

Study programs in Environmental Informatics at Carl von Ossietzky University of Oldenburg (Germany)

Ute Vogel, Michael Sonnenschein

Carl von Ossietzky University Oldenburg, Department of Computing Science

D-26129 Oldenburg

Michael.Sonnenschein@uni-oldenburg.de

Ute.Vogel@uni-oldenburg.de

Abstract

The paper outlines the options to study Environmental Informatics at Oldenburg University. We focus on the Environmental Informatics specialisations in the Bachelor and Master programs in Computing Science. Our specialisation in Environmental Informatics is currently being changed in the process of a re-accreditation. So, we give an overview of the current and of the future constitution of the specialisation in the study programs, motivate the changes in the programs, and discuss the success of the specialisation and the included special courses. Besides the specialisation 'Environmental Informatics', in the revised study programs are offered some more environmental-related specialisations in computing science ('information technology for energy management systems' in the Master program of Computing Science and a specialisation in 'Corporate Environmental Management Information Systems' in the Master program of Business Informatics). Additionally, environment-related Master programs of other faculties are open to our Bachelor students and therefore briefly addressed here.

1. Introduction

Environmental protection and sustainable development have been a central focus of the research and teaching agendas of the University of Oldenburg since its establishment in the year 1973. Located in the vicinity of the North Sea coast, Oldenburg has pioneered marine research and renewable energies research. Parallel to these core competencies in the field of natural science, Oldenburg's ecological research and teaching activities have reached out to include the economic and social sciences, information technology, educational research and other disciplines.

The resulting broad and still growing base of environment-related courses has supported the introduction of an Environmental Informatics study as a specialisation and emphasis in the degree program Bachelor in Computing Science and the former German study program 'Diplomstudiengang Informatik' in the year 2001. An extension to the study program Master of Computing Science is currently in implementation.

The idea of setting up a specialisation in Environmental Informatics has developed from the research interest of our research group 'Environmental Informatics': Several projects with ecologist at this time have roused our interests in specialised tools for modelling and simulation of ecological systems (e.g. Lorek et al., 2000; Lorek et al 1999; Vogel et al., 2000; Köster et al., 2000; Sonnenschein et al., 2001). So, originally the Environmental Informatics study in Oldenburg has been affected by an orientation towards ecological applications.

Accompanying the constitution of Business Informatics in Oldenburg, the variety of courses has expanded to application of Environmental Informatics in economics. Besides, the Master's program 'Business Informatics', which has been implemented in 2007, offers a specialisation in 'Corporate Environmental Management Information Systems' provided by our colleague Jorge Marx Gómez.

In accordance with the research and study activities in renewable energies in diverse disciplines and research centres at the University of Oldenburg, as well as in our research institute for applied computer science, OFFIS, the newly restructured study program Master of Computing Science also allows an orientation towards information technology for energy management.

In this paper, we will focus to the specialisation of Environmental Informatics toward ecological applications. The paper is structured as follows: first we give an overview of the current structure of the Bachelor's and Diploma specialisation in Environmental Informatics. After that, we describe the new structure of the Bachelor's and Master's specialisation in Environmental Informatics after its re-accreditation that holds for the programs starting from winter 2009. Finally we will shortly discuss the options of changing between programs and to other Master's programs related to environmental topics also offered at Oldenburg University.

2. Curricula

We currently offer a specialisation in Environmental Informatics embedded in the Bachelor study program of Computing Science as well as in the former Diploma study program which was closed in 2007. With the re-accreditation of the Bachelor program in 2009, our Bachelor and Master study programs have been revised. So, firstly, we will describe the present environmentally related study program and afterwards the changes of the revised programs.

2.1 Bachelor study program

2.1.1 General structure

The Bachelor study curriculum consists of an education in core subjects of computing science and its underlying basic mathematics. It lasts 6 semesters with 5 modules per semester and is assessed with 150 Credit Points (ECTS).

The core modules are specified as

- Mathematics (4 modules, 24 credit points): Calculus 1, linear algebra 1, discrete mathematics and a choice of courses in calculus 2, numeric, statistics or stochastic,
- Introductory courses to theory of computing science (12 credit points), computer engineering (12 credit points), algorithms, data structures, and programming concepts (12 credit points), software engineering (6 credit points),
- Laboratory courses: Programming in Java (6 credit points), software project (12 credit points), and computer hardware technologies (6 credit points),
- Courses in 'soft skills' and 'IT and society' (6 credit points each).

