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THE GIS LEARNING ENVIRONMENTS AT THE INSITUTE OF TERRESTRIAL ECOSYSTEMS OF THE ETH ZÜRICH

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Abstract: *In the frame of the major "forest and land use management" within the Bachelor (BSc) and Master (MSc) studies of environmental sciences, the Group of Forest Engineering (PIW) of ETH Zurich has developed a concept for the GIST education and training with a total amount of 180 hours (BSc), respectively 90 (MSc) hours.*
The aim is the development of a modern learning environment, teaching on one hand the theory of GIST and on the other hand, using real world problems, to stimulate the development of students' practical skills in GIST applications. The students are trained using a standard GIST approach for their analysis abilities as well as on some important qualification keys like problem solving, project management, design and the use of media technologies for communications.
GIST courses are be carried out with commercially available GIS software, installed on selected computers on a training classroom using a geodata server working environment.

1. Introduction

Geographical information sciences and - technologies (GIST) became an interesting topic around the end of the 1990's, strengthening its introduction into most diverse branches of space referred science, management and administration. This was naturally followed by a large and constant grow of demand for training at university education level.

As GIS technology has become generally available, as well as more user-friendly, an erroneous notion developed in some quarters that these changes mean that the technology can be mastered by almost anyone with only a minimal investment of intellectual effort. This has led a number of academic units to structure their programs so that only an introductory course in GIS (and often one that concentrates only upon the details of operating a specific, off-the-shelf software package) is all that is considered necessary to fully make use of this now powerful tool, while the learning path in GIS should be seen as a multi level approach as suggested by Prof. Duane Marable.

The need in spatial analysis today is not for further polishing of existing tools and ideas, but rather to realize that we can now move on to a host of exciting new research areas that GIS technology makes possible. Besides this also in the filed of environmental sciences there is clearly a very strong and increasing demand for individuals who are educated to a level where they can effectively work with, and continue to develop, modern GIS technology (Marable, 1997).

With the introduction of the bachelor (BSc) and master (MSc) course "environmental sciences" at the ETH Zurich, 3 GIS courses will be offered to the students. In this article we describe the structure and content of our GIS courses as well as our experiences.

2. Overview

The Forest Engineering Group of the Institute of Terrestrial Ecosystems offers three courses for the Bachelor and Master students of environmental sciences at the ETH Zurich:

1. Introduction into Geographic Information Science and Technology (GIST), 6th semester BSc;
2. GIS Case Studies (GISCS), 6th semester BSc;
3. Spatial Analysis and Modelling (SAM), 8th semester MSc.

All three GIS courses have the following teaching aims:

- Providing an understanding of the theoretical and practical-operational, basic knowledge and its application in the area of the geographical information sciences and technologies.
- Acquisition and application of independent analysis skills.
- Appropriation of systematic problem analysis techniques and - methods as well as (medium) technical, communicative, cooperative and social capacity to interact in a working group environment.
- Master a method to implement spatial modelling using GIS technology.

2.1. Learning philosophy

The teaching environment used for the three GIS courses is based on a moderate constructive learning philosophy, defined by REINMANN-ROTHMEIER et al. (1997) as follows:

- The courses shall spark interest and motivate the students.
- The conceptual design should allow self-directed learning.
- The courses shall include previous knowledge and integrate this knowledge.
- The acquisition of knowledge shall occur in interaction with other people.

Additionally, due to the integration of a project work, we follow the approach of problem-based, respectively problem-orientated learning, too.

From a cognitive point of view, the courses are orientated on Bloom's taxonomy (BLOOM, 1972), which includes – from the simple recall or knowledge of facts up, to the ability to evaluate something - the following 6 levels: knowledge (level 1), comprehension (level 2), application (level 3), analysis (level 4), synthesis (level 5), and evaluation (level 6).

Considering this taxonomy we can state that our GIST course covers the levels 1 to 3. The GIS Case Study course and the Spatial Analysis and Modelling courses cover all 6 levels.

