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HARMONIZATION OF GI EDUCATIONS IN SWEDEN AND THE BOLOGNA PROCESS – VIEWPOINTS OF UNIVERSITY OF GÄVLE

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Abstract: With the implementation of the Bologna declaration, many study programmes and course curricula needs to be updated and revised. This paper describes the current situation in Sweden regarding GIT educations and courses and whether a harmonization is needed. A survey was made to see which GIT courses that are given and at which level they are given at the various universities. For some universities, interviews were conducted about their courses' contents and their strategies for determining course levels. Discussions were also made about harmonization of courses between Swedish universities. Some problems due to lack of harmonization was noted, which probably will be more severe in the future due to increased student mobility. To harmonize courses, Bloom's revised taxonomy is put forward as a tool which is used to clearly state the level of the course in relation to learning objectives.

Key words: Bologna declaration, harmonization, geographical information systems (GIS), Bloom

1 Introduction

1.1 Background

With the implementation of the Bologna declaration, universities in Europe face reorganization and harmonization of educational programmes and courses. One of the intentions of the declaration is to increase and facilitate movements of students between universities. For example, it should be possible to get a bachelor's degree (3 years) at one university, a master's degree (2 years) at another university, and a PhD (3 years) at a third university. If a student has a bachelor's degree in *e.g.* physical geography, it should be possible to begin master's studies in the same subject, but the question is – will it be possible to continue in a closely related field, such as geodesy? Master's programmes must be flexible to a certain extent, *i.e.* it must be possible to enrol students with slightly different backgrounds, but there also has to be some common background. Geographical information technology (GIT) courses can be considered such a common denominator and will serve as the example on harmonization problems on geographical information (GI) courses curricula.

An earlier study on GI educations was made by Dimitrov and Popov (2005). They looked at how geographical information systems (GIS) courses are implemented in geography educations in Europe. They conclude that studying only a couple of GIS courses is not efficient enough. GIS programmes must be designed in several stages, tightly connected to geography as an academic discipline. These stages are: fundamental concepts of GIS, spatial modelling, etc.; necessary computing skills as well as in other relevant disciplines (*e.g.* remote sensing); problem-based learning for solving real-world problems; and GIS practice in the field (*e.g.* "mobile" GIS applications). A properly performed education places "an emphasis on the scientific fundamentals of the technology and on the deployment of concepts and analytical skills, rather than keyboard commands" (Dimitrov and Popov, 2005, p. 129). Therefore, to get sufficiently skilled, the student may have to study at more than one university. This puts pressure on the universities not only to present course curricula with clear objectives and content, expected outcomes, etc., but also to properly place the courses on appropriate levels. The adjustment to cycles of 3+2+3 years may make it even more challenging, including extensive rearrangements of study programmes at the universities.

1.2 Aims

The aims with this paper are manifold, namely:

- Trying to describe the current situation in Sweden of GIT related courses. Closely related subjects, like *e.g.* cartography courses, have been left out in this study.
- Find out if there is general need for harmonization of course levels between universities,
- and if so, describe the problems and possible solutions.

2 Current situation in Sweden of GI education

In Sweden, most universities classify their courses into one of four levels: A, B, C, or D. Usually, three one-semester courses of A, B, and C levels, respectively, are required within a three-year, or 180 ECTS credits, bachelor's programme. To complete the bachelor's degree, one semester (30 ECTS credits) on another subject and two semesters of optional courses are added. To get a Swedish master's degree, a D-level semester is added within a total of four years (240 ECTS credits). After that, it is possible to continue with four years of doctorate studies. As can be seen, the Bologna model will rearrange the Swedish 3+1+4 year system into a 3+2+3 year system. This, however, is not treated in this study.

In Sweden, GIT is mostly taught as 7.5 ECTS credit courses in a variety of programmes, such as geography, geomatics, geoinformatics, earth sciences, etc., but also other educational programmes begin to see the advantages with GIT. The courses are given at different stages of the educations, and preferably where they fit the needs most. However, sometimes a basic GIT course is given as an A-level course at one university, while it is given as a C-level course at another university, which automatically leads to confusion about levels and course content. Obviously, the course contents cannot differ much, since they all treat basic GIT. The main reasons for classification differences lie in which year the course is given on the programme or if the course has prerequisites from another subject area. Often, but not always, courses inherit their level from the year of study, *i.e.* A-level courses are given on the first year, B-level the second year, etc. Another example is the somewhat confusing nomenclature. Some universities divide subjects into courses of GIT, cartography, photogrammetry, geodesy, etc., while others may call their course GIS, including all these subjects.

