Objectives of GIS Teaching in Higher Education: developing experts or training teachers?

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Abstract

Subjects taught in elementary, secondary and vocational schools are covered by two, more or less, separate programs dtin higher education. One of them aims to educate experts while the other one provides for regular teacher training. The natural "development" of a subject within higher education is that the "experts-only" program should be extended to teacher training when a new social need appears (e.g. recently in computer science). In our global age this process has accelerated remarkably and the relevant decision-makers have a hard time to identify and respond properly to new, rapidly increasing needs. In the case of new developments, the following key questions need to be answered:
1/ ***when*** *to introduce the subject to the general education?*
2/ ***who*** *will do it?*
3/ ***what*** *they will teach?*

As a relative "newcomer" in higher education, GIS is still mainly at the "for experts-only" stage within subjects such as geodesy, geography, environment, geology and civil engineering. GIS is mainly absent from most teacher training courses, though there are some excellent individual initiatives to apply GIS as an educational tool in secondary education (e.g. internet site of teaching history with GIS – www.library.thinkquest.org) there remains no concerted program yet to teach GIS as a subject to teachers.
This chapter reports on a survey conducted in secondary schools with the conclusion that teachers have recognised the need to use GIS as an educational tool and they would be willing to integrate it in their teaching program. Although the institutions have the necessary technical background, they lack the teachers who are trained to be able to use and teach GIS. Therefore higher education faces two challenges
1/ to establish continuing in-service educational programs for secondary school teachers (geography, history, information) on the application of GIS as a new teaching tool and subject; and
2/ to integrate this knowledge in the curriculum of relevant undergraduate programs.
In the paper the likely content and methodology of such a program is discussed with a specific focus on the following questions:
What subjects should be included in the curriculum? What level these subjects should be taught?

1. Introduction

The range of ordinary intellectual and practical activities is extended from day to day due to the rapid developments in digital technology. For example, complex navigation in permanently changing city traffic, with complicated interchanges and foreign road networks has already become a part of our everyday brainwork. Standard routine activities are already encompassing the use of geoinformation like that forming part of the navigation system of recently manufactured cars.

Many popular PC applications support everyday activities such as writing, drawing, calculation and data organisation. It is clearly reflected in the composition and content of most widespread application program packages. The development of basic skills is the foundation of most computer-based courses in elementary and secondary education. There are three main reasons, which support this:

1. everyday intellectual activities are supported by the software programs;
2. several relevant and elaborate teaching methods and materials have been developed and are available;
3. the generic software package is applied in almost every workplace.

According to a study conducted in 1986 known as the First National Assessment of History and Literature in US, students appear to have extremely low recollection of the history taught in school (library.thinkquest.org/COO628/index1.html). While students only correctly answered 54% of all history questions, they were able to correctly answer 71.3% of questions related to maps and geography. This suggests that these students were more comfortable with questions of a geographic nature.

GIS is the obvious means to relate several subjects to maps (Barron, Daniel D. 1995; Alibrandi, Marsha. 1997). However this 'obvious means' can be applied

by teachers possessing the 'know-how' of application of GIS in education. The key question here is the knowledge of teachers because the schools have the necessary technical background and the students are happy to apply computers as educational means. Several studies confirm the basic elements of GIS (like information gathering, organization and representation of information and using them for supporting decision-making) are easily adapted by high school students if they have proper guiding (Broda, H. and R. Baxter, 2003; Carlstrom, Dick., & Ouinlan, Laurie A. 1997; Baker, T. and S. White. 2003; Wigglesworth, J. 2003).

The modern navigational technology (GPS combined with GIS) appears in the everyday life (mobile phones, common cars). It is an other important argument that GIS must appear in the general education alongside topics like literacy, numeracy and computer skills etc. cars Beside the educational application

If geoinformational skills and competences are needed by society (Harb, E. 2002.), then the following questions need to be answered: What will be introduced, by whom and when?

