScience Teaching Aid using GIS Open-Source Software

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Abstract
Empirically, Geographic information System (GISs) and Geographic information science: (GIScience or GISci) teachings in geography as well as environmental sciences are usually depended on certain solutions designed around from proprietary GIS software packages. This has formally been an origin of new legally technical superior software derived from original one with respect to new solutions with better functionality or user friendly interfaces that the graduates who can deal with these particular Geographic Information System (GIS) software products (or the widely used one) well are demanded by most industries. Furthermore, widely adopted web-based GIS and mapping applications today still require advance skill users in considering and evaluating the new sets of GIS software products. Thus, the appropriate GIScience teaching aids are currently necessary to the courses. However, many efforts to develop and improve desktop GIS free software products over the past decade look shorter than user needs. To obtain suitable teaching media or tools, several free GIS software were evaluated for functionality, licenses, and organizational aspect in project development. The software beneficial contexts as well as strength and weakness of free GIS software uses were also discussed in this article.

1. Introduction

In the past, teaching Geographic information science: (GIScience or GISci), often designed by using Geographic Information System (GIS) software is proprietary. During the past ten years there has been a collaborative effort to develop and improve the free software called Free GIS Software (FGISS) by developing in both the desktop and the Internet. Currently, the FGISS has been used extensively in teaching. From the educational perspective, many current approaches existed in student instructions such as peer response groups (Walvoord, 1986, Ginott and Haim, 1993 and Freiberg and Jerome, 1996) collaborative learning (Davis, 2001, Hart, 2005 and Education and Inspections Act, 2006), and alternative perspectives (Grasha, 1990) are all regularly parallel elements of open source approaches. Such open source solutions including their built upon philosophies play the important roles in being metaphors and methods that provide students practically alternative ways in collaborating and learning. The needs of FGISS teaching software products are subsequently increased not by the functionality and usability evaluation only, but as reasons of their benefits and limitations emerged from open software licenses also. With these points of view, this article thus attempts to answer the following questions: (1) can proprietary software be instead with FGISS in GISci teaching? (three elements of GISci, shown in Figure 1) and (2) what are the advantage and disadvantage of using free software in such teaching?

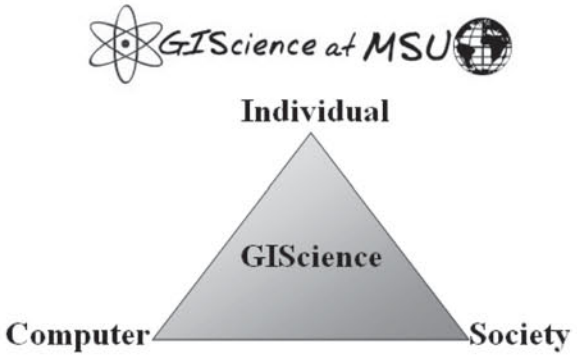

Figure1: The three elements of GIScience

2. What Free Software Actually is?

Concept of "what free software actually is?" is always confused. The term "free", as used here, does not mean "free-of-cost", but it means independence are granted to the user with the software license. These independence include the right to (1) run the program for any purposes (e.g. educational or business uses); (2) study the program; (3) freely copy and distribute the program; and (4) modify the program, and distribute the modified version (see the Free Software Foundation webpage: FSF.org). Note that the independence

does not prohibit even selling the programs. Hence, the opposite of "free software" is "not for further commercial-purpose software" and "software for the proprietary only", which stresses ownership. Typical free software licenses such as the GNU, LGPL, Mozilla, Apache, MIT-style and BSD-style licenses grant all these four independence.

3. Requirements Software for GISci Teaching

3.1 Case Studies

Several articles have tried to compare the FGISS either against other FGISS or against proprietary software. In particular, Donelly (2010) evaluated FGISS for the map creations within a library environment. He concluded, based on the comparison done in 2008 context, that free desktop GISs were weaker, compared to ArcGISs, with respected to projection and coordinating system supports, joining tables and labelling. Wood (2008); Steiniger and Bocher (2009) discussed the states of free desktop GIS and outlined its utility for GI-Science research in comparison to the proprietary software. Grohmann (2004); Conrad (2007); Brenning, (2008); Hengl et al., (2009) compared the free desktop GIS, GRASS and SAGA for automated elevation data analysis while Jolma et al., (2008) and Steiniger and Hay (2009) analyzed and compared FGISS used in the environmental sciences. Our analysis based upon undergraduate program such as B.Sc., B.Eng., of applied geoinformatics courses at the faculty of science, mahasarakham university, Thailand. In two courses engaged with lectures and exercises covering introductory and advanced GISci topics for 2nd and 3rd year students, representing the GISci I and GISci II. The third and forth courses (GISci III, GISci IV) engaged with a GISci project I and GISci project II courses in which one person or group (two person) of 4th year students were assigned with a basic web GIS implementation such as UMN map server (GISci project I in first term). The GISci project II (second term) the 4th year students course were assigned with Map mashups, Web 2.0 and the GIS revolution.

