Geoinformatics education in different disciplines – Challenges - approaches and experiences

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ABSTRACT

On the one hand side Geoinformatics, GIS or GI Science, and maybe other names/variations, is the main subject of autonomous study programs, but on the other hand side Geographic Information (GI) related issues play a role in more traditional study programs like Civil Engineering, Computer Science or Geography. The requirements in this study programs are quite different concerning the content (methods) as well as the skills the students are supposed to acquire during the program. As Geographers are in general more interested in using GI methods for various analysis tasks, Computer Science specialists should for example be able to design and develop applications which make use of Geographic Information in any sense. But there are basic concepts of space which are (hopefully) relevant for all of them. The question here is if these issues have to be taught in different ways, as the background of the students in the various programs can be very different.

The author of this paper is teaching different GI modules in Civil Engineering as well as in Computer Science and in Business Informatics. In these disciplines GI modules of 3-6 ECTS credit point size are offered and the GI relevant modules have a size of up to 30 ECTS credit points in total, mainly in Master courses. In the paper the challenges of teaching GI in various contexts is discussed. Further the UCGIS GI S&T Body of Knowledge (BoK) is checked whether this approach is suitable to describe the necessary core topics of a GI education within different study programs. It is shown that there are some deficits within the BoK and an extension of the BoK is suggested which allows for a more declarative depiction of the curriculum.

INTRODUCTION

There are quite a number of terms around, which are related to the education in the field of Geoinformation (GI), some examples: Geoinformatics, Geographic Information Science (GI Science), Geographic Information Systems (GIS), Geomatics, Geomatic Engineering …

It is not the goal of this paper to discuss all of these terms, it should only be mentioned that the relation between the term GIScience (used in BoK) and Geoinformatics (used in this paper) has been discussed in [Reinhardt et al, 2008]. It has been stated there, that both definitions say that it´s the "science behind GIS" but in more easy words one can say that GIScience is a term developed and shaped from the Geographic Society in the US while Geoinformatics better expresses the European view, that GIS is built on three pillars, Geography, Geodesy and Computer Science. For this reason the term Geoinformatics is used here instead of GIScience.

The University Consortium for Geographic Information Science (UCGIS consortium) has developed a Geographic Information Science and Technology (GI S&T) Body of Knowledge (GI S&T BoK) [DiBiase, 2006]. This valuable work can be used for many purposes like curriculum development, curriculum review, program evaluation and assessment as well as professional certification and employee screening, just to mention a few examples. The "European discussion" on the GI S&T BoK (in the paper shortly "BoK") started in 2006 after a presentation from UCGIS [Johnson, 2006]. At the

EUGISES 2008 [http:/www.eugises.eu/] conference there was a presentation on a European perspective related to the BoK [Reinhardt, 2008] and in a discussion session around 30 people involved in GIScience education in Europe devised a common view on the BoK. Some of the statements developed there:

- The BoK in general is seen as a valuable work, it is considered to be very important and helpful for quite a number of tasks.
- A BoK of GIScience should not represent primarily a Geography point of view (as the available version of BoK does) because it is believed that mainly Geodesy and Computer Science also play an important role within GI Science. This leads to the request to add Computer Science, web based services, Geodesy and GPS more explicit to BoK, preferable on the top level.
- The definition of topics related to basics in Natural Sciences, Mathematics, Computer Science etc. is as important as the definition of GI Science topics
- The core knowledge e.g. for a Master of GI Science should be defined more explicit.
- Laws, directives, initiatives like INSPIRE, Galileo, available data like the “Amtliches Topographisch-Kartographisches Informationssystem” (ATKIS), Data given policies and also the combination of GI with other disciplines in study programs lead to the fact that regional perspectives (like Europe) have to be considered in a BoK.
- An indicator for the depth of teaching should be added to the topics, e.g. Blooms taxonomy
- …

More details about these issues can be found in [Reinhardt et al, 2008]

In 2008 the BoK was first used for mapping different curricula [Rip, 2008] and this work has been further extended and discussed [Rip et al 2010, Rip et al, 2011]

There are other initiatives which are aiming at the definition of a core curriculum in the “GI field”. For example the German Society of Geoinformatics (GFGI) published a draft of a core curriculum for Geoinformatics (in German language) [GFGI, 2009]. The approach of the GFGI is different from the BoK approach. It´s not including a BoK, it defines core competences which Geoinformatics students should acquire, not only in GI itself but also in basic sciences like Mathematics and Computer Science. As the goal of this paper is more related to the topics of the curriculum only the BoK is used as a base for the discussion in this paper.

The paper presented is organized in the following way: In the next section the background and the goals of the paper is explained and the utilization of the BoK for the purpose of the paper is discussed. After this the question of what is “core” in GI education is addressed and it is discussed whether the BoK is suitable for this task or not. Next an extension of the BoK is suggested and 2 cases of curricula from the authors experience are mapped to the suggested extended BoK. Last some conclusions are drawn.