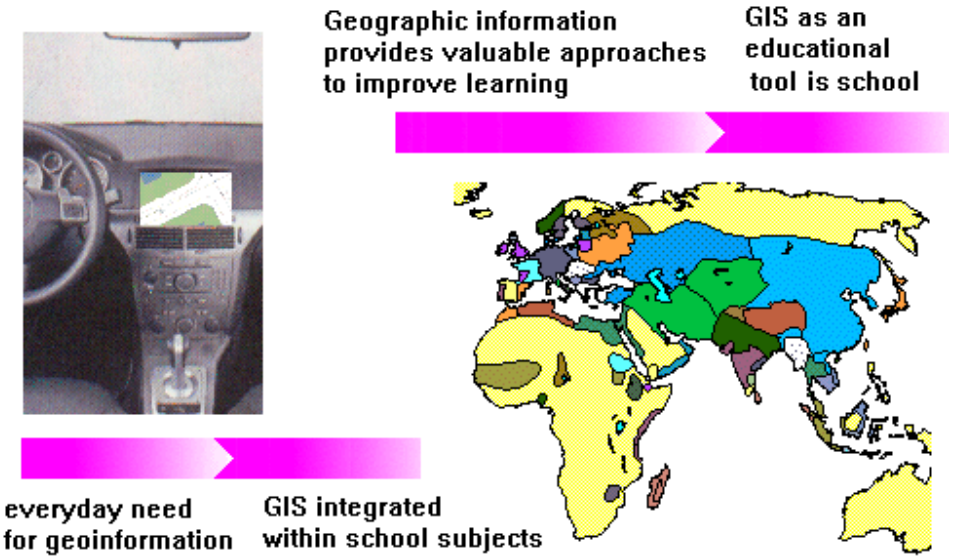

Figure 1. Introducing GIS to general education as a new subject and innovative teaching tool

Generally the timing of the introduction of a subject to general education is one of the most frequently debated issues (Lloyd, W. 2001; Broda, H. and R. Baxter 2003). According to authors the proper time arrives when a large part of society needs the new knowledge. A debated issue is then the identification of social needs – particularly the extent of a demand. There is no standard method to size it up therefore one should rely on a mixture of relevant objective signals and the subjective estimation of the experts. Based on the mentioned factors (navigation, map-associated teaching) and opinions of educators, we believe that there is a strong need for a basic knowledge on GIS. Sticking to facts: 82 % of high school students have mobile phone and they expect new services (Internet, navigation, picture and video transfer etc. Finczicki B. 2004). The car dealers ofer GPS-GIS based navigation system almost to each new model and several of them have it as standard accessory. (Csikos Zs. 2004)

While the background to using computers in subject disciplines is available in schools, the introduction and possible integration of GIS applications and the resultant ideas and approaches faces the following difficulties:

- there is relatively little motivation either from the curriculum or from the schools for change
- there are few teachers who are able to teach with GIS or to use it as an educational tool;
- there is little teaching material widely available where GIS can be used for general educational purposes
- suitable software and hardware are not always available or accessible

It is therefore the role of higher education institutions to support the introduction and development of GIS by researching and identifying the social and economic needs for the use of geoinformation in society and to prepare activities and programmes that will prepare teachers, educators, schools and parents for the introduction and

development of GIS as a core component of general secondary education.

2. GIS in secondary schools – survey

The University of Miskolc has been involved in research to examine the perceived role and value of GIS in secondary education. The survey sought to combine two main tasks, namely to estimate the perceived need for GIS and the preparation needed for it to be developed in secondary school education. The original hypothesis was that a GIS' program for teachers needs to be developed as initially as part of a continuing education program, due to fact that it is the fastest way to "produce" trained teachers for a new subject and to ensure that the elder generation is not "left behind" as a result of technological developments.