3.2 Software Requirement

For the above fourth courses, the following data were analyzed:

- The course setting such as infrastructure: to describe general limitations with respect to course administration etc;
- General course objectives: to define software features (e.g. license, usability, customizability, etc.) that support the teaching, and
- The course comfortable with respect to lecture and tutorial topics: to get hold of data about required software usefully. The results of our study, i.e., GIS software requirement, were presented in Figure 2.

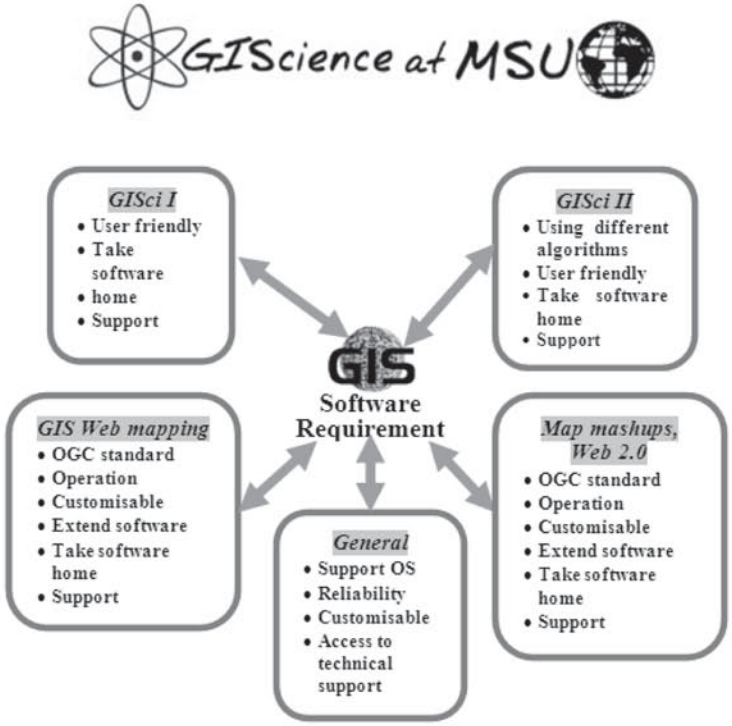

Figure 2: Illustration software requirements for chosen GISci courses

4. Software Analyzing Results

To decision for proper teaching aid software used in the teaching, several free GIS software were evaluated according to their functionalities. The desktop GIS software was used for the GISci I and II courses whereas the GISci group project required several types of software to build a web GIS system. The functional assessment of the desktop GIS included the proprietary software, ArcGIS as the software was currently provided by the university and generally used for all GIS educations. Table 1 presents the results from three free desktop (GI-System: GISs) based on space restrictions. Other software that met the functional needs might be including: gvSIG through the Sextante Toolbox, and SAGA (Steiniger and Bocher 2009, Hengl et al., 2009). For the GIS web mapping project, the detailed functionality assessment was not presented here, but the software which discovered the needed functionality were listed in Table 1.

5. Considering by using FGISS in Teaching

5.1 Advantage

At least three software-concerning points were analyzed in undergraduate GISci teaching with free software assistance: 1) software functionality & features, (2) the software license, and (3) organizational aspects of a software project. Under such conditions, the qualified free software which was able to use in web mapping group project were listed in Table 2.

Table 1: Software functionality assessment in GISci I and GISci II courses teaching

Function	Course Level	ArcGIS	GRASS	QGIS	OpenJ	Function	Course Level	ArcGIS	GRASS	QGIS	
Raster/vector data	I	A	A	A	A	Carto Projections	I	A	A	A	C
Create a map	I	A	A	A	C	Vector-to-raster	I	A	A	F	E
Query attributes	I	A	A	A	A	Raster resampling	II	B	A	F	E
Query distance	I	A	A	A	A	Reclassify	I	B	A	F	E
Edit attributes	I	A	A	A	A	Landscape indices	I	C	A	-	E
Table/txt joins	I	A	A	A	A	Thiessen polygons	I	C	A	F	A
Basic statistics	I	A	A	A	C	Slope	I	C	A	F	E
Thematic maps	I	A	A	A	C	Contouring	I	C	A	F	E
Polygon overlay	I	A	A	F	A	Curvature	II	C	A	F	E
Zonal statistics	I	B	A	F	A	Flow direction	II	C	A	F	E
Map algebra	I	B	A	F	E	Flow accumulation	II	C	A	F	E
Multi-Criteria-Eval	I	B	C	-	E	Watershed	II	C	A	F	E
Sliver removal	II	B	A	F	-	Compound indices	II	-	A	F	E
Geom. Union	II	A	A	A	A	Viewshed	II	C	A	F	E
Geom. QA/cleaning	II	A	A	A	A	Hillshade	II	C	A	F	E
I:IDW	I	B	A	A	E	Profile graph	II	C	A	-	E
I:Spline	II	B	A	F	-	Extract raster vals	II	C	A	F	E
I:Contours to DEM	II	B	A	F	-	Fuzzy sets	II	B	C	-	E
I:Kriging	II	B	D	-	E	Change matrix	II	-	A	F	-
Geo-referencing	I	A	A	A	E	SQL	II	A	A	A	A
Metadata editing	II	A	-	-	-	Scripting/Modeller	II	A	A	A	A