Up to 54 credit points can be used for studying a specialisation in computing science and its application - alternatively a minor subject can be chosen (up to 42 credit points). 18 credit points are dedicated to the Bachelor's thesis. If a specialisation is chosen, the topics of the Bachelor's thesis as well as the choice of the mathematics course may be claimed to be related to the specialisation.

2.1.2 Specialisation in Environmental Informatics

The specialisation program in Environmental Informatics is based on courses in the application domain, courses on applied informatics, and special courses on environmental informatics. It consists of nine courses each achieving 6 credit points.

Environment related courses constitute about 24 credit points of the curriculum. These courses are chosen to give student an insight to environmental related topics from the natural sciences point of view as well as from the economics' point of view. The students are quite free in their choice of courses: the catalogue of suitable courses covers

- Introduction to the life sciences and geo sciences,
- Urban and regional planning and development,
- Ecology,

- Courses related to ‘ocean, climate and energy’, which covers special aspects of geophysics, wind energy and energy meteorology,
- Environmental planning, protection and law,
- Decentralized energy systems, an interdisciplinary course of electrical engineering and computing science,
- Environmental politics from the economists view,
- Environmental economics,
- Economics of resources and energy.

Three courses - 18 credit points - are chosen as courses in applied computing science: the course information systems has to be chosen, the two other courses are recommended to be related to databases, computer networks, internet technologies, knowledge representation, business administration or multimedia.

The remaining credit points are dedicated to courses covering the bridge between computing science on the one hand, and its transfer to applications on the other hand.

Beside courses and seminars covering specialised and current topics, the core courses

- Modelling and simulation of ecological systems,
- Environmental information systems (EIS), and
- Environmental business information systems

are offered yearly.

The course ‘Modelling and simulation of ecological systems’ gives an overview about various methods in mathematical modelling (e.g. ODE, markov processes) and in discrete modelling and simulation (e.g. cellular automata, individual based modelling, discrete event based simulation) which can be used for modelling and simulation of ecological systems. The course offers also a lot of examples of ecological models, and a short overview of techniques for model validation.

The course ‘Environmental information systems’ covers on the one hand the topics data capturing and pre-processing, esp. in sensor networks, data storage with a focus to spatial databases and multi-dimensional access methods. These contents have evolved from (Günther, 1998) and adapted to the development of the field. On the other hand, data analysis, in particular an introduction to data mining methods and geo-statistics, as well as basic methods of meta-databases, and multi-criteria decision support are treated.

In order to encourage our students’ competence in transferring techniques and methods of information technologies to environmental related applications, the Bachelor’s thesis (18 credit points) has to focus to a topic which is relevant to Environmental Informatics. In the last years, a wide variety of topics have been treated, partly in cooperation with researchers of other disciplines, e.g. landscape ecology, water and coastal management, or wind energy.

2.2 Diploma study program and Master study program

The Diploma study program at University of Oldenburg, a study program of 9 semesters, was revised in 2001 in order to get a maximal accordance of its curriculum in the first 6 semesters with the curriculum of the Bachelor’s degree. Hence, the first six semesters of the Diploma study program consist of the same courses as the Bachelor program, currently the last three semesters confirm with the curriculum of the Master study program. In correspondence to Bachelor theses, Diploma students have to complete a so called ‘individual project’ which is a small stand-alone project of four months length. In addition to the Diploma thesis, a so called ‘project group’ has been part of the curriculum. The project group is a course of 24 credit points, which lasts one year. The 6 to 12 students of such a group are meant to become a virtual company, getting the task to develop a software or hardware product for a (virtual) customer. The role of the customer is often played by the teachers of the course.

In the Environmental Informatics specialisation, we bound the Diploma thesis and the task of the project group to be related to environmental topics. Furthermore, one to three more courses from the application field ecology or environmental economics, and an additional mathematics course in nu-

merical mathematics or statistics have to be chosen. The students are free to choose courses from the study program 'Business Informatics' and are especially encouraged to choose courses in environmental business information systems. Due to shortages in the teaching resources for core environmental courses, students have to choose at least two of the three modules individual project, project group and Diploma thesis in Environmental Informatics.