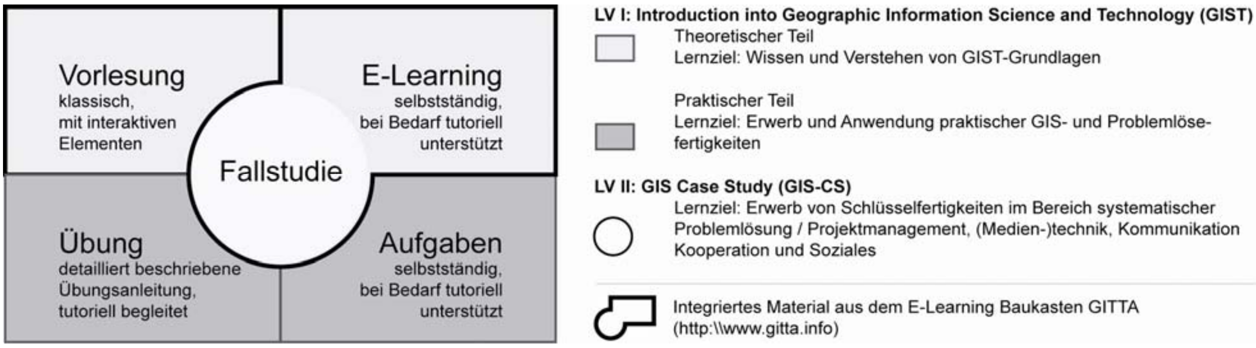
3. BSc courses description

Based on this philosophy and the above mentioned overall learning objectives, the following two courses have been developed for the BSc:

LV I: Introduction into Geographic Information Science and Technology (GIS)

LV II: GIS Case Studies (GIS-CS)

The selected learning/teaching arrangement is blended-learning and is shown for these two courses in figure 1:



3.1. Course I : Introduction into Geographic information Science and Technology (GIST)

This course gives the fundamental concepts of Geographic Information Systems (GIS) imparted and subsequently enlarged using practice-related examples. The course is a 5 credit points (~ 150 hours) and is composed by 7 modules. It include plenary lectures (Vorlesung), selected complemented self-study modules (e-learning), detailed instructed exercises (Übungen) and duties (Aufgaben).The aim is to give students the ability to independently solve elementary close to reality problems in the domain of GIS. Within the lectures, interactive elements are integrated in order to assist the students' learning process. The lectures are integrated using selected e-learning lessons. Every theoretical part is followed by one practical exercise explained using a step by step approach. To complete the practical part a realistic problem oriented tasks must be worked and solved by the students independently.

Contents

Module 1: System Definition

The objective of the first module is to understand the fundamental definitions within the range of geoinformation system, science, and technology. Additionally, an outline on the substantial conditions and components of geoinformation systems and their fundamental functionalities is given.

Module 2: Spatial Modelling

Students learn different methods of spatial representation, where these methods differ in principle, how and why a certain spatial representation is determined by the application purpose. Finally the student learn the fundamental characteristics of the vector/raster representation, understand their geometry and the use of their attributes.

Module 3: Data Capture

This module gives an overview of the main sources of geographic data: data acquisition methods and data purchase, looking at the fundamental technologies and systems of data acquisition as well as their functionality in principle. The students also get an overview of the most important internet sources for geodata: Geographic data institutions and on-line sources.

Module 4: Data Modelling

The fundamental concepts of data base management systems are explained and illustrated in this module. This also gives the tools to understand the relation between spatial representation and data modelling and the importance and function behind a conceptual data model. Part of this lecture is also an introduction to UML (Unified Modelling Language) as a visual language for data modelling, to its fundamental elements (classes, attributes, relations, cardinality, role) as well as proprieties and functions. At the end of the lecture the students are able to use UML on the basis of a simple example.

Module 5: Data Analysis

Within this module, the fundamental purpose of spatial analyses and the most important methods are explored and explained. An overview of fundamental operators of the vector/raster analysis is given including the topological function and relational operators as well as the main raster functions types.

Module 6: Data Presentation

In module 6, an introduction to the subject data presentation and cartographic aspects is given. Its emphasis is on topographical cartography and the components required for map development, including graphical design with text and colour by reference to readability rules. A further focus concentrates on cartographic generalization concepts, procedures, and methods. Within the intermediate lessons, thematic map designs as well as mapping with a GIS and cartographic software are discussed.

Module 7: GIS in the praxis

An extern expertise is invited as referent to describe his professional experience with GIS in the private sector.

3.2. Course II : GIS Case Studies (GISCS)

Based on the learning contents of GIST, this second GIS course offers a case study on environmental problem. The theme and the structure of the case study help reframe the learning contents of GIST.

The case study is designed as follow: Based on a real problem, the students have to carry out a systematic problem analysis. In a second step, they have to write a project plan, build up a conceptual data model and a data process model. Then the students carry out the analysis and finally, they present and defend their results to the other students within a role-playing game.

4. MSc course description

In the MSc “environmental sciences” course, major “forest and landscape management”, the Forest Engineering Group developed the concepts and contents of the course „Spatial analysis and Modeling (SAM)“. This course is a 3 credit points (3 ECTS) of 90 hours and continue the development of the contents taught in GIST within the BSc of studies in „environmental sciences“.

4.1. Course I Spatial Analysis and Modelling (SAM)

The lectures of „Spatial analysis and modelling (SAM)“ have as primary objective to give students a good theoretical knowledge on spatial analysis and modelling and to mediate the use of GIS in this field of application. Besides the theoretical knowledge transfer, the goal of the course is to support the students in a problem-based thinking and working environment. The aim is to give them the tools to use when implementing an operative project using the available technology bringing them to communicate between each other in a co-operation and social contest.

The practical aspect of the course takes advantage of many official geo and spatial data available at the PIW referred to a specific research area, Waegital in canton Schwyz (CH) where many research projects have been carried out in the past. Besides the data availability the area was chosen because taken as reference by the Interdiciplinary Project a field course schedule in the same semester as SAM where students have to answer scientific questions and real land use problematic using GIS.

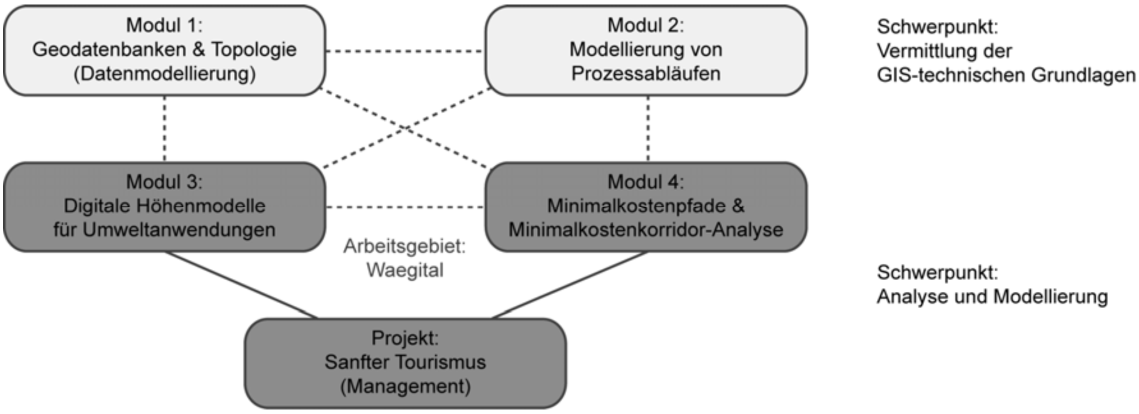


Fig. 2: Course structure and topics of „Spatial analysis and Modelling“

As shown in figure 2 SAM is subdivided in 4 main modules and a final project. As in the GIST course, the theory is complemented with selected e-learning lessons. Every theoretical part is followed by one practical exercise, in this case not using a step by step approach, but giving the students different open tasks to solve using the learned theory and coaching them with a more interactive approach.