A= Functionality provided, B= functionality provided with ArcGIS not with ArcView,
C= Separate plug in/extension, D= GRASS, E: OpenJUMP with Sextante Toolbox
F: QGIS with GRASS Toolbox

Table 2: Free software that can be used for the web mapping project

Software type	Objective	Software
GIS Web map server	Create & service map	UMN MapServer, GeoServer, etc.etc.
Spatial DBMS	Input data	MySQL, PostgreSQL
Development Frameworks	Scripting/programming environment	jQuery, AJAX, etc.
Web map development	Functionality for user interface	OpenLayers, GeoExt, GeoMoose, Suas, etc.
Desktop GIS	Editing/preparation	QGIS, GRASS, OpenJUMP, MapWindow etc.
Map mashups, GIS Web 2	Web service mapping	Google Map and Flickr mashups, etc.

Firstly, for the software functions and features point of view, it can be seen from results in Section 4 that the evaluated software, Quantum GIS: QGIS with the GRASS toolbox and OpenJUMP with the Sextante toolbox, can fulfill almost all functional requirements for the GISci I and II courses. In addition, it is appeared that several free software solutions for the web GIS projects can also be used under the given conditions. Other positive pedagogical points include: (1) benefit from different algorithms for the same function (e.g. several slope algorithms in Sextante) that allows students to compare results from different methodologies easily, (2) most desktop GISs are customizable and allow various scripting supports, (3) the user interfaces are more user friendly, and (4) the FGISS often support a range of OGC standards, allowing interoperability among components in web mapping system. Secondly, for the software license point of view, advantages emerge from the free software licenses include: (1) the software can be taken home, (2) the students can reach their source code to learn any technical algorithm, structure, and process flow, (3) the software are freely modifiable, and (4) their acquisition are often free-of-costs. Finally, for the organizational aspects point of view, various free-of-cost and in-time supports of FGISS can be obtained by email and internet forums. Moreover, many hotline supports and training courses are also available.

5.2 Disadvantage

Before adopting FGISS in teaching, there are some points that the instructors should be aware of: (1) not all functionalities needed for demonstrating certain GISci concepts are available in single desktop solution without the aid of additional plugins, (2) the quality of software documentation, i.e. user manuals, varies among projects and its publication may possibly not match software releases, (3) similar to proprietary software, free software can also possesses associated indirect costs, such as the cost for switching to free software, the cost for training staff, and any maintenance costs. Other points that are not directly related to the software itself may also be important, but are not necessarily weaknesses of free software. For example: (1) ArcGIS employs different terminologies from one that used by common GIS standards such as OGCs Simple Features Specification – particularly in overlay functions. (2) There is generally lack of marketing for free software. That is, a user needs to follow software upgrading information by oneself, etc. (3) Finally, it is still unclear whether the industries welcome the students trained with free software (for instance, with ArcGIS) or not. Although it is noted here that, according to our experience, GIS user companies show much strong interest in FGISS uses. Further miscellaneous points about options and threats can also be found beyond the use of FGISS in teaching but are discarded because of space limitation.

6. Conclusions

With respect to the use of FGISS in teaching, it is believed that free software have achieved a level of maturity that enables them to replace proprietary desktop GIS software in GISci I and II level courses teaching. The reviewed software projects appear to be stable and reliable; nevertheless for other software projects, one should think about the development of the project before implementation. With respect to course projects focused on web GIS development, no strong proprietary that is alternative to using the free software are seen. It is found from evaluation that the free web GIS solutions are normally more agile in their abilities to adopt new web technologies and standards. In addition, when focusing on a web GIS development

project, an instructor who uses open source software would be able to extend projects from a single term to many terms so that the projects can be built and incrementally developed from term to term. This would enable students to perceive themselves as a part in larger work scope rather than only carry out of one project.

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