As up to 2006 our freshmen were free to choose between the Bachelor or Diploma study program, most of them have studied the Diploma study program.

2.3 Acceptance of the study programs

Our study program has been introduced with the implementation of Bachelor's and Master's study programs in Computing Science in 2001. As Environmental Informatics is not a study program of its own but a specialisation only, exact numbers of students have not been recorded.

But according to the membership in our courses and the number of theses with environment-related topics, the highest interest in our study program was in the years 2004 and 2005, in which about 10% of the computing science students have chosen an environmental-related topic for their individual project and Bachelor's thesis. The number of students who officially registered for this specialisation has been decreasing since.

Interestingly, the number of students finishing their studies with a Diploma (or Master's) thesis in our Environmental Informatics group are increasing since 2007 (to 11% of all Master's and Diploma's theses in 2008), when the research interest of our study group shifted from ecological applications to renewable energy, in particular distributed energy management. Many of these alumni have not registered for Environmental Informatics but have studied environmental related course as voluntary course.

Our students have been very successful with their project groups and theses: In 2003 and in 2008, our project groups have won the Environmental Informatics Prize for students (Eysholdt et al., 2008; Giesecke, 2003). Many Bachelor and Diploma theses have lead to publications, e.g. (Hinrichs et al., 2009; Müller et al., 2008; Warner et al. 2008; Lünsdorf et al., 2008; Bremer et al., 2008; Giesen et al. 2006).

Although the interest in the Environmental Informatics courses is stagnating considering the students of computing science, the general number of students in our courses is growing, as the interest of students from other disciplines (Landscape Ecology, (Marine) Life Sciences, Sustainability, Engineering physics, Environmental modelling, ...) is currently increasing.

3. Re-accreditation

At the moment, the computer science study programs of the Department for Computing Science at University of Oldenburg are in the process of re-accreditation. As the university board ordered us to close our well-accepted diploma study program in 2007, we are using the upcoming re-accreditation for extending our Master's study program to a length of four semesters and to integrate well-defined specialisations into the program.

3.1.1 General changes

The re-accreditation affected our study programs in diverse aspects:

- The Master's program was extended to four semesters and 120 credit points.
- Due to the former, desired accordance between the old Diploma study program and the Bachelor/Master-program, our students were free to integrate Master's courses in their Bachelor study. With the re-accreditation, we were advised to separate between these more strictly.
- The Bachelor program had to subordinate to the structure of the university's Bachelor curriculum, which assigns each module to belong either to one or two fixed disciplines or to be chosen from a catalogue of so called professionalisation modules.

- Each course had to be integrated in detail in the university's general examination regulations.

The structure of the Bachelor program is shown in Figure 1. It contains free selectable modules of 45 credit points and the Bachelor's thesis of 15 credit points which allow an individual choice of topics partly constricted to courses of the professionalisation modules. These modules can be used for defining a specialisation or for studying a minor subject (30 Credits).

1.Sem.	Programming & Algorithms	Program- ming in Java	Computer Engineering 1	Discrete Structures	Mathematics 1 (Lin. Algebra)
2.Sem.	Algorithms & Data structures	Soft Skills	Computer Engineering 2	Theoretical Comp. Sc. 1	Mathematics 2 (Calculus 1)
3.Sem.	Information Systems 1	Software Engineering	Choice	Theoretical Comp. Sc. 2	Mathematics (special)
4.Sem.	Computer Networks 1	Software Project	Hardware Laboratory	Operating Systems 1	Choice (P)
5.Sem.	Informatics and Society		Choice	Choice	Choice (P)
6.Sem.	Bachelor's thesis module (BSc-Thesis and Seminar)		Research Seminar	Choice	Choice

Table 1: Structure of the Bachelor's study program

The Master's study program has been extended to a length of four semesters. Its structure can be seen in figure 2. It demands two modules to be chosen from a different discipline (NI module: non informatics module), four modules of computing science, four 'area modules', which cover the four areas 'theoretical', 'practical', 'technical', and 'applied computer science', the student's project group, and the Master's thesis. For students changing her or his specialisation, or coming from a different Bachelor's program (i.e. business informatics, electrical engineering) the four 'area modules' can be used as so called assimilation modules to achieve a common standard of knowledge for the other computing science modules in the Master's program.

