Designing a Danish GIS-curriculum for university students – What to prioritize in a beginner's course?

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Abstract

This paper outlines the development of GIS education at Institute of Geography, University of Copenhagen (IGUC) from its initialization in 1988 and ahead. After describing the development of the curriculum from offering only one single specialized course in GIS to creating a separate curriculum for a BSc in Geoinformatics this paper considers the future challenges of GIS teaching:

a. Which topics should be addressed in a beginner's course today when GIS has become an overwhelming piece of integrated software collected from many scientific disciplines?
b. How to introduce these topics the most pedagogic way to new students in the future in order to provide the best consolidation and off-set for further GIS studies?
c. How can ESRI contribute to widen the doorway to enter the world of GIS?

Background

In 1988 IGUC was the first institute to introduce GIS to Danish students, and since then we have played a leading role in this field among Danish universities. Today, five basic courses are offered for undergraduate students in geography and geoinformatics and four graduate courses are considered for kick-off in 2005, hopefully, leading to a new master education in geoinformatics.

The development of the institute's GIS-curriculum has been a great challenge to the staff and students involved and a redesign of the involved resources are continuously ongoing. From a teacher's viewpoint it has been extremely satisfying to watch over the years how many of the institute's candidates have achieved job employments in a wide variety of private companies and governmental institutions nationwide and abroad based on their GIS competences.

So, we may have offered the right range of basic courses during the last sixteen years. Meanwhile, we feel that with the increasing development in ESRI's software on which we have based our education since 1994 it has been more and more difficult to introduce the students to GIS because the software from the teachers' as well as the students' viewpoints is getting more and more monstrous from release to release. The necessity of providing a well-arranged and well-planned pedagogic introduction to GIS is therefore becoming more and more urgent.

IGUC recently met a great challenge when migrating from ArcView 3.3 to ArcGIS 8 encountering some difficulties in achieving an adequate level of understanding among novice students. So: what will be the pedagogic and most efficient pathway with respect to the time and other resources available in future introductions to GIS for newcomers and ahead?

GIS didactics

Didactics is concerned with educational goals, content and media. However, it seems like the idea of studying and discussing didactics seldom has a priority when developing university GIS courses. This may be due to the nature of the universities where the focus often is on 'pure' knowledge rather than the process of learning. Meanwhile, the importance of being concerned with educational goals, content and the media in play must be stressed especially when introducing GIS. If not, the chance of not teaching in an academic way but 'only' how to use software will be against us.

Some might jump to the viewpoint that GIS is (or may become) the magic box that will create modernisation and improve explanations of the old geography school. Biilmann (2001) explains that there is a fear that GIS in these places turns into a convenient tool compensating for lacking knowledge and skills rather than being a tool for enquiry. Bringing GIS into play requires even more attention than on educational goals due to the risk of students getting lost behind the technicalities and eventually missing full understanding of the geographical theories.

While many institutions offer teaching in the technicalities of GIS, far fewer seems to be educating with it. That is, using GIS to teach the geographical disciplines better. At IGUC we have decided to hold the focus on educating geographic information systems and not 'just' providing training in a specific software system. This results in what Unwin (1997a) states as the problematic ´G´ in GIS that has more or less automatically directed the main responsibility for putting GIS into academic geography departments. This responsibility needs to be dealt with very carefully because the need to present students to technical issues more related to computer science is weighty and, in reality, a geography department seldom holds all the required teaching resources (Unwin 1997b).

The consequences of the decision to teach with (and not just about) GIS lead to some important considerations. As the software packages get more and more monstrous we need to cut into the bones of GIS and simply leave some of the more peripheral elements for later courses. The choices are closely connected to the level of skills needed for the further involvement in GIS later in the students' years of education. This is a way of making GIS less dependent upon the speed of software development and has the advantage that the curriculum is somewhat independent of new software releases and thus creating continuity in the curriculum. Facing this we needed to clearly define the pedagogic aspects relative to the aims of teaching, so we knew for sure what we were doing and why. These considerations are very important since almost all concepts of GIS can be dealt with either as a superficial topic or in depth. Unwin (1997b) emphasizes the balance of width against depth as the core of curriculum design.

Throughout the past fifteen years a number of papers concerning GIS teaching have been published (i.e. Kemp 1995, Green 2001 and Alibrandi 2003). However, more or less all literature originates from the US leaving (in our case) our country in a vacuum of knowledge to support our learning traditions. Therefore, nearly all experience concerning teaching of GIS at IGUC are gained the hard way by the involved lecturers on a continuous basis.

The development of GIS education at IGUC.