Data of person completing the form	**Male/Female**	**Age**	**Subject**
Data of school of person completing the form	**Number of students**	**Number of teachers**	**Have you Computer Lab.**

Use of GIS in school *tick where it is proper*	**Yes, I use GIS as**	**No, I do not use GIS because**
	☐ **teaching tool**	☐ **I do not know GIS**
	☐ **subject to teach**	☐ **we do not have GIS**

Intention of use of GIS *tick where it is proper*	**Do you want to use GIS in your work ?**
	☐ **Yes, I do**
	☐ **I should learn more on GIS**
	☐ **No, I do not want to use**

Continuing Education *tick where it is proper*	**Would you like to take part in a continuing education program on GIS?**
	☐ **Yes, I would**
	☐ **No, I would not**

Fig. 2. Questionnaire for secondary school teachers on GIS

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A questionnaire was developed for relevant educational officers and secondary school teachers of information technology, geography, economics and history to complete in order to assess their consideration of the potential for GIS. The study assumed that their answers would also be a reflection of the likely social needs concerning whether the teachers wanted to introduce GIS into general education. The questionnaire was distributed via post or completed by us using phone interviews. So far we have conducted about 70 interviews in 20 schools and 2 countries (Hungary and Greece)

As a result of this pilot survey, some initial conclusions can be drawn which may provide an insight into wider European issues. The main points that arose were::

- *every* school surveyed has its own computer laboratory;
- half of economics and history teachers did not know about GIS, but every information technology and geography teacher knew about it;

- only approximately 5% of teachers had GIS in their school, only half of these teachers used it as an educational tool, but none of them teaches GIS;
- almost all those who knew about GIS wanted to use it in their work and would participate in a continuing education program;
- teachers who did not know about GIS would like to learn more about it;
- *nobody* opposed the introduction of GIS to secondary education.

These preliminary results encouraged further research and other developments, including a number of information events (a conference, exhibition and workshop) on GIS for secondary school teachers and to begin to prepare a continuing education program on GIS for teachers.

3. GIS in higher education

Geo-information is taught at the Faculty of Earth Sciences and Engineering in Miskolc University as independent subject for geophysicists, miners, hydrologists and environmental engineers and as a specialised program for general geo-engineers.

These courses are intended to be for specific groups of experts. The overall program covers the following topics:

- information basics with an emphasis on data-base management;
- acquiring geo-data with an emphasis on remote-sensing and photogrammetry;
- basics of geodesy, cartography and thematic mapping;
- GIS' types and elements of GIS;
- Geo-objects and geo-modelling.

The courses are complemented by information technology topics (such as computer hardware, operating systems, computing, programming, software engineering) and introductory lectures and exercises on specific GIS programs like Geomedia, ArcInfo and GRASS as part of the specialised program.

On analysis it is clear that this type of 'expert' curriculum could not be used as part of a continuing education program for history, economics, geography or even information technology teachers. The expert curriculum described here is rather 'typical' of those that have developed in European Universities; therefore it might be implied that as yet there is no higher education expert curriculum for teachers on the use of GIS. The remainder of this chapter therefore seeks to contribute to a possible elaboration of this curriculum and to suggest some of the associated teaching materials which might be required.

4. GIS for teachers – continuing education

The curriculum developed for the continuing professional development for teachers on GIS might be composed of four main topics:

1. Computer basics (hardware and software);
2. Geodesy and Cartography;
3. Elements of GIS;
4. GIS applications.

The knowledge and interest of the target audience is likely to be very varied. A joint course on computer hardware and software for teachers of history, and geography for example, as well as for information technology teachers is very difficult even to imagine. However, a solution to this is likely to be in trying to identifying common elements or approaches in the needs of the participants and then to introduce flexibility in the applications and development of different types of material that can be more or less directly implemented or easily adapted for use in secondary school classrooms. **With other words, the level is for high school students, focusing to didactical issues**. Such a course would have the advantage in that it provides a directly usable knowledge base for teachers of humanities subjects, and it is a good methodological training for teachers of information technology.

