

A harmonized GIS course curriculum for Swedish universities

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Abstract

With the implementation of the Bologna declaration, European and other universities must change or adjust courses and programmes so they fit into the Bologna model. In Sweden this will take place during 2007. The intention with the declaration, for example, is that a basic course in one subject at one university should be treated as equivalent to the same type of course at another university. Once a year, the recently formed section for education of the Swedish Cartographic Society gathers university lecturers and others for an education conference to discuss matters concerning higher education in geomatics, geoinformatics, geography, etc. Last year's conference identified the need for a harmonized course curriculum in basic GIS. One of the advantages of such a course is easier transfer of study records for inclusion of course credits in study programmes at other universities. Therefore, an attempt has been made to write a harmonized course curriculum for basic GIS. The course will contain about 50% common content and about 50% of content decided by the individual university. The common content will be described as learning outcomes, and then it is up to the universities to place the learning outcomes into a context. Thanks to this common core, the course can be given for such diverse programmes as archaeology, land surveying, or economy, and still be able to include the required knowledge for students to continue on more advanced courses at other universities.

Introduction

Background

A network of Swedish university lecturers in subjects related to geographical information was formed in 2004. Quite soon it was realized that some problems and educational questions were common in nature to participants. One of the big challenges identified was the implementation of the Bologna declaration. Important parts of that is "Adoption of a system of easily readable and comparable degrees" and "Promotion of mobility by overcoming obstacles" (Bologna Declaration, 1999). The ultimate goal is to do that on a European level, but already at national level it seems like a delicate task. In Sweden, basic courses in geographical information systems (GIS) are given at several universities and in a wide range of study programmes. Although, from a general competence development point of view this is desirable, sometimes it may cause problems when students want to continue studying at another university or when employers try to evaluate their skills. In 2006, the university lecturer network was included as a section of education in the Swedish Cartographic Society, and since then, one of the main working questions of the section has been to follow up and facilitate the implementation of courses and programmes related to geographical information according to the Bologna declaration at the Swedish universities (See Brandt and Larsson, 2006, for a description of the section of education at the Swedish Cartographic Society). In Sweden, the new Bologna regulations take effect from the fall of 2007 and onwards.

Besides general treatment of the Bologna process, much time on the lecturer network meetings has been spent on discussing course literature. In the mid 1990s many scholars felt a need for a Swedish book in GIS. After discussion, some lecturers decided to write a book that could be used by students at social science, natural science and technical faculties. However,

the problems faced by the authors were significant since too many formulas and mathematical approaches would make the book of less use for some subjects, but, finally the book covered the field of GIS as perceived by the financier, reviewers and authors. Since 1999 the book (Eklundh, 2003) has become the standard textbook for many basic courses in GIS. The book is now under its 4th revision, and along with implementation of the Bologna declaration by Swedish universities and request of harmonization forced by the Swedish Government, this gives opportunity for a broader discussion of course curricula.

Aim

To smooth the progress of implementing the above mentioned challenges of the Bologna implementation, the aim with this paper is to formulate a general course curriculum for a basic course in GIS that most of the Swedish universities can agree upon; irrespectively the different nature of the programmes within the course is given.

Methods

The creation of a common course curriculum has been a continuous process. At the meetings of the section of education of the Swedish Cartographic Society, the question of creating a common course curriculum was first discussed in 2006 and later decided upon in 2007. On the last meeting in June 12007, its general content was discussed, and a draft was produced and sent to most of the universities that give courses in GIS. Based on the comments of this draft a revised curriculum has been made which is shown and discussed later on in this paper.

Bologna implementation

Directorate-General for Education and Culture (2005) has produced a short document mainly dealing with credit transfer, but also including some general guidelines of the Bologna implementation. There it is described that the educational system is based on three cycles: undergraduate (bachelor), graduate (master), and post graduate (doctorate). Courses are classified as belonging to one of these levels. Furthermore, each course curriculum should contain a description of course content, learning outcomes, prerequisites, teaching methods, recommended reading, etc.

Course content and goal in a course curriculum is not intended to connect to specific literature and assignments, but should rather be expressed in more general terms, for example: “The course treats basic terms and theory for geographic information science. In this lie geographic database management, spatial data structures and spatial analysis using geographic information systems. Applications are directed towards environmental issues, monitoring and natural resources. The course is intended to give a theoretic, practical and subject-related insight in basic spatial analysis and how data from different sources, e.g. remote sensing, digital maps and field observations can be merged, processed and presented. The course is useful for individuals looking for positions in private, municipal and governmental agencies” (taken from the course GIS, 15 ECTS, at Stockholm University). More precise, however, is the expected study result, or “learning outcomes”. Stockholm University recommends to restrict this to a few general statements. For the mentioned course this is: “After completing the course the student must be able to # give further details of basic terms and theory in geographic information science, # combine external data into own databases, # perform processing, analysis and presentation in GIS from data collection to report, # evaluate geographic data and processing methods in GIS, # use GIS in a project”.