1. Sem.	Choice	Choice	Area Choice / Assimilation	Area Choice / assimilation	Choice
2. Sem.	Project Group		Area Choice / Assimilation	Area Choice / assimilation	NI Choice
3. Sem.			Choice	Choice	NI Choice
4. Sem.	Master's thesis module				

Table 2: Structure of the Master's study program

This structure holds for the Master programs of our department, i.e. Master in Computing Science, Master in Embedded Systems and Micro-robotics and Master in Business Informatics. All the modules of the Master's study program can be used to define a specialisation.

To be free to give up-to-date-suggestions for a sensible choice of concerted modules to our students, we changed the status of the specialisation field in a study program to be merely a recommendation for a study track. The successful completion of such a track can be certified independently of the university's student's office by our Department of Computing Science. So, we are able to offer always an up-to-date variety of specialisations.

3.1.2 Specialisation in the new Bachelor and Master program

As a quite small group of teachers in Environmental Informatics, we can offer only a limited number of interdisciplinary Environmental Informatics courses. Besides, an evaluation of our interdisciplinary courses showed that their learning objective and methods have to be assigned to the Master's level. So, the specialisation in the updated Bachelor's study program requires only three of the ecological oriented courses or courses in environmental economics listed in section 2.1.2, and two more computing science courses. The Bachelor's thesis and a seminar are still dedicated to environment-related topics. So, the Bachelor's specialisation is merely a preparation for the specialisation in the Master program.

The Environmental Informatics interdisciplinary courses will be placed in the Master program. The Master's curriculum includes the core module 'project group' which has also been part of our former Diploma program (see sect. 2.2)). In the Environmental Informatics specialisation, this core module as well as the Master's thesis has to be chosen with an environment-related topic.

The certification of Environmental Informatics in the Master program requires the certificate of the Bachelor's specialisation in Environmental Informatics and the Master's courses

- Modelling and simulation of ecological systems,
- Environmental information systems (EIS),
- an additional mathematics module,
- two additional modules from the catalogue of environmental economics or ecology, and
- the Master's thesis as well as the project group having an environment-related topic.

If a student, who has not fulfilled the requirements of the Bachelors specialisation, wants to study the specialisation in the Master program, he or she can catch up on the missing Bachelor's modules to a certain degree by choosing adequate assimilation modules.

4. Flexible Structure

Beside the Bachelor's study program 'Computing Science', which allows the choice of a minor subject or a specialisation as Environmental Informatics, the Department for Computing Science at Oldenburg University also offers the Bachelor's and Master's study programs 'Business Informatics'. The structure of the Master's study programs allows changing the specialisation from the Bachelor program to the Master program as well as the study program itself. If an applicant with a Bachelor degree e.g. in Business Informatics wants to study the program for Master in Computing Science, such a change is possible. In this case, the four modules 'area choice' in the Master's program can be used for assimilating the candidate's knowledge of the discipline.

Beside the specialisation in Environmental Informatics, in the Master study programs 'Computing Science' and 'Business Informatics' there are offered – among others – specialisations in

- Corporate Environmental Management Information Systems (MSc Business Informatics),
- Information technology for energy management systems (MSc Computing Science)

which are both open to our Bachelor students and complement the diverse interests of our students.

The specialisation 'Information technology for energy systems' has been motivated by the profound structural change in the energy business by the liberalisation of the energy trade on the one hand, and the increased supply by renewable, decentralized energy sources on the other hand. This change affords new techniques for the energy management and administration. By studying this specialisation, our students learn about the foundations of energy business, and especially about the management of decentralised energy production and adaptive consumption.

The specialisation 'Corporate Environmental Management Information Systems' addresses design and development of information systems for companies, which also take environment-related information into account. This is necessary for environmental accounting, resource and energy efficient production, and reduction of environmental burden. In this specialisation technical solutions for modelling and managing information and material flows are considered. But it also includes economical and regulative constraints, in particular concurrent legislation and policies on the national and international

level, in its curriculum. These factors are highly important for the accomplishment of global objectives as for example sustainable development, stakeholder integration and ecology-oriented optimisation of business processes.

Beside these choices given as part of study programs of the Department of Computing Science, the Master programