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Review of Environmental Informatics Education in Germany and selected European Universities[2]

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Abstract

In this introductory article for the Environmental Informatics education workshop an overview of study programs in Germany and rudimentary for some other European universities is presented. The focus is laid on degree programs with a significant fraction of informatics content as recommended by the German Computer Society (GI-Gesellschaft für Informatik) for Informatics Bachelor and Master programs, classified in type 1 and type 2 curricula. Thus only degree programs have been stated where informatics departments are solely responsible (type 1) or where Informatics is jointly in charge with a related application discipline (type 2). Six relevant German degree programs within this scheme have been identified and analyzed.
Further we have a look overseas and point to master programs in England, France and Scandinavia. Interestingly, there are no bachelor programs in Environmental Informatics known in these countries which could be classified into type 1 or type 2 curricula in accordance with GI regulations.
This listing does not demand completeness although a thorough analysis of literature and of the web and personal contacts has been carried out and documented recently in the context of a bachelor thesis.
Finally this article refers to a German PhD program in Environmental Informatics embedded into a terrestical ecosystems research school.

1. Introduction

The core characteristic of the emerging discipline of Environmental Informatics is an interdisciplinary endeavor resulting from a blurring of the boundaries between applied informatics (including information systems) and environmental sciences as well as a number of areas in the natural and social sciences as well as in economics. Therefore, all educational efforts in Environmental Informatics are based on a strong trans-disciplinary approach.

The aim of this conference workshop is to sketch a picture of academic educational programs in Environmental Informatics with a substantial computing background in Germany and selected European countries. In general, the spectrum spans from single courses on related topics, over fields of specialization in Environmental Informatics within other degree programs (e.g. applied informatics or applied computer science, respectively, geosciences, business, ecology,..) up to full degrees in Environmental Informatics (e.g. on bachelor or masters level). However, in this workshop we laid the focus on academic programs with a significant fraction in informatics; i.e. programs compatible to the rec-

ommendations of the German Computer Society (GI – Gesellschaft für Informatik) for Informatics study programs on the Bachelor and Master level with a special application subject (minor) such as environmental sciences (so-called Type 2 curriculum) (see [2]). In Germany altogether six universities offer Environmental Informatics degree programs on bachelor or master level under the given GI constraints have been found.

The paper is organized as follows: In the next paragraph we describe the six identified German degree programs in Environmental Informatics. Chapter 3 sketches out several European university programs in this field, namely from England, France and Scandinavia. In chapter 4 we briefly introduce a related PhD program at the University of Göttingen. Finally we round up the paper with a conclusion.

2. Study Programs in Germany

Under the six German universities offering Environmental Informatics academic curricula according to the GI-classification mentioned above we can refer to seven bachelor and 5 master degree programs wherein one case a dual approach for the studies (joint professional and academic education) has been chosen. The allocation of credit points is following the "European Credit Transfer and accumulation System" (ECTS) (see [3]).

2.1 University of Bayreuth

University of Bayreuth offers a consecutive bachelor – and master program in applied informatics with a field of specialization in Environmental Informatics (see [4]). The student can choose between the elective application fields environmental modelling, environmental chemistry, hydrology, or soil ecology. Here instructions in informatics, mathematics and in interdisciplinary courses are identical in all application directions. Course distinctions result from the according application subjects where modules from chemistry, hydrology, atmosphere, and soil science are made available. On the basis of the credit point distribution between informatics (80 CP) and application field (52 CP) this study program is getting close to a type 2 curriculum in the GI-classification mentioned above.

The master course of applied informatics allows the selection of the elective subjects hydrology or soil ecology where not a standardized curriculum is required, but a research oriented study plan related to the research areas of the university lecturers is developed on an individual basis. The distribution of credit points is arranged in such a way that 30-48 credit points each are assigned to the areas of informatics and the application field including 12 CP compulsory for seminars and projects. Thus the CP distribution can vary largely between the fields which classifies the curriculum as a type 2 study program.

2.2 HTW Berlin

HTW Berlin runs a unique consecutive bachelor/ master program in Industrial Environmental Informatics with the special application subject of corporate, production-integrated environmental protection (see [5]) since many years. It can be classified as type 2 study program with a sound informatics foundation (appr. 50%) combining computing with economical application fields and applied mathematics, natural sciences and engineering courses. Computing topics address programming methods, data bases, web technologies, and corporate environmental information systems.

On the Master level deepened knowledge in modelling and simulation, software quality and decision support systems is conveyed. For more details see the paper "Study programs in Industrial Environmental Informatics at HTW Berlin" by V. Wohlgemuth in this workshop section of the conference proceedings.

2.3 University of Göttingen

At Georg-August University of Göttingen a master degree program "Applied Informatics" with direction of eco-informatics and forest ecosystems has been established (see [6]). It is built on a bachelor's degree program in applied informatics where similar elective subjects from these areas can be taken. The distribution of credit points in core informatics (31 CP), eco-informatics applications (18 CP), application subject forestry (18 CP) as well as interdisciplinary project work (20 CP) suggest a type 2 curriculum.

2.4 Leuphana University of Lüneburg

Leuphana University of Lüneburg originated a rather different study model for a bachelor's degree. It is composed of a major (90 CP), a minor (30 CP) and complementary studies (30 CP) as well as the introductory Leuphana semester (30 CP) (see [7]). The Leuphana semester and complementary studies are completed jointly by all student groups and allows an insight into different disciplines. At Lüneburg a major in informatics or information systems can be combined with a minor in sustainable development. In the informatics major the fraction of informatics subjects adds up to 75 credit points, in information systems slightly lower to 60 CP. Both correspond to type 2 curricula. The contents of sustainable development are more oriented towards humanities. Beyond that a major in environmental sciences can be combined with a minor in applied informatics. Due to the rather low computing fraction this program can be seen more as an additional informatics qualification, but not as an informatics degree program as addressed by the GI-classification introduced above.

2.5 University of Oldenburg

Carl von Ossietzky University Oldenburg offers a bachelor and master informatics degree program with field of specialization in Environmental Informatics (see [8]). Students can choose their three application modules (18 CP) from environmental systems or environmental economy. With 90 CP from informatics and only 36 CP from the application field this curriculum can be classified more as a type 1 study program. For more details see the workshop paper "Study programs in Environmental Informatics at Carl von Ossietzky University of Oldenburg" by M. Sonnenschein and U. Vogel in this workshop section of the conference proceedings.

2.6 College Ostwestfalen-Lippe

At Ostwestfalen-Lippe College the study program Applied Informatics with specialization Environmental Informatics can be completed on a regular basis as well as in dual mode (professional training and college courses, see [9]). The college courses are the same, but professional training includes practical instruction in enterprises (leading to an additional IHK (chamber of commerce) degree). With a fixed fraction of 62 credit points from informatics this curriculum can be classified as type 2 informatics degree program in the sense of the GI-recommendations. The study program offers a wide range of course selections and combinations between informatics and the application fields (e.g. landscape planning/ spatial development, water technology/ management, material flow modelling). On the master's level a degree in environmental science with specialization in engineering and modelling is offered at the interface of engineering and informatics. However, the informatics content is quite low and the study program can be therefore considered rather as a type 3 curriculum.

Tables 1 and 2 summarize the overview on the bachelor and on the master programs in Environmental Informatics with the contents and related credit points.

Bachelor Program	**University of Bayreuth**	**HTW Berlin**	**Leuphana Major Informatics**	**Leuphana Major** Business Informatics	**Leuphana Major Environmental Sciences**	**University of Oldenburg**	**College OwL**
	Credit Points	**Credit Points**	**Credit Points**	**Credit Points**	**Credit Points**	**Credit Points**	**Credit Points**
Bachelor Thesis	15	15	15	15	15	18 (Incl. Project)	14
Practical phase	-	15	-	-	-	-	-
Intermediate Sum	15	30	15	15	15	18	14
Category							
Informatics	80	66	75	60	30	90	At least. 65
Application field	52	38	30	30	At least 75	36	Up to 43
GI-Type	Type 2	Type 2	Type 2	Type 2	Could not be assigned to a type!	Type 1	Type 2

Table 1: Bachelor Degree Programs Environmental Informatics in Germany (cp. [1])

Masterprogram	**University of Bayreuth**	**HTW Berlin**	**University of Göttingen**	**University of Oldenburg**	**College OwL**
	Credit Points	**Credit Points**	**Credit Points**	**Credit Points**	**Credit Points**
Master Thesis	30	30	30	30	30
Total Course Load	120	120	126	90	120
Category					
Informatics	30- 48	39	Minimum 35	48	Maximum 32
Application Field	30- 48	24	Minimum 18	12	Minimum 35
Internships/ Projects	12- 30 (Environmental Informatics)	18 (Industrial Environmental Informatics)	9 (extern) + 6 (Informatics)	24 (Informatics)	12 (Environmental Sciences)
GI-Type	Type 2	Type 2	Type 2	Type 1	Type 3

Table 2: Master's Degree Programs Environmental Informatics in Germany (cp. [1])

2.7 PhD Program at University of Göttingen

Only recently a specialized PhD program including Environmental Informatics has been initialized at University of Göttingen as integral part of Göttingen Graduate School of Terrestical Ecosystems which is under constitution. Here Environmental Informatics is understood as a synthesis of bioinformatics, geoinformatics, ecoinformatics and scientific computing (see [10]). Under the umbrella of Environmental Informatics a knowledge transfer and a system-oriented integration of spatial bio-, eco and environmental systems over scale levels should be enhanced and improved by modern informatics methods and technologies.

3. Study programs in selected European Countries

Study programs for Environmental Informatics on the European level could only be identified on a more detailed level in England and France despite extensive inquiries on diverse search engines for university place search (see e.g. [11]) and with different key words.

3.1 Environmental Informatics in England

In England Environmental Informatics is only offered on the Master level (i.e. 180 credit points). The degree programs normally takes 12 months and credit points are granted in accordance with „Credit Accumulation and Transfer Scheme "(CATS) (see [12]). Hereby a divergent distribution of credit points from ECTS arises. All master programs are arranged closely to research. If the student is not completing the full master program, intermediate final degrees are available, i.e. Postgraduate Diploma (120 CP) or Postgraduate Certificate (60 CP).

The master's degree program Environmental Informatics at University of Leicester (see [13]) is in particular geared towards the application of GIS- technologies. In addition, basic contents concerning sustainable development and on research methods are covered. Beyond that, other courses from geography/ geoinformatics or topics like climate change, environmental economics and resource management can be signed up as elective modules. The second semester excursions deal with the impact of global change on tropical East Africa or neo-tropical rain forests, respectively. Informatics contingent can differ, however the compulsory share is about 50% of the courses excluding the Master thesis. .

Another master's degree in Environmental Informatics is offered by University of **Lancaster** (see [14]) dealing especially with contents from geoinformatics - and Environmental Informatics. It is carried out under the umbrella of Lancaster Environment Centre (LEC) which brings together environmental researchers with international background to form one of the largest environmental research groups of its kind anywhere in Europe. The modules from Environmental Informatics deal with theoretical requirements for environmental information on one hand, on the other hand with problems of practical conversion of information processing in the environmental domain. In the field of geoinformatics students learn the basic principles of the application of geoinformation systems, remote sensing and computer modeling. Informatics content of the courses lies at 50% at minimum. The elective subjects can be chosen from a wide variety of courses and disciplines. Studies can be completed with a research internship or a research thesis.

University of **Bournemouth** is another academic institution in England with a master's degree program in Environmental Informatics (see [15]). The study program distinguishes itself by the aim to qualify its graduates to gain leading positions in high ranking consulting positions with political influence and scope of design. This becomes apparent by key aspects like environmental policy and decision support systems as well as by a professional internship available at different governmental organizations. It seems that informatics content is quite low in this curriculum. Thus the study program can be rather assessed as type 3 curriculum in accordance with GI-recommendations.

3.2 Environmental Informatics in France

In France the master's degree is organized in a different way, namely they are typically two years long (with 120 Credit Points according to ECTS) and are divided into a Master 1 (M1) and a Master 2 (M2) comprising one year of study each (see [16]). By combining an environmental M1 with a M2 in informatics an Environmental Informatics study program comparable to the German model comes about. In doing so the M2 in informatics serves as means for preparing students for the practical professional life. It is on purpose not research oriented.

At University **La Rochelle** a Master M1 in environmental sciences with direction on applied geography in coastal management is provided (see [17]). Thus a clear focus on issues of coastal preservation is given for the compulsory course modules. Beyond that a large number of electives from very different related disciplines are in supply in both semesters.

University **Paris** Sud 11 offers a M1 master program in environmental sciences with fields of study in ecology, physics, chemistry, geology, economics, law or medicine – each with an environmental orientation (see [18]). A number of modules are assigned to the major subject, others are passed by all graduates jointly. Topics belonging to the joint courses deal with environmental protection, ecology, chemical and physical interferences, environmental law or environmental economics.

The M2 master's degree programs at University La Rochelle and University Paris Sud 11 in informatics hardly differs in regards to content, except for the length of the professional internment. These contents are operating systems, computer architecture, programming, date bases and networks. The rate of Informatics in both degree programs is about 50% due to the fact that M1 (60 CP) mostly consists of non-informatics fields of study and the M2 (60 CP) nearly fully consists of informatics contents.

3.3 Environmental Informatics in Scandinavia

The faculty of computer science at Ostfold University College in the Norwegian cities of Halden und Sarpsborg runs a "Master of Computer Science" allowing a field of specialization in the discipline of Environmental Informatics (see [19]). Altogether 120 credit points are required where 45 CP are allocated to the master thesis and individual research. The remaining credit points are divided into 45 CP of Environmental Informatics and 30 CP of core informatics.

The study focus are the representation and visualization of large environmental data, covering digital maps, computer graphics, decision support systems, and simulation modelling.

4. Conclusions

Environmental Informatics is a quite novel academic discipline with a strongly interdisciplinary character and only few special study programs on university level (bachelor's or master's degrees). In this study an overview on specialized academic degree programs in Environmental Informatics has been elaborated where a significant informatics content has been paid attention to (defined as type 1 or 2 curriculum in accordance with the German Computer Society (GI) regulations). Although a thorough search and analysis on the national and international level has been performed only few specialized programs with significant computing foundation could be identified on the European level, most of them in Germany (6 study programs) with only a few others in England, France and Scandinavia. In many cases they are closely linked to geosciences or GIS, respectively, more recently also to business informatics (i.e. information systems).

It is clear that there must be many other related curricula outside the informatics discipline (e.g. environmental or geosciences) with some specialized environmental computing courses around, however these have been out of the scope of this study.

Several of the German degree programs have a longer history (e.g. HTW Berlin or University of Oldenburg) and have been introduced already at the time of the traditional German diplome scheme. It is apparent that the two-level bachelor's/ master's degree today provides an even better basis for the introduction of an interdisciplinary course like Environmental Informatics. The two-year master program with two different phases (one year environmental sciences, one year informatics), typically found in France, seems a very suitable framework for establishing an ambitious Environmental Informatics course on the graduate level.

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