In the course curriculum, the examination grading scale is decided. Though, more important is to understand how course content and goals is implemented in the grading template. The Bologna directives imply a seven-graded scale that should not be described in the course curriculum, but in the attached course information package. It is the expected result of the course study (expressed as learning outcomes above) that should be examined, and the template comes along with a method to merge the outcomes of the study goals. Hence, there is a need to know the weight of the learning outcomes in the final course certificate, which only shows the final weighted grade.

Assessing a candidate for a position means that the course curriculum, the individual transcript, as well as the course information with the grading template, is needed. This is understandable as a course curriculum may appear to be the same at different universities, but implemented differently as described in the examination of the goals according to the grading template.

The current situation of GIS courses in Sweden

A survey over the Swedish GIS courses was made in 2006 (Brandt et al., 2006). 23 universities give about 150 courses in GIS at different levels, from basic to advanced. If the course curricula for all courses are scrutinized, it is obvious that the course levels are based on different criteria. Some courses are given on master's programmes and are, therefore, automatically classified as advanced even if the content treats introductory GIS. Other courses function as tool-kit courses for other subjects, and consequently are placed at the same level as the other subject. Finally, a course may treat basic issues in GIS, but the way it is treated scientifically may be advanced. Very seldom an advanced course is classified as a low level course. In general, those universities who provide complete programmes, with GIS courses from basic to advanced levels, also are the ones that probably have the most proper differentiation between courses and their levels.

Not only do the levels differ, also do their thematic content. Especially the introductory GIS courses are given as support for a wide range of subjects. Examples include: geography, land surveying, archaeology, logistics, etc. Hence, with the implementation of the Bologna directives, a revision of courses are both needed and wanted if the intentions of the Bologna declaration are to be fulfilled.

Results – A new course curriculum

Based on the discussions at the university lecturer meetings and following comments, a harmonized course curriculum has been produced (in the following course curriculum, xxx means content decided by the individual university). It should be noted that this is the first version of a template which, certainly, is due to revision as the subject develops and more experience is reached from implementing the Bologna directives. In this section the course curriculum is shown, and in later sections the curriculum is commented and related to Bloom's revised taxonomy and grading criteria.

Basic course in geographical information technology

Level: Basic (First cycle)
Depth of study: Introductory
Course code: xxx
ECTS: 7.5

Moment

Written examination	2.5 ECTS
Exercises	5 ECTS

Education area: xxx

Subject area: xxx

Learning outcomes

The purpose with this course is to give the student knowledge of and training in geographical information technology. Xxx.

On completion of the course, the student will:

1. understand how geographical information systems work
2. be able to explain the difference between raster and vector format
3. understand how geographical data are gathered and stored
4. describe the basics of how geographical databases work and are built up
5. be able to perform simple overlaying in both raster and vector environment
6. be able to perform simple network analyses
7. be able to describe and give a basic analysis of economical and organisational aspects where GIS is included
8. be able to evaluate when raster or vector format is to prefer
9. be able to evaluate quality and usability of different data sources for different GIS applications and analyses
10. be able to critically evaluate the use of GIS for different types of applications
11. xxx
12. xxx.

Course content

- geographical data and databases
- analyses in raster and vector environment in GIS
- cartographical presentation techniques
- economical and organisational aspects
- reference systems and map projections
- creation of maps ready for printing or digital publishing
- topology
- xxx
- xxx.

Tuition forms

Lectures, exercises and own studies.

Prerequisites

Basic eligibility for university studies.

Examination

The student must receive a passing grade on the written exam as well as all exercises.

Grading

The ECTS grading scale, A, B, C, D, E, FX and F, is used where FX and F mean fail.

Limitations

xxx

Other

xxx

Course literature

xxx

Reference literature

xxx

Comments to the new course curriculum

At least 50% of the course content should be common, independent of which university that gives the course, and the remaining up to 50% can be given according to own preferences.