Under this approach, some content for computer basics might be recommended:

- Principal Operation of Computers;
- Components of Computers (Motherboard, Chipsets, Processors, Interfaces, Memory);
- Data Storages (FD,HDD, CD-R/CD-RW,DVD);
- Input Output (KB, Monitor, Mouse, Scanner, Printers);
- Multimedia (Graphic&Sound Cards, Cameras, Video);
- Communications (Networking, Internet);
- Basic Softwares (Op.systems, Applications);
- Programming Basics (Algorithm, Programming Languages, HTML, Javascript)

You can get a basic idea of the style and level of our textbook from the following eBooks on Internet:

Anderson: www.pctechguide.com
O'Sullivan: www.htmlcodetutorial.com

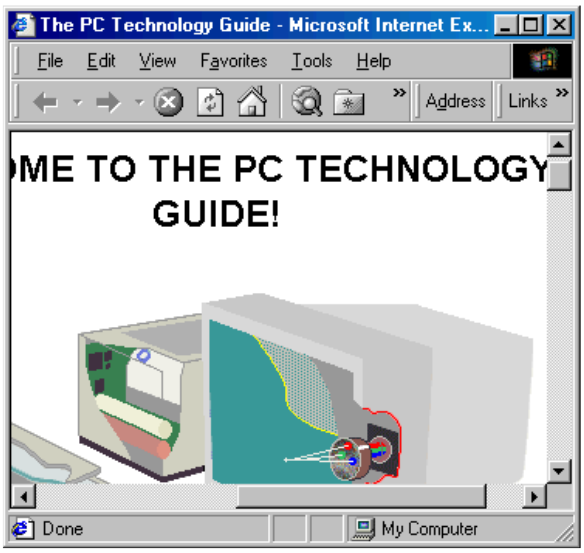

Fig. 3. Anderson: PC Technology Guide www.pctechguide.com

The difference in pre-education is remarkable between geography and other teachers in case of Geodesy and Cartography. To develop the content of the subject we follow our concept – to teach a material that can be directly taught in the school:

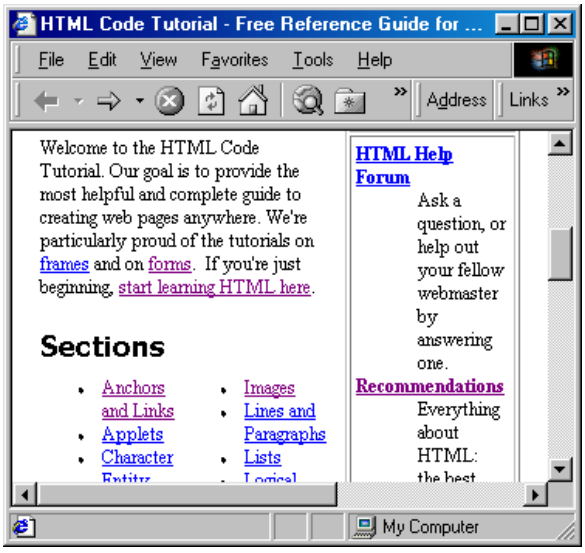

Fig. 4. O'Sullivan:HTML Code Tutorial www.htmlcodetutorial.com

- Figure of the Earth (History, Geometrical and Physical approach, Ellipsoid and Geoid);
- Coordinate systems (Astronomical,Terrestrial, Topologic systems, Geodetic Datums);
- Geodetic Methods (Classic and Satellite Geodesy, Remote Sensing, Photogrammetry)
- Geometrical Projections, Mapping, UTM.