Contents

Module 1: Geodatabases & topology (data modelling)

This first module generally presents the concept of geodatabases and the 4 steps which can be used to implement a geodata model: a) describe a spatial model, b) extract the elements to implement in the conceptional model, c) define a logical model and d) implement the data in the physical model.

Using the implemented geodatabase the students will define their own geodatabase, and import data from different formats. An overview of the available topology rules to become familiar with the spatial relationships between objects, which will be of use in the following modules, is also given.

Module 2: Modelling data processing

Module 2 deals with the development of models to automate GIS data processing as well as their documentation. The students learn first, to read and understand given models and in a second step they develop their own models and will have to document them.

Module 3: Digital terrain models (DTM) for environmental applications

Here the students get a closer look to this type of geographic data and learn the processes involved in generation, manipulation, interpretation, visualization and some of their application. The students will generate different DTM from a point dataset by means of different algorithms and interpolation techniques, will compare and discuss the calculated surfaces and will select one of the models. The chosen model is corrected using a standard method and the student will utilize it to extract the drainage network of the research area.

Module 4: Minimum cost paths/minimum cost passage analysis

This module concerns the development of spatial models to estimate the accessibility costs and the evaluation of economical measures on the basis of the height and water drainage models calculated in module 3. With the help of practical examples (e.g. modelling of game animal corridors) the students learn how and when it is useful to implement the distance functions, cost functions and minimum cost algorithms.

While in module 1 and 2 the technical bases, like data structure and data processing, are given to handle the following modules and the implementation of the final project, the emphasis of module 3 and 4 lies in the range of the analysis and modelling of spatial scientific questions. The four modules are directly linked to each another, i.e. the results of a preceding module flow as inputs into the module that follows. Together the four modules build up the theoretical and technical basis for the final project implementation.

Project

The topic of the project is the development of a sustainable tourism management plan in order to stimulate tourist flux into the Waegital, finding suitable locations for biking, hiking, and animal observations. With the help of different scenarios the students understand, what is the effect on the distribution of tourists in the investigated area, driven by different type of measures that have to be taken (e.g. plan of new parking lots, restaurants and hiking paths, etc.).

To carry out this analysis the Good Modelling Practice (STOWA/RIZA, 1999) approach is used. This handbook was written in order to stimulate the correct use of models giving a list of steps and guidelines to be followed to perform a truthful implementation of a modelling process.

5. Results

The evaluation of the written and oral interviews has shown that the students like the selected learning philosophy, in particular the problem-orientated approach within the case study and project work. The students also liked the role-playing game and described their experiences as “interesting and informative in respect to the demands of a future employee” and “informative concerning the grading of the own solution”.

Although the students have the possibility to work at home, most of them prefer to attend the fixed time slots, where tutors are available in order to get a fast feedback. Otherwise, small problems like “where to find that tool”, “why doesn’t that work”, “what happens there” takes to much time.

6. 6. Outlook

The future development of the GIS learning environment at the department of environmental sciences can be seen from two points of view.

Technically the focus is putted on the development of a new soft-grid geodatabase infrastructure. The idea is to develop a lighter working environment for the students, accessible via the web. Soft-grid (Microsoft TM) is a software virtualization solution to deliver applications that are never installed, yet securely follow users anywhere, on demand. The Geodata server is a central entity in a multi user GIS environment where geographic information, spatial and non spatial, is stored into an object relational database using different data format. These two elements will define a new GIS environment for didactic purposes, giving students and researchers a new tool to access GIS data and applications using a “virtual” solution and a structure to better manage their GIS data via a real database environment from every internet facility.

On the didactic side a new course which will deal with GIS and web applications and programming tools, is under development and will probably be scheduled in the next year and a half.

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