The suggested course name is geographical information “technology” and not “systems”, since it is the technology and its use that is in focus, not the system as such. This, however, does not mean that the course have to be a technical in its nature. It could be in social science or any other subject. Compare a course in scientific writing with a course in a word processing software or a course in presentation techniques compared with a course in Microsoft Power Point. Obviously, the course name can be changed to suit the particular study programme.

Level: Directorate–General for Education and Culture (2005) divides courses into three cycles, undergraduate (bachelor), graduate (master), and post graduate (doctorate). This is an introductory course to the subject area and the students can read it as a free standing course or as included in a Bachelor’s or undergraduate engineering programme. Therefore, the course level belongs to the first cycle (undergraduate or Bachelor).

Depth of study: Since the student is not expected to have any previous knowledge of GIS, the depth is introductory (equals old A-level in Sweden).

ECTS: 7.5 ECTS equals 5 weeks full time student work effort (200 hours or 40 hours a week).

Moment: Here it is suggested that the course is examined through a written exam (2.5 ECTS) and through mandatory exercises with hand-in reports (5 ECTS). This can be changed according to the universities’ own wishes. Other possibilities include projects, seminars, etc.

Education area: Examples on areas can be geomatics, geoinformatics, geography, physical planning, etc., depending on the context.

Subject area: Examples on areas can be technology, natural science, social science, etc., depending on the context. There may also be combinations of subjects.

Learning outcomes: First the general purpose of the course is described, then the more specific knowledge that is required (in terms of expected learning outcomes) to pass the course. These learning outcomes are preferably expressed in line with Bloom’s revised taxonomy (Anderson and Krathwohl, 2001) (cf. next section on Bloom’s revised taxonomy). The listed learning outcomes described in this paper should be included irrespectively of the institution, programme or subject that gives the course. Besides the listed learning outcomes, depending on the context of the course, more specific ones can be added – e.g. introduction to remote sensing, GIS in a specific type of organization, cartography, use of GPS, etc. Note that all learning outcomes express minimum requirements for the students to achieve and that they all must be examined and receive a passing grade. Thanks to the expected learning outcomes, the potential employer can more easily estimate the student’s acquired qualities.

As every learning outcome should be examined it is advisable to have a few general items for grading. Furthermore, learning outcomes that are to be graded between A to F should preferably be written in a general style to make it easier to separate student performances into A to F. This is implemented for the proposed harmonized course later on in this paper (cf. Table 2).

Course content: Besides the listed learning outcomes, further information is given on the content of the course – e.g. which type of databases that used. Other things that are not examined, but treated in the course, should also be listed here – e.g. use of satellite images or elevation models in different application areas.

Tuition forms: Here lectures and exercises have been suggested. These can be changed according to the universities' own preferences. Other forms can be projects, seminars, etc. It should also be possible to see if the course is given wholly or partly on distance.

Prerequisites: Basic eligibility, which means secondary school. If the course is given with a particular aim or content, further prerequisites may be specified – e.g. if this is a basic course in GIT which deals with data or analyses where advanced skills in another subject is needed.

Examination: Depending on how the course is built up, other forms of examination can be used – e.g. oral presentations, etc.

Grading: The expected learning outcomes form the minimum requirements for a passing grade, i.e. grade E or pass. If a student shows deeper knowledge and skills, a higher grade is granted. Some of the learning outcomes may be graded between A to F and some may be just pass or fail (Directorate-General for Education and Culture, 2005). Criteria for grading the learning outcomes should not be included in the course curriculum, but must be available for the students in the course information package.

Limitations: Here it can be specified if the numbers of examination occasions, etc., are limited.

Course literature: The particular textbook "Eklundh, L. (Ed.), 2003: Geografisk Informationsbehandling – metoder och tillämpningar" was decided upon the lecturer network meeting. Other textbooks may also be used, especially for programmes in non-technical areas, but the meeting wanted one book to be recommended and to that give more detailed reading directions. If the course is given in a special context, further literature may be included.

Comments on Bloom's revised taxonomy and learning outcomes

The learning outcomes in the proposed harmonized course curriculum are expressed according to Bloom's revised taxonomy (Anderson and Krathwohl, 2001; Krathwohl, 2002). The taxonomy is most easily understood if viewing it as a spread sheet (Table 1). On the vertical axis the knowledge dimension is shown, consisting of four different knowledge levels. The levels vary intuitively from Factual knowledge over Conceptual and Procedural knowledge to Metacognitive knowledge. On the horizontal axis, the cognitive process dimension is shown, consisting of six different cognitive levels. Also those vary intuitively, from Remember over Understand, Apply, Analyze, and Evaluate to Create.