Fig. 5. Quest Geo-Solution Ltd: Geodesy-Tutorial www.geodetic-solutions.com

The following eBooks are being used as reference materials for our textbook on this subject:

Quest Geo-Solution Ltd: www.geodetic-solutions.com
Burkard at al.: www.nima.mil

The GIS'elements are a new topic for everybody in the program but the pre-education difference between the information teachers and the others requires a completely different treatment. Therefore we follow again the basic concept: to teach a material that can be taught straight in the secondary school. The content of

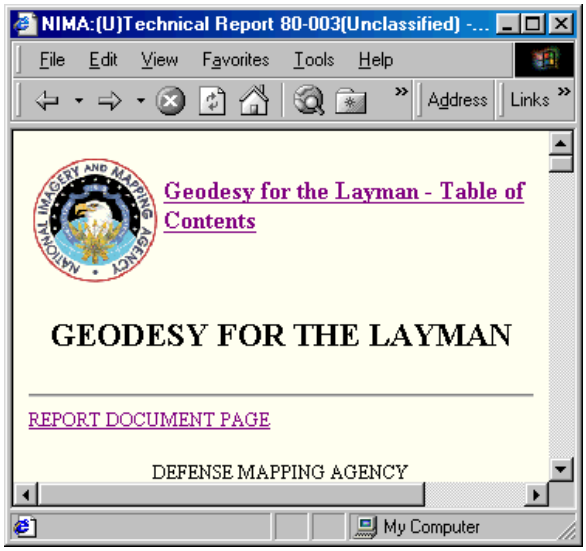

Fig. 6. Burkard at al. Geodesy for the layman www.htmlcodetutorial.com

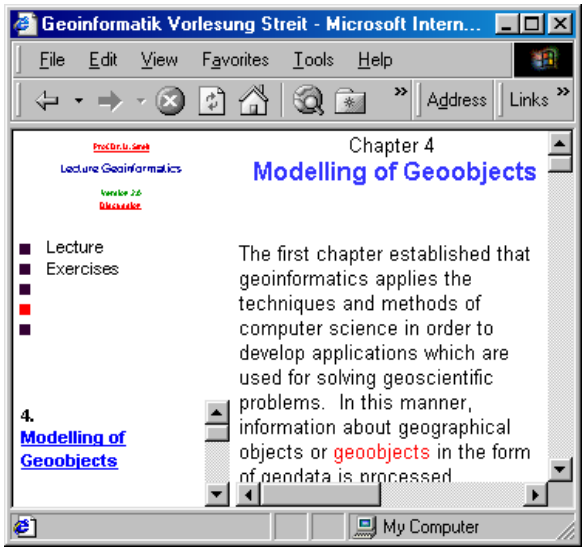

Fig. 7. Streit: Introduction to Geoinformatics www.kermit.uni-muenster.de

the subject is planned as follows:

- Digitalization and Digital Mapping
- Image Processing
- Geo-data, Geo-objects, Geo-modelling
- Data-visualization
- Topographic and Spatial Analysis

The most characteristic reference materials we have been using for the textbook on the subject include:

Streit: www.kermit.uni-muenster.de
Itami – Raulings: www.dlsr.com.au

We consider the subject called GIS application as the most important one. The content and the textbook of the subject is mainly our work – we used very few references. The basic idea is that the practical use of a GIS program package is taught within the framework of real GIS projects. The projects can be easily transformed to other GIS projects - e.g. producing supporting materials for teaching – that can be carried out by the teachers themselves. Recently, we work to incorporate 3 projects in the curriculum of this subject:

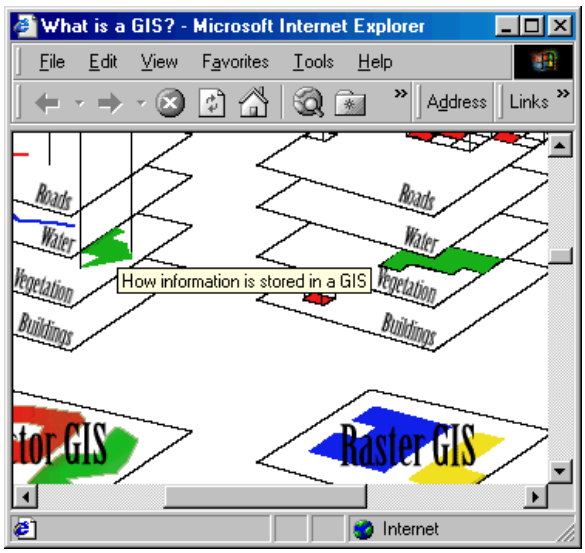

Fig. 8. Itami – Raulings: What is GIS? www.dlsr.com.au

- GIS for history

The project in raster layers contains the map of Hungary in different historical periods. The layers can be visualized separately or together to trace the historical events on the changing shape of the country.

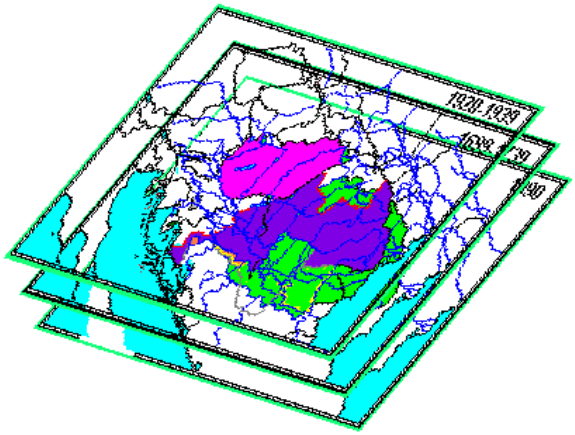

Fig.9. Hungary throughout the history

- GIS for economy

The project shows the units of an imaginary super-market chain in Hungary. The country is divided into districts by the program for supervision. All districts have about the same proportion of workers and building areas. The program is able to visualize the stock and consumption of certain goods to support the supply and marketing decisions of the company.

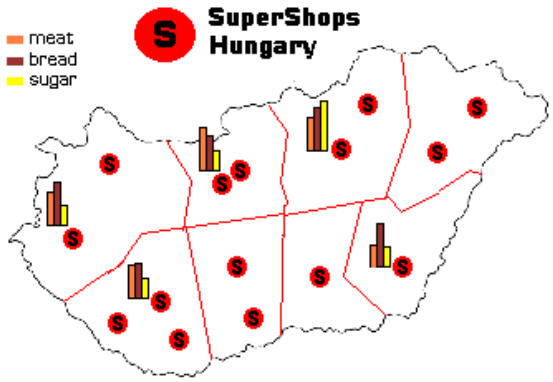

Fig.10. SuperShops chain in Hungary

- GIS for navigation

The project aims to plan the optimal route of a vehicle that starts from the parking house (P) and should reach the destination **1**, **2** and **3**. The first layer is an ordinary map with the starting points and the nodal points of the mission. The second layer contains the traffic directions of the roads, while the third, fourth, and fifth layers show the traffic load on them in the morning, afternoon and evening periods. The program should give the optimal routes

*Fig.11. Optimal route from **P** to point **3** via points **1,2***

taking into consideration the one-way streets and the traffic load. We are planning to establish a similar project on countryside roads where the topologic information should be taken into consideration for the planning of the optimal route.

The projects provide for a guideline and an exciting framework for the students to acquire the practical knowledge on a GIS package, especially the following operations :

- transforming graphic file to raster, vector file;
- providing for graphical input by digitalization;
- analyzing thematic and topologic information;
- visualizing results for the support of teaching and economical decisions;

5. Conclusions

We give a report on the project we have been carrying out at our University to establish a continuing

education program for teachers. Within the framework of this project:

- we conducted an investigation among secondary school teachers to size up the need for the course;
- the preliminary results confirm that there is a need to learn GIS, use it as an educational tool and teach it as a new subject;
- we elaborated the draft of a curriculum composed of 4 subjects (Computer Basics, Geodesy Basics, GIS Elements, GIS Applications) on a level and in a form that can be directly taught in secondary schools;
- we described the development of the textbooks on the subjects of the curriculum.

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