BACKGROUND AND GOALS OF THIS PAPER

The author of this paper is teaching GI issues in different disciplines like Computer Science (CS), Business Informatics and Civil Engineering (CE). The challenge here is to adopt the curricula to the different competence profiles of these disciplines. This will be discussed in more detail in the following, taking Computer Science and Civil Engineering as an example.

In Computer Science one of the specialisations is “Geoinformatics and Computer Vision” (30 ECTS). The Geoinformatics part includes the following modules:

- Geoinformatics Basics (3 ECTS)
- Geoinformatics I (Reference Systems, datum, map projections .., 3 ECTS)
- Geoinformatics II (Spatial data bases and data types, analyses, quality …, 3 ECTS)
- Geoinformatics III (Basics of services, geo web Services, security …, 3 ECTS)
- Geoinformation programming, project based (3 ECTS)

The Computer vision part includes image analysis, photogrammetry and remote sensing, but will not be further discussed in this paper.

In Civil Engineering there are only 2 Modules related to GI:

- Geodesy, Surveying and GIS (which includes GI Basics and DTM) (6 ECTS)
- Geographic Information Systems (Data bases, analysis, visualization) (3 ECTS)

The competences students should have after having attended the course are:

- In Computer Science they should be able to design and implement applications which also include (among others) any handling of Geographic Information
- In Civil Engineering they should acquire the necessary basic knowledge to use GI methodology in water management and planning

This shows that the requirements in different study programs can be quite different.

It leads to the following questions:

- What is the core of GI topics which should be taught in every program with GI content?
- Is the BoK suitable to describe the content of GI modules in other disciplines than Geography?
- Can the differences in the learning goals and the content be expressed with the BoK?

BOK AND GI CURRICULUM CORE CONTENT

The BoK describes the content of GI education in a hierarchical manner and it includes 10 knowledge areas (see table 1). These knowledge areas (KA) include 72 Units and around 1330 topics [Rip et al, 2010]. For a complete list of units and topics please refer directly to the BoK [DiBiase et al 2006].

Table 1: BoK – knowledge areas, derived from [DiBiase et al]

Analytical Methods (AM)	Data Manipulation (DN)
Conceptual Foundations (CF)	Geo Computation (GC)
Cartography and Visualization (CV)	Geospatial Data (GD)
Design Aspects (DA)	GI S&T and Society (GS)
Data Modelling (DM)	Organizational and Institutional Aspects (OI)

“Core” has been defined in the BoK on the level of units (see table 2). From these two tables we can see that Geo Computation is the only knowledge area with not a single core unit. At all 26 (of 72) units are considered to be core. The knowledge area Geospatial Data contains the most core units (9!).

Table 2: BoK – core units, derived from [DiBiase et al]

Knowledge Area	Core Unit	Knowledge Area	Core Unit
Analytical Methods	Geometric measures	**Data Manipulation**	Representation transformation
	Basic analytical operations		Generalization and aggregation
	Basic analytical methods	**Geospatial Data**	Earth geometry
Conceptual Foundations	Domains of GI		Georeferencing systems
	Elements of GI		Datum's
Cartography and Visualisation	Data considerations		Map projections
	Principles of map design		Data quality
	Map use and evaluation		Land Surveying and GPS
Design Aspects	Data base design		Aerial imaging and photogrammetry
Data Modelling	Database management systems		Satellite and shipboard remote sensing
	Tessellation data models		Metadata standards and infrastructure
	Vector and object data models	**GI S&T and Society**	Ethic aspects of geospatial information and technology
		Organizational and Institutional Aspects	Institutional and inter-institutional aspects
			Coordinating organisations

With respect to the size of this paper a discussion of core elements is done here on the level of units. In "real" curriculum design of course this has to be done on the level of topics. The main points from a "non-Geography view" which have to be discussed are:

- In general the core for GI studies within the framework of another subject is depending from the number of credit points dedicated to GI modules. But the core topics within AM, CF, CV, DA, DM, DN and GD should be addressed in any case. Of course the extent of the core modules then has to be adapted to the total number of credit points available for GI. Also the subject plays an important role here, as it might be that part of the GI core is already taught within other modules (see further comments in this section).
- The AM core units as well as the CF ones can be accepted as core also in Computer Science and Civil Engineering. CF can be treated shorter than in Geography.
- Related to Computer Science the main focus in this field is visualization of geographic and thematic data, so we decided to include topics which introduce the principles from thematic mapping. In both subjects basic knowledge of map use are important but map production is not really of interest in these fields (besides some very basic things of map legends etc. which can be done with 3-4 slides)
- Design aspects is interesting in these conjunction as it shows extremely how important it is to consider the background and the subjects the students have in their "main subject". In Computer Science of course students are familiar with all aspects of data bases as well as with modelling languages like UML, so it's sufficient to teach about Geographic Data types, Index structures and Geo Data Bases in general. In Civil Engineering it is the opposite, they have an introduction into object oriented programming, but they have no knowledge in Data Bases at all which makes it necessary to include basics about data bases, SQL …

- Data Base Management systems are included in DM but have been discussed already. The two other core unit's tessellation and vector and object models are important for both subjects although there are differences in the way this is taught, which holds for other topics, too.
- DN covers, from the point of view of the author of this paper, many things which would fit within other modules better, for example interpolation (in AM), vector to raster conversion and vice versa (in DM) but there is no doubt, that this 2 units should be really core.
- GD includes the highest number of core units as already mentioned. According to [Reinhardt et al, 2008] topics like SDI, Services, Metadata, ISO and OGC Standards, Geo Web Services are not represented adequately. This is shown by the fact that all these topics are included in one single unit! (Meta data standards and infrastructures). This is not acceptable. These topics are very important today and can represent around 30% of a curriculum (see below). Consequently this area should be defined as an own KA!
- GS units are considered to be not that important for technical subjects like Civil Engineering and Computer Science. But according to their relevance for other subjects they should be in the list for core units.
- OI core units are for sure important for almost all subjects.
- As the design and implementation of applications which make use of Geoinformation is a major skill of GI experts (and the market requires this), some subjects related to this should be added. In Computer Science and also in some parts of engineering this is a major task, hence this should be a knowledge area. But this is a matter of discussion. It could also be established as a unit.

This leads to a suggestion of the following knowledge areas included in table 3.

Table 3: Suggested knowledge areas, based on BoK

Analytical methods (AM)	Data Manipulation (DN)
Conceptual foundations (CF)	Geo Computation (GC)
Cartography and Visualization (CV)	Geospatial Data (GD)
Design aspects (DA)	GI S & T and society (GS)
Data Modelling (DM)	Organizational and Institutional aspects (OI)
Spatial Data Infrastructure (SI)	Application Programming (AP)

The suggested new KA´s in more detail:

Spatial data infrastructures (SI)

SI1 General purpose and background, initiatives, non-technical aspects, laws etc.
SI2 Metadata (purpose, models, challenges)
SI3 Introduction to Interoperability (syntactic, semantic)
SI4 Basics of Services (HTTP, REST, SOAP)
SI5 Services I (basics, WMS, WFS)
SI6 Services II (advanced, WCS, WTS …)
SI7 Security of Services (authentication, access control ..)
SI8 Relevant Standards (GML, Spatial Schema …)

Application Programing (AP)

AP1 General approaches
AP2 Open Source API´s
AP3 Proprietary APIs
…

The content of the unit have to be defined in more detail on the level of topics. The intension here also was to be as close to the BoK as possible!

As already mentioned the curricula description should also include information how deep the topic is taught. For reasons of simplicity as a first approach only 3 levels are suggested and this describes which competences the students can acquire in the module:

- Students Know about it
- Students can apply it in their domain
- Students are able to use the concepts for the design and implementation of any GI related application

Mapping of the study course content to the proposed schema

The content of the two cases introduced above has been mapped to the knowledge areas introduced in this paper. For the GI content (9 ECTS) within the Civil Engineering program the result of the mapping is given in table 4.

Table 4: Result of mapping of the GI content of the CE program to the adapted KA

Knowledge Area	Content (%)
GD	45
AM	15
SI	10
DA	15
CV	6
CF	5
OI	4

For the GI content (15 ECTS) within the Computer Science program the result of the mapping is given in table 5.

Table 5: Result of mapping of the GI content of the CS program to the adapted KA

Knowledge Area	Content (%)
SI	30
AP	25
GD	25
DA	8
AM	6
CF	3
CV	3

If the original knowledge area structure from the BoK would have been used, in both cases GD (Geospatial Data) would be 55%. But it would not be clear, that in CS much more SDI related topics are included than in CE. In CE one strong focus is Geodesy/Surveying, which is expressed by the high percentage of GD (45%).

Also the introduction of AP clearly shows that this curriculum is intended to convey programming competencies. For the knowledge areas in general some information should be included about their deepness as suggested above, so that it´s clear if the graduate's know about a knowledge area or are able to apply it.

CONCLUSION

For the conclusion we should go back to the questions asked above:

- What is the core of GI topics which should be taught in every course with GI content?

The core topics which have to be taught in every course - and we are only talking about courses where GI in not the main subject– can be very well oriented on the BoK core units. But it depends on the amount of credit points dedicated to GI and also on the topics which are included in the main subject. In general at least the core units from Data Modelling, Analytical Methods, Geospatial Data and some Conceptual Foundations have to be addressed.

- Is the BoK suitable to describe the content of GI modules in other disciplines than Geography?

As the BoK is mainly addressing GI within Geography education it lacks in an appropriate consideration of IT related topics like GI Standards, Services and SDI in general. If we would modify the BoK as suggested in this paper a mapping of a curriculum to a modified BoK would be more declarative.

- Can the differences in the learning goals and the content be expressed with the BoK?

It has been shown by [Rip et al] already, that the BoK is very suitable to compare curricula by means of "EduMapping". Some deficits in using the BoK as it is have been identified in this paper. An extension of the BoK as suggested would give a more declarative picture also in this context.

UCGIS is working on a further development of the BoK. It is hoped that the European view can be integrated in the next versions to be able to arrive at a "common BoK" in near future which expresses the US and the European perspective!

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