Table 1: The revised Bloom’s taxonomy after Anderson and Krathwohl (2001), including the learning outcomes of the proposed harmonized GIT course (indicated by numbers in order of occurrence in the course curriculum).

Level	The cognitive process dimension The knowledge dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
A	Factual knowledge (Basic element of discipline)		1, 2, 3, 4	5	6, 7	8, 9, 10	
B	Conceptual knowledge (Basic elements and their interrelationship)						
C	Procedural knowledge (Knowledge of methods and criteria for using them)						
D	Metacognitive knowledge (Awareness of one’s own cognitive)						

By combining the knowledge dimension and the cognitive dimension, learning outcomes can be expressed in a straightforward manner. The knowledge dimension gives the “noun” and the cognitive dimension gives the “verb” of the learning outcome. For example, the 2nd learning objective: *The student will be able to explain the difference between raster and vector format* places “difference between raster and vector format” together with “explain” on the A level in the box with the number 2 in Table 1.

In a crude sense, the knowledge dimensions appear to follow the progression of different university levels. In many subjects, and especially GIT, students have no or limited earlier knowledge and the courses on undergraduate programmes start by giving the students factual knowledge. At intermediate level, the courses tend to be more conceptual and the students are trying to put different elements together and use them. At the more advanced C level, the students should be aware of different types of methods and how to use them. Many Bachelor theses are based on this level of knowledge. At master’s level the students are expected to have Metacognitive knowledge, i.e., not only are they supposed to be able to carry through projects with different types of knowledge, they should also be aware of their own limitations in relation to the chosen methods.

Despite all discussions on learning outcomes in connection to course curriculum, it is in the course information package learning outcomes have to be expressed in relation to specific assignments. Here the course objectives and content must be elaborated as well as the requirements; for example if practicals, assignments, and seminars are obligatory elements for the students to attend. An example of how grading criteria can be written is shown in Table 2. Although this is based on the previously mentioned curriculum from Stockholm University, which serves as an example since grading criteria still is under development at most universities, the learning outcomes can also be used on combinations of the list given in the suggested curriculum. As all learning outcomes should be examined, here it is argued that more general descriptions of outcomes should be used. In the example given in Table 2 students are expected to use an adequate terminology, show that they are aware of which data is primary and secondary, and that they have arguments for choosing appropriate data structure for the problem at hand. Hence, the project part of the task will include items 1, 2, 3, 4, 5, 7 and 9 of the suggested curriculum. Here, it is essential that awareness of reference systems and projections be shown. The literature seminar focuses on items 9 and 10. The second part of the written exam is mainly theoretic problem solving. Expected answers cover a conceptual model of suggested solution(s) and argumentation for the chosen method. As can be seen from Table 1, the latter will try to examine learning outcomes on Bloom’s B and C

level, which is a somewhat deeper knowledge level than is proposed in the harmonized curriculum.

Table 2: Example on how grading criteria can be written for different types of learning outcomes. The learning outcomes are combinations of listed outcomes of the general curriculum. Note that these criteria also evaluate Bloom's knowledge levels B and C, and not only A which is the level focused on in the proposed harmonized curriculum.

Learning outcome	Use GIS in a project	Evaluate geographic data and processing methods in GIS	Give further details of basic terms and theory in GIScience	Combine external data into own databases. Perform processing, analysis and presentation in GIS from data collection to report
Examination Grade	Reporting application project	Seminar assignment and participation in literature seminar	Written examination, part 1, max 20 p	Written examination, part 2, max 20 p
A	A-B: Worked through analysis with alternative solutions.	A-C: Developed discussion and comparison of information in textbooks, papers and tutorials as well as good oral argumentation D-E: Reviewing discussion of information in textbooks, papers and tutorials and oral argumentation	Sufficient (>= 80%)	Very well-reasoned data collection with well motivated choice of clearly defined data (>=95%)
B	Relevant method with strong theory connection and good documentation			Well-reasoned data collection with well motivated choice of clearly defined data (90-<95%)
C	C-D: Worked through analysis and relevant method with strong theory connection and good documentation			Well-reasoned data collection without evident shortcomings. Relevant choice of data (80-<90%)
D	E: Relevant method and documentation			Well-reasoned data collection without evident shortcomings. Relevant choice of data but with a narrow outlook (70-<80%)
E	Fx: Relevant method but is not possible to follow in documentation. Lacking formals.			Well-reasoned data collection with some shortcomings. Relevant choice of data but with a narrow outlook (60-<70%)
Fx	F: Irrelevant method	F: Mainly a review of textbooks, papers and tutorials as well as insufficient oral argumentation	Insufficient, part 2 is not considered	Irrelevant methods or insufficient extent (55-<60%)
F				Irrelevant methods and insufficient extent (<55%)

The nature of problem treated in a course is more an issue for the main study subject, and focus will be different for an archaeologist and an engineer. In the discussion of map-making, e.g., this topic may be subdivided into those who will use maps mainly as a data source, and those who will use GIS for map making. In basic courses there is limited time to teach map design, but most people using GIS will use map data as source material. Hence, the perspectives of data acquisition and subdivision of map features using paper maps are essential for the final quality of an analysis in GIS.

Comments on grading

Participation in mandatory tuitions is a prerequisite for grades A to E. In the final grade the learning outcomes, as illustrated by the example in Table 2, are weighted. For example, assume the following result: the project C-D, the seminar assignment A-C and written examination C. Grades are qualitative data on ordinal measurement scale. Possible methods to summarize the final grade are to use mode or median. Here median is preferred, which gives

the central tendency. The problem is that there is better precision in the written test – one grade corresponds to a range of grades in other outcomes. This can be managed by weighting the grades: CD, ABC, CCC. The grades are sorted from lowest to highest grade: ABCCCCD. The median is the middle value. If it is an even number of letters there is a need to use a rule, for example that the value is truncated. This will give the final grade C. If the project is weighted higher, then it could look like CCDD, ABC, CCC. Also note that learning outcomes that are graded with the highest precision, i.e. all grades of A to F are used, together must have enough weight, otherwise they will have no effect on the total grade. With this method no transformation to numbers is needed. Furthermore, since emphasis often is put in explanation of measurement scales in GIS, as it is a GIS operator's task to consider the interpretation of numerical data values; this is an example of applied use of awareness of measurement scale.

It is not necessary to use seven grades for all learning outcomes. However, the principle to weigh the performance of every task has to be transparent. Also, referring to Bloom's revised taxonomy, in a more advanced course there may be a certain level of factual knowledge the student need to perform in order to be evaluated in a second part of theoretical examination, namely conceptual and procedural knowledge. The literature seminar trains the cognitive performance and finally the application project the creative capacity. Generally, this principle is possible to keep on all levels. Difference can be done in implementation difficulty of the application project, theory needed in the science field applied in the project or overview of the field of geographic information science, to mention a few options.

It must be noted that new regulations in Sweden state that all grades must be goal related. A common way to express such grades are, e.g., A as excellent, B as very good, C as good, D as satisfactory, and E as sufficient fulfilment of a learning outcome. The ECTS grading scale, on the contrary, is a relative scale. Of those fulfilling the learning outcome, 10% are supposed to get an A, 25% a B, 30% a C, 25% a D, and 10% an E (Directorate-General for Education and Culture, 2005).

Discussion

The idea of this course curriculum is to produce a template for a basic GIS course that most universities in Sweden can use. Courses are normally announced by describing the course content, which is included in the curriculum and adapted to a main subject, a study program, etc. Some idea of employability is also anticipated in the description of the subject, program, etc. Likely, there will be a number of curricula in GIS/GIT depending on study subject. If a course is given on master's level, e.g. where another subject requires deep knowledge, but where the GIS is on basic level, this "double classification" should be noted in the course curriculum. However, thanks to a harmonized course curriculum, other universities can assess the students' knowledge which facilitates enrolment on more advanced courses.

It should be noted that if all introductory GIS courses would have the same content, certainly they also would not be appealing to all types of study programmes. Therefore, it is important that each university carefully supplement the proposed course curriculum so it fits the general content of the study programmes. For universities in Sweden, normally five to eight learning outcomes are listed. If more learning outcomes are added, as is suggested here, it may seem that the course will appear too scattered. But, the advantage of including more than eight should have a positive effect on making the course enough general so that it can be used as a prerequisite for most of Sweden's more advanced GIT courses. What may seem to be lost in

specific content will be gained with respect to further study possibilities for the students. A drawback on having too many learning outcomes is that it possibly may lead to more work for the lecturer to grade students' achievements. The proposed curriculum could in fact have many more learning outcomes, since many more were suggested, mainly depending on which subjects the respondents represented. However, it was decided to leave out learning outcomes such as basic cartography, etc., since they either can be added to and included in the proposed curriculum, or be present in a strict cartography course, as is the case at many of the Swedish universities.

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