The differences in course length, naming and classifying courses among the universities, has lead to a confusing situation with possible difficulties for students and lecturers, to see if the students satisfy the requirements for a specific course when changing from one university to another. Furthermore, *ad hoc* movability between universities may get discouraged, since much effort may be spent on finding out prerequisites for the courses.

3 Methods

There are about 50 universities in Sweden and half of them have GIT courses. To see how many and which courses every university has, searches were made on the university's homepages. To double check and discuss the content of the courses, key persons at the universities with most GIT courses were contacted and interviewed. The interviews were informal and performed in the style of discussion. Some key questions were, however, included in the interview:

- Which courses within GIS/GIT does the university give?
- Which criteria are used for different course levels?
- Is Bloom's taxonomy (or any other system) used for course planning, etc.?
- How is the progression of course content dealt with between courses? Academic and professional progression, respectively.
- Poses enrolment of new students from other universities any problems?
- Is harmonization of courses between the universities in Sweden an issue?

A literature study was also performed to find a possible solution if harmonization of the courses, their levels, and educational programmes is needed. The study focused on commonly known educational taxonomies in Sweden such as Bloom's revised taxonomy (Anderson and Krathwohl, 2001), based on the original Bloom's taxonomy from 1956, and the SOLO taxonomy (Biggs and Collis, 1982). One of the taxonomies was chosen as a possible solution to overcome the problems with harmonization of GI courses and to the implementation of the Bologna declaration in general.

4 GIT education and professional skills

Before making any attempts on how to classify courses, the ideas of Marble (1997) will be presented. Marble notices that there is a general opinion that the technology of GIS can be mastered by almost anyone with a minimum of intellectual effort. Hence, many universities only give introductory courses in GIS and consider this to be sufficient for any type of analysis. However, not only may the use of GIS be inadequate or even erroneous, there is also a risk of future shortage of competent professionals, *i.e.* people that have deep knowledge in both spatial science (like geography) and computing. Depending on the student's ambition, Marble uses a pyramid to guide the student through the studies (Figure 1).

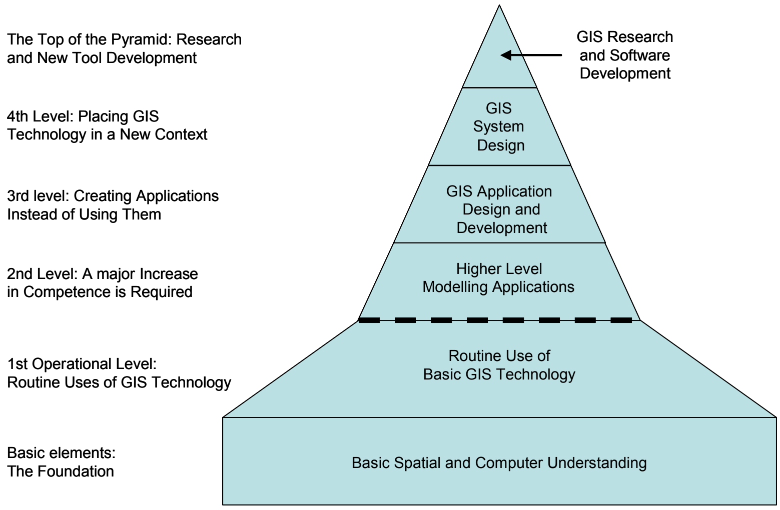

Figure 1: Marble's (1997) idea on how to structure GIS education to support future professionals in GIS development and research.

The basic elements of GIS can be seen at the bottom of the pyramid. These include basic cartography, basic spatial analysis, computing and the development of "thinking spatially". All elements are necessary before the student can continue with further studies in GIS, since without sufficient knowledge, GIS outcomes may be erroneous (Marble, 1997). At the 1st operational level, the students use GIS routinely and can without too much effort create simple overlays or make standard maps and understand what is happening. Important at this level is the understanding that there is far more that the GIS is capable of (Marble, 1997). The 2nd level is lying above a dashed line, which signifies a significant amount of training and education. The ability to think spatially must be highly developed and the students also need to understand basic computer programming, database systems as well as to structure and operate complex models. Necessary courses on this level include content with GIS algorithms and data structures (Marble, 1997). At the 3rd level, substantial spatial analysis and modelling are used to develop and implement sophisticated GIS applications. Programming, software engineering and advanced database systems are used together with elements from geography and spatial analysis

(Marble, 1997). In the 4th level, GIS technology is implemented for complex situations in a new context, where knowledge of systems analysis and GIS design is vital (Marble, 1997). At the top of the pyramid, new analytic approaches and algorithms are developed and implemented. This level, as well as the 4th, receives much academic research interest (Marble, 1997).

5 Using taxonomy for course classification

To group GIT courses according to appropriate levels, some kind of system or strategy is needed. One way is to use Bloom's revised taxonomy. Another is to use the SOLO (Structure of the Observed Learning Outcome) taxonomy created by Biggs and Collis (1982). Both are educational taxonomies, based on learning objectives, that evaluate a student's cognitive level from the simple tasks to the more abstract construction.

Biggs and Collis' (1982) taxonomy is based on Piaget's cognitive development stages. They revised Piaget's development stages from a focus on the student's cognitive level to the student's cognitive level of responses (see description in Table 1). They argue that a student can belong to different levels of cognitive processes depending on *e.g.* motivation and prior knowledge of a subject. This indicates that a student's knowledge on a subject can shift from week to week and from subject to subject (Biggs and Collis, 1982). They distinguish a student's actual response to specific learning tasks, *i.e.* SOLO, from a student's hypothetical cognitive structure, meaning the student's potential maximum. Thereby, SOLO describes a student's particular performance at a particular time in a subject matter.

Table 1: The SOLO taxonomy after Biggs and Collis (1982). The development base stage is isomorphic, but clearly distinct from SOLO.

Piaget's Development base stage	SOLO Description	SOLO Relating operation
Formal operation (16+ yrs)	Extended abstract	Deduction and induction. Can generalize to situations not experienced.
Concrete generalization (13-15 yrs)	Relational	Induction. Can generalize within given or experienced context using related aspects.
Middle concrete (10-12 yrs)	Multistructural	Can generalize only in terms of a few limited and independent aspects.
Early concrete (7-9 yrs)	Unistructural	Can generalize only in terms of one aspect.
Pre-operational (4-6 yrs)	Prestructural	Denial, tautology, transduction. Bound to specifics.

Bloom's original taxonomy was developed as a means of coordinating tests between various universities in order to measure the same learning objectives (Krathwohl, 2002). The taxonomy was created using a hierarchy of cognitive levels of which the student had to master the former to get to the next level. The cognitive levels went from concrete to abstract containing the levels of knowledge, comprehension, application, analysis, synthesis and evaluation (Krathwohl, 2002). Anderson and Krathwohl (2001) altered Bloom's taxonomy by introducing a second dimension to the cognitive levels; the knowledge dimension. "Knowledge" was taken from the original cognitive levels and was split up into three knowledge levels in the new knowledge dimension. One more category, metacognitive knowledge, was added since it has been widely accepted as a level of knowledge (Krathwohl, 2002). With minor alteration, the remaining original cognitive levels became the cognitive process dimension: Remember, Understand, Apply, Analyze, Evaluate and Create (Table 2). The two dimensions, the knowledge dimension and the cognitive dimension, give the noun and the verb to the learning objectives, respectively. Anderson and Krathwohl (2001, p. 41) describe their approach as based on that "social experiences and context play [a role] in the construction and development of knowledge".

Table 2: The revised Bloom's taxonomy after Anderson and Krathwohl (2001).

The cognitive process dimension / The knowledge dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual knowledge (*Basic element of discipline)*						
Conceptual knowledge (*Basic elements and their interrelationship)*			X			
Procedural knowledge (*Knowledge of methods and criteria for using them)*						
Metacognitive knowledge (*Awareness of one's own cognitive)*						

To create a learning objective from the revised taxonomy, the lecturer must use the knowledge dimension to the noun of a learning objective and the cognitive dimension to give the verb. *E.g.*, the learning objective: *The student will be able to apply basic principles of GIS* gives a noun *Basic principles of GIS* which is a part of the conceptual knowledge and a verb *able to apply* which is a part of the cognitive level Apply (see the X in Table 2). The higher the educational level, the higher should be the minimum knowledge and cognitive level of learning objects. Besides being a measuring tool, the revised taxonomy may serve as a "common language about learning objectives to facilitate communication across persons, subject matter, and grade levels" and "means for determining the congruence of educational objectives, activities, and assessments in a unit, course, or curriculum" (Krathwohl, 2002, p. 212). Furthermore, Anderson and Krathwohl (2001, p. 301) state that their "revision will be most beneficial to those who adapt it to their purposes".

Anderson and Krathwohl (2001) argue that the SOLO taxonomy is more precise in differentiating lower levels of learning, but is coarser in the complex levels. Considering that the harmonization of learning objectives for GI courses is for higher education, it is more appropriate with a precise division of the more complex cognitive levels. Therefore, in this study Bloom's revised taxonomy is chosen over the SOLO taxonomy as a tool for harmonizing and producing similar learning objectives at different Swedish universities.

6 Results

6.1 GIT courses at the Swedish universities

Of the Swedish universities that have GIT courses, most give courses to support other subjects. Table 3 shows the study programmes in Sweden where GIT is a major subject. Some of the alternatives after finishing a GIT programme include professions like GIS application developer, GIS analyst, GIS manager, etc., often combined with another subject area.

Table 3: Study programmes in Sweden where GIT is a major subject (Note that MSc in Sweden ranges from +1 to +2 years after a BSc).

University	Programme	Duration	Degree	Prerequisites
Karlstad University	GIS Engineering	3 yrs	BSc	-
Linköping University	MSc in Geoinformatics	1.5 yrs	MSc	BSc in GIS-related area
Lund University	LUMA GIS	1.5 yrs	MSc	BSc
Royal Institute of Technology	Geodesy & Geoinformatics	1.5 yrs	MSc	BSc (pref. surveying)
Umeå University (Lycksele & Örnsköldsvik)	Engineering progr. in GIS	3 yrs	BSc	-
University of Gävle	Geomatics	3 yrs	BSc	-
University of Gävle	Geomatics	2 yrs	MSc	BSc in GIT-related area

Table 4 shows a summary of all GIT courses in Sweden, including the ECTS credits and levels for each university. Note that many universities give several courses with more or less the same content, *e.g.* a basic course in GIS for different types of study programmes; hence, the column for unique number of courses. Sometimes a course is given as an advanced course with respect to the subject the GIT is applied to. Here the courses have been adjusted to show the approximate levels of GIT. Since most of the information was gathered from the internet, please note there may be courses missed or misinterpreted by this survey.

Table 4: GIT courses at Swedish universities listed in order of adjusted ECTS credits.

University	No. of courses	ECTS Credits	Adjusted no. of courses	Adjusted ECTS Credits	Levels	Adjusted GIT level
Lund University	26	276.0	17	127.5	A-D	A-D
University of Gävle	13	97.5	12	90.0	A-D	A-D
Linköping University (Linköping)	15	112.5	9	67.5	A?-D	A-D
Luleå University of Technology	9	67.5	9	67.5	A-B	A-B
Royal Institute of Technology	8	60.0	8	60.0	B-D	A-D
Umeå University (Lycksele & Ö-vik)	6	60.0	6	60.0	A-C	A-C
Umeå University (Umeå)	8	120.0	3	52.5	A-D	A-C
Karlstad University	7	75.0	7	45.0	A-C	A-C
Södertörn University College	3	45.0	3	45.0	A	A-B
Högskolan Dalarna	6	82.5	3	30.0	A-D	A-B
Stockholm University	5	52.5	2	30.0	?	A-B
Mälardalen University	4	45.0	2	30.0	A-D	A-B
Göteborg University	4	45.0	2	30.0	A	A-B
Linköping University (Norrköping)	5	28.5	4	24.0	A-C	A-C
University of Kalmar	3	37.5	1	15.0	A-C	A-B
Uppsala University	3	30.0	2	15.0	?	A-B
SLU (Umeå)	3	22.5	2	15.0	A-C	A-B
Mid Sweden University	2	22.5	1	15.0	A-B	A-B
Gotland University	3	22.5	2	15.0	A	A-B?
Blekinge Institute of Technology	2	15.0	2	15.0	B-C	A-B
SLU (Skinnskatteberg)	2	15.0	2	15.0	B	A-B
University of Skövde	2	15.0	2	15.0	A	A-B
SLU (Uppsala)	2	10.5	2	10.5	A-B	A
University West	1	7.5	1	7.5	B	A
Växjö University	1	7.5	1	7.5	B	A
Chalmers University of Technology	1	6.0	1	6.0	A	A
Malmö University	1	4.5	1	4.5	A	A

To show how the course curricula may differ some excerpts from typical and representative examples from different levels and universities are given below.

6.1.1 Basic introductory courses on A level

(Luleå) GIT (GIA) (distance): <u>Description</u>: The course gives basic knowledge in GIT and knowledge about the structure and functions in the software ArcGIS. You will get knowledge about handling layers, editing, database management and cartographic problems.

(Umeå) Business GIS: <u>Aims and content</u>: The purpose is to provide an introduction to GIS and their applications within a business context. After an overview of GIS principles and of their relevance for marketing and other business problems the participants have an opportunity to get experiences in the practical operation of a GIS. Computer exercises address real-world cases and aim to exemplify the potential of GIS for business development.

6.1.2 *Intermediate courses on B level*

(Gävle) GIS databases: Aim: The course is designed to give understanding of the working processes needed for a successful specification and construction of spatially referenced databases, normally known as geographical databases. The students will be given the theoretical and practical knowledge that will be needed in projects for creation of geographical databases within different types of application fields. Contents: database systems and requirements analysis, introduction to relational models in GIS, information security and vulnerability, metadata, quality and availability, standardization of GI, spatial data infrastructures.

(Karlstad) GIS III: Aim and goal: After this course the student shall: be oriented about different software used in digital mapping, be able to describe, structure and edit digital cartographic data and transfer data between different systems, make adjustments of digital data to be able to use the data in analysis in GIS software and connect to external databases. Content: The course treats real-world examples. Practicals with data from CAD and GIS include elementary map editing, creation of topology and export of data from different software environments, connection of attribute databases to GIS and thematical mapping.

6.1.3 *Advanced courses on C level*

(Gävle) GIT – Project: Aim: The course is designed to give deepened knowledge of GIT. The students are given the theoretical and practical knowledge that will be needed in projects where GIS is used as an analysis and presentation tool. Contents: Practical handling of different GIS software, manipulation between and integration of different kinds of data formats, interpolation of scattered data, digital elevation modelling and volume analysis, stream networking and network analysis, multicriteria analysis, viewsheds and presentation techniques, legal aspects and ethics in GIS, literature seminar, project work dealing with aspects of the course contents on a selected geographical area. The project work will result in a written scientific paper.

(Karlstad) GIS VI: Aim and goal: After this course the student shall: have theoretical and practical knowledge of different types of data analysis with GIS software, be oriented about application areas where GIS analysis is used in the society. Content: The course advances from basic knowledge of using GIS software, mainly ArcInfo and ArcView. Analysis and modelling with GIS are dealt with and examples of applications of methods are given. Example of analysis is network analysis, spatial analysis, 3D-visualisation and modelling.

6.1.4 *Highly advanced courses on D level*

(Gävle) Time-GIS: Objectives: To provide overview on various aspects of time-GIS involving ontologies, modelling, databases, visualization, applications, and to develop student research ability towards the advanced GIS. Contents: Temporal representation and ontologies, temporal modelling and databases, visualization of dynamic phenomena, applications of time-GIS.

(Linköping) Advanced Course in IT, GIS and Mobility: About the course: The aim is for the students to acquire a deeper knowledge of and theoretical perspectives on commercial and other applications employing mobile information technologies and GIS. The course comprises theoretical elements as well as an overview of current research in the area, especially with a focus on how GI can be used to describe and model the physical world as well as technical and social systems. The students should also improve their knowledge of the interdisciplinary processing of spatial data in different application areas. Discussed are sensors and sensor information, methods to handle databases, methods to transfer data and information in mobile information systems, query languages and analysis methods regarding data with spatial and time dimensions, and studied are also how data can be presented and indexed to manage GI.

To get an idea of the range and variation of C- and D-level GIT courses in Sweden see Table 5.

Table 5: C- and D-level GIT courses in Sweden.

University	Name of course	University	Name of course
Karlstad U.	GIS VI	Lund U.	Internet GIS
Linköping U. (Lin.)	Advanced geoinformatics	Lund U.	Open source GIS
Linköping U. (Lin.)	Advanced health GIS	Lund U.	Remote sensing and GIS
Linköping U. (Lin.)	Advanced GIS for business and service planning	Royal Inst. of Techn.	A GIS project
		Royal Inst. of Techn.	GIS architecture
Linköping U. (Lin.)	Adv. IT, GIS and mobility	Royal Inst. of Techn.	Spatial analysis
Linköping U. (Lin.)	GIS for transport applic.	Royal Inst. of Techn.	Web GIS
Linköping U. (Lin.)	Res. prep. in geoinformatics	Umeå U. (Ly. & Ö-v.)	Vector-GIS III
Linköping U. (Lin.)	Usability issues in GIS	Umeå U. (Ly. & Ö-v.)	GIS on Internet
Linköping U. (Nor.)	Positioning and GIS	Umeå U. (Umeå)	Physical geography D3: GIS
Lund U.	Algorithms in GIS	U. of Gävle	GIScience seminar
Lund U.	Dynamic modeling in GIS	U. of Gävle	GIT – project
Lund U.	Geographical databases	U. of Gävle	Spatial analysis and model.
Lund U.	GIS and geo-statistics	U. of Gävle	Time GIS

6.2 Interviews of key personnel at the universities

In informal interviews with persons at some of the universities the following key questions where used to get a general idea of how the Swedish universities construct their curricula.

- *Which courses within GIS/GIT does the university give?* This confirmed if we had found the right information on the university's homepage. See Table 4 for results.
- *Which criteria are used for different course levels?* Generally, a progression from a basic A-level to B-, C- and D-level is followed, where the knowledge from A-level were prerequisites for the B-level and so forth. In some cases the levels of courses were inherited from the year of study, *i.e.* A-level courses are given on the first year, B-level the second year, etc. In those cases, usually problematisation of the GIS problems is used in a scientific way in order to comply to the level.
- *Is Bloom's taxonomy (or any other system) used for course planning etc.?* In some cases Bloom's taxonomy was used to check if the course had the right level. Furthermore, it was used as the tool for rewriting curricula for courses to adapt to the Bologna declaration. One of the universities used the SOLO taxonomy for developing course curricula. There were also universities that never used any taxonomy.
- *How is the progression of course content dealt with between courses? Academic and professional progression, respectively.* The professional progression was usually faster than the academic progression, but the academic level of the courses on C and D levels where always considered to be high.
- *Poses enrolment of new students from other universities any problems?* Of the interviewed universities no one saw this as a big problem, the answers where both yes and no, but most universities did not have too much experience of that issue. A couple of the universities noticed that although students have records of some GIS experience (often from some of the universities with few GIS courses), these students often have to do extra assignments before catching up with their own students.
- *Is harmonization of courses between the universities in Sweden an issue?* One university answered that for GIS in general they could see it as a positive issue, but for special areas there was no need. The remaining universities agreed that harmonization would be positive and that it could benefit everyone involved, at least to some level.

6.3 Harmonization of courses

An attempt was made to find guidelines to harmonize courses and educational programmes, since the course curricula and the interviews showed how learning objectives and levels differ. Bloom's taxonomy and its different categories of knowledge dimensions can be related to the

Swedish system of A to D level courses. The knowledge dimension increases from factual knowledge (roughly equivalent to Swedish A level) over conceptual knowledge (Swedish B level) and procedural knowledge (Swedish C level), to metacognitive knowledge (Swedish D level). Besides that a B-level course has an A-level course as prerequisite and so on, each level also has increasing requirements regarding the learning outcomes. This in turn can be related to the Bologna model of two cycles (bachelor and master level) and courses for these cycles, *viz*. basic and advanced. Note that the differentiation between basic and advanced courses not automatically means that bachelor's programmes only have basic courses and master's programmes only have advanced courses. For master's programmes to be able to recruit students from other universities or programmes, basic level courses must also be given on master level.

The other part of the taxonomy includes the cognitive process dimension which increases from remembering over understanding, applying, analyzing and evaluating, to creating as the last cognitive level to be reached for the student. The learning objectives can be created in the same way as Anderson and Krathwohl (2001) describe in their revised taxonomy. *E.g.* a Swedish A-level course should have most of its learning objectives to coincide with the row of factual knowledge, a B-level with conceptual knowledge and so forth. However, it does allow for learning objectives of a course to be created outside the given knowledge level, *e.g.* to repeat earlier learning or to prepare the student for the next level. The construction of noun and verb, from Table 2, is also helpful in creating similar learning objectives at different universities.

7 Discussion

As Marble points out, the base of the pyramid has been widening while the upper levels shrinks, leading to a poor reputation and weakening of the discipline of geography, as well as negative impacts on the GIS industry (Marble, 1997). For a relatively small country like Sweden, to serve Swedish students with sufficient number and quality of advanced courses one possible solution is to join forces and cooperate between universities on MSc- and PhD-study levels. Probably, to get sufficient number of students, these advanced courses have to be given in English, which also may increase the student exchange between countries, as one intention of the Bologna declaration. On the other hand, rigorous and useful introductory courses must be given at many universities to create the broad base for future experts (Marble, 1997).

Since classification based on combination of both professional level and academic level poses problems when relating each university's courses to another university, it is argued that the prerequisites are clearly shown in the courses' curricula. *E.g.*, if GIS merely is used as a tool for advanced theories in geodesy, this must be noted. This implies that a double classification should be used – one for the level of GIS and one for the subject interacting with GIS. With the Bologna implementation, all courses will belong to either the first basic cycle or the second more advanced cycle. This stresses the importance of being even more precise when stating the course prerequisites.

To implement Bloom's revised taxonomy on course level nomenclature, the Geomatics Programme at University of Gävle has initiated a revision of the courses on the programme. Courses that do not comply with the taxonomy either have to be reclassified or to be changed in order to fit the requirements of the level. The courses at the Geomatics Programme are classified both according to their professional level and their academic level and in the near future learning objectives will be included. The C-level course "GIT – project" may serve as an example. The course has the B-level course GIS Raster/Vector as a prerequisite, which in turn has the A-level course GIT I as a prerequisite, or equivalent, respectively. The professional, or technical level, including analytical skills and understanding, is more advanced than the A- and B-level courses, and the academic level relates to the students' scientific approach. In the GIT –

project course, the students are trained in reading and treating scientific papers, and their final report on the project is written as a scientific paper.

With the Bologna implementation the creation of learning objectives is soon a reality. Therefore, the use of Bloom's revised taxonomy can help getting objectives that actually reflect certain knowledge and cognitive levels. The advantages with a table include the easiness to implement the taxonomy into different GI courses. An example of the adjustment process is shown through a GIT course at the University of Gävle. The course "GIT in Land Management B", 7.5 ECTS credits, was created in 2005 according to the guidelines of the original Bloom's taxonomy. The course curriculum shows the use of different cognitive levels in the course, e.g. "to be able to *analyze* and *model* geographical data" or "to be able to *evaluate* and *summarize* scientific literature". One of the learning objectives was "to give the student *training* in different types of GIS-operations and analyses", which indicate a conceptual knowledge level. It shows that the student is not expected to fully grasp the techniques behind the operations and analysis, but merely to give the student an idea of how different elements are interconnected; hence conceptual knowledge level. However, it also shows that the learning objectives were created in unawareness of the revised Bloom's taxonomy, since the noun used could be more clear and concise in showing the relation to the conceptual knowledge of a B-level course.

Bloom's taxonomy is relatively easy to follow and different lecturers should be able to produce similar results when deciding the learning objectives. Prior knowledge of Bloom's taxonomy among Swedish educators should also help the Bologna implementation process in a time of limited recourses. When it comes to harmonize courses between countries, this may be harder. Some countries do not have particular GIT courses, but include GIT within the other subjects.

8 Future work

Obviously, the universities have much work to do before complete implementation of the Bologna declaration. However, the interviews revealed great interest in cooperation, especially on advanced level. If course curricula gets clearer in prerequisites and learning objectives, probably also the possibility for life-long learning will be facilitated. Further use of Bloom's revised taxonomy than for classifying courses involves not only the typical relation to learning objectives, but also to grade the students' results. By using the knowledge dimension for determining the course level, the grading can be related to the cognitive process dimension. Recently, the Swedish Cartographic Society initiated a new section for Education. This section will work actively with questions like those put forward in this paper to promote the use, knowledge and research in the GI area.

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