IGUC introduced its first course in GIS in 1988 based on C.D. Tomlin's and Ohio State University's grid based system named OSU-Map-for-the-PC. In 1991-1993 we swapped to using a combination of Clark Labs grid based IDRISI system and introduced PC ArcInfo primarily as the tool for digitizing of manuscripts. The focus on grid based modelling walked very nicely and hand in hand with our serious involvement into remote sensing/image processing and the development of IGUC's CHIPS software initiated in 1987 (later named WinCHIPS and just recently shut down). Thus, our main reason for changing our software to ArcInfo on a UNIX-platform in 1994 was primarily the access to the newly released GRID module and secondly the access to vector based facilities. Since then we began to introduce ArcView from around rel. 2.1 in 1996 and in 2003 we decided to build our basic GIS teaching upon ArcGIS 8.3.

During our GIS evolution we have been in contact with a variety of operating systems ranging from IBM's VM/SP, DOS, UNIX, Windows 3.11, NT and now XP. Before the students have had experiences with computers in public schools or high schools it was a challenge to introduce them to file and operating system (OS) before (or parallel to) their introduction to GIS. We have always managed to successfully introduce the minimum level of understanding to the OS in quite few hours. However, it has always been a difficult issue for the students to understand the problems of moving and copying coverages and gridfiles using Windows Explorer forgetting the importance of the components stored in common INFO-folders. In this context ArcCatalog has provided a most welcome ?

Anyway, it is notable to mention that the GIS training has moved from approx. 10 years ago being a course for the graduate students in their final phase of their studies only, to become a mandatory course for all new students in geography and geoinformatics from day 1 since year 2002 (see Figure 1).

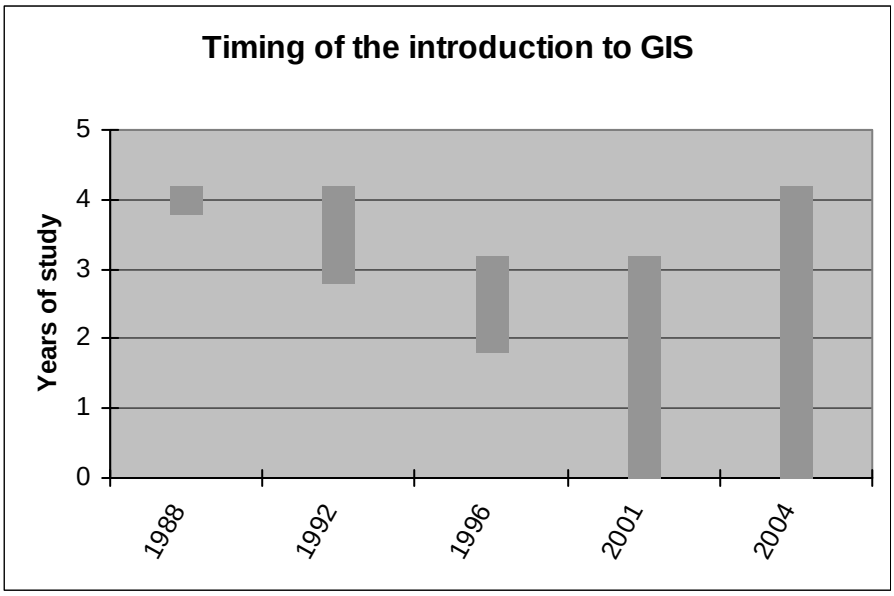

Figure 1 Timing of the introduction to various GIS courses at IGUC.

So, the moment of GIS introduction has become earlier and earlier in the students' period of study partly because

1. The software's user interface (UI) has become more and more user friendly over the years.
2. The software has become available on operating systems familiar to the students from training in public schools, high schools and home computing
3. Being part of an ESRI University Site License agreement it has been negotiated with ESRI and the Danish distributor that the students can have access to GIS software from their home computers.
4. The lecturers have been more and more experienced with the potentials of and training in GIS.

All of the above mentioned preconditions are fundamental to form a successful curriculum. However, although mentioned by others in various ESRI forums the demands to hardware in order to obtain good performance of ESRI components are severe to all but not the least to academic institutions involved in GIS training as they very often lack behind a steady renewal of hardware. Looking back to 1995 when ArcView 2.1 for Windows was introduced it is recalled that demands to an overall good performance was a computer with 16 MB of RAM (although 32 Mb was recommended) and a processor speed of 90MHz. Gasp! Such a configuration was very expensive and when ArcGIS 8 was released in 2000 new gasps where expelled when the minimum hardware capacity was announced to be 650 MHz and 128 MB of RAM (256 MB recommended). Today around ArcGIS 8.3 it is well known that your computer can not be powerful enough and a configuration of 2.7 GHz and 1GB of RAM gives only acceptable performance. Additionally, the demands to a fast graphic processor and a fast bus are very important. Thus, it is clear that the performance of ArcView 3.3 on one of the powerful machines of today is a pleasure. However, from a training viewpoint the focus ought to be based on ArcGIS and its better integration with the operating systems, its updated components and variety of extensions etc. However,

IGUC has not phased out ArcView 3.3 and it will probably take several years, still, as many applications are running most efficiently in this environment and several models created by third party vendors are, yet, not available in the ArcGIS environment.

Present structure focused on GIS and the collaboration with other courses

The present structure of GIS-education at IGUC is based on an idea of integrating GIS into all relevant introductory courses at the institute. The mandatory GIS and Cartography Course (GIS&C) is the very first course the freshman-students attend. The course objective is explicit because it only mentions the use of GIS as a first-hand meeting. So, the GIS&C provides students with knowledge on generic GIS-theory and has focus on teaching GIS while using geographical data. We begin the education by using a principle similar to the "basics first" approach with controlled exercises (see also Doering, 2002). Through the exercises (laboratory classes) the students build up comprehensive skills that will be useful throughout the rest of their geography studies. As a supplement some open ended optional exercises based on "structured enquiries" are available for those seeking extra adventures. The GIS&C introduces all the basic elements of both vector- and raster-GIS and the 140 page compendium use illustrations, screen dumps and in depth explanations in Danish so the students can use it as a reference book while using GIS in other courses or in individual projects.

A textbook in Danish introducing concepts of GIS has been lacking and will, unfortunately, not be available before year 2005. So, in need hereof we have based most of our theoretical introductions to GIS components upon English, American and Canadian textbooks and the students have been bored with introductions to many irrelevant information such as the US TIGER/DIME formats, British postcodes systems etc. These books have mainly been supplemented by technical articles in the books "GIS in Denmark" (Balstroem, Jacobi & Sorensen, 1994) and "GIS in Denmark 2" (Balstroem, Jacobi & Sorensen, 1999) which present various domestic data sources and uses of GIS.

Parallel to the GIS&C course and closely coupled with it IGUC introduces the classical disciplines of human and physical geography based typically on national cases describing and analysing reasons for and results of differences in the resource base and structural development. Early in these courses (after having obtained basic GIS-skills) the students starts using GIS for analysis and presentations and thus extend their skills to projects defined by themselves. Contrasting the GIS&C course the aim here is to teach geographic theory using GIS as a tool. A simple example of this is on-screen digitizing. At the GIS&C course we teach digitizing of objects from orthophotos and topographic maps and introduce some of the associated issues such as snapping environment, projections, geo-referencing, data quality, scale and precision. Also, the definitions and precepts for digitized objects implemented by the Danish National Survey and Cadastre are introduced, so the students are aware of the abstractions of the real world representation carried by the map objects in their products.

After this exercise it is up to the concurrent courses to teach the students how to adopt the tool into their respective discipline e.g. interpretation of land use in old maps or analysis of sinusoidal rivers in pro-glacial landscapes. Figure 2 illustrates the relationship between GIS and the introductory courses to human and physical geography at IGUC.

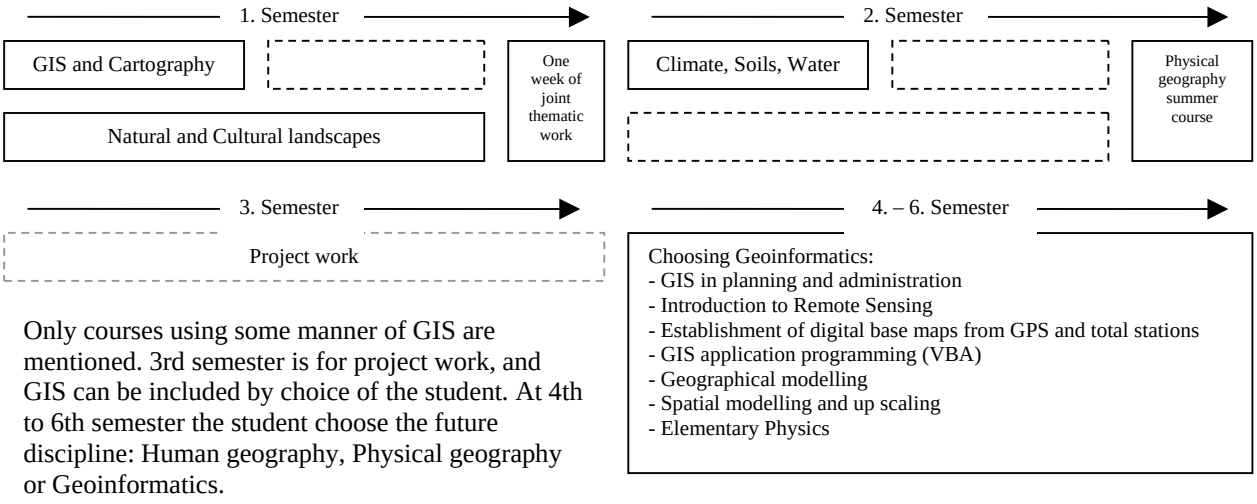

Figure 2 The relationship between GIS and the introductory courses at IGUC.

Integrating GIS into these courses is by no means an easy task. Some teachers see the introduction of GIS in their course as a gentle rescue of modernisation and an opening to discussion of globalization thus paying no attention to the pitfalls. Some believe that the collaboration with a colleague having special knowledge on GIS needs only little attention because the magic GIS-box will solve all their problems. This attitude is well known, however all precautions must still be taken – otherwise these kinds of course implementations will lead to a local rise and fall of GIS within a specific topic. The balance has to be found between what is feasible for GIS and what is not, and as a contradiction one may have to talk colleagues from using GIS in some exercises simply because it may jeopardize the proficiency in the topic.

Experiences when migrating from ArcView 3.3 to ArcGIS 8.3

As the heading of this section indicates IGUC decided to migrate from ArcView 3.3 to ArcGIS 8.3 in the GIS&C course leading all following courses to swap to ArcGIS as well. We were indeed looking forward to the upgrade as ArcGIS had many improvements that were missing from a beginner's viewpoint e.g. the full integration with Windows and improved graphical user interface. We hoped this could help improving our pedagogic methods and results concerning faster and better learning.

When we first started using ArcGIS 8.3 we really felt like driving a Limousine! It was good looking and huge. However, what we soon discovered when writing the introduction to the compendium was later confirmed by the novice students: The Limousine was too big – they only needed a mid-size car to learn how to drive.

As the course progressed and in the final evaluation, several students expressed views similar to this student comment: 'You (the teachers) should elaborate some more on the architecture of the software – how it is build up. It seems to be a very big system and we (the students) tend to loose overview…'. This student hits the nerve of our thoughts about our GIS&C curriculum! How are we to present the world of GIS in a pedagogic and time

efficient way? This is the question that may seem obvious to many professionals; however, one could suspect them for forgetting their own first GIS experience.

One has to remember that the main aim of the GIS&C is to give students a first-hand meeting with GIS and provide generic GIS-theory and skills that will serve as a basis for the future geography education. As our goal is to teach generic knowledge about GIS we are not interested in spending many hours explaining the architecture of a specific piece of software. So, we hereby suggest that ESRI issues a more pedagogic and basic overview of the architecture of ArcGIS than the detailed description provided in the book 'Modeling Our World' (Zeiler, 1999). This would indeed help us in obtaining our teaching goals.We are impressed by many of ArcGIS capabilities but from a beginners viewpoint the GUI and the menus are very difficult to overview. One solution could be to customize and cut the functions of ArcGIS into the bone of what we dose.

In relation to the scope of this paper we may, however, address a few examples pointing at problems with the pedagogical side of the software. One of the better examples is the ArcMap message when loading a set of layers that do not share the same georeference: 'One or more layers are missing spatial reference'. This is an important message, but as one of the students mentioned: 'Why should we spend time searching for the one or more layers – can't the programme do that for us?' Another good example is the problem that the programme does not have an automatic updating of the attribute fields concerning area, length and perimeter if a polyline's or polygon's shape is modified. Okay, we may download one of the many brilliant scripts to be found on the Internet but to all users such a function is basic and it is very difficult to understand why it has not been build into the system from the beginning but needs to be added by customization. Missing such an automatic feature leaves the user (and the trainer) uncomfortable with the teaching situation.

Hence it is important that the media used to reach this goal is suitable for the task, and as the students relatively fast begins to carry out their own projects we are determined on not to start up by using smaller geographical information systems although available.

So did we choose the right approach in our design of a GIS curriculum?

Teaching in other universities GIS courses have automatically kick-started the mind in search for pros and cons for the choice of course structures. At another Danish university they have been offering a basic GIS course for some years. Comparing the two universities may not be fair in the sense that the number of courses offered is very different and therefore of course influencing the choice of teaching method. This introductory course is taught using a didactic concept similar to what Unwin (1997a) explains as being somewhat procedural open ended. The method is using lightly structured laboratory sessions which require students to develop their own procedures on a defined set of data. Using an open ended approach is in general viewed upon as a positive element, however some problems occur when the students do not master the "basics first". Students tend to spend lots of time waiting for a supervisor to help them move on. They do not seem to have full understanding of the basic GIS concepts that, if present, would make them progress on their own. We therefore advocate that the full understanding of the basic GIS

is required before students set off on their own. Not only does this mean that creating own GIS is more fun, it also insures that GIS is deployed in a critical and time efficient manner.

We hope that our experiences beyond the points listed in this paper may lead to forthcoming collaborations with ESRI in order to provide a better launching pad to newcomers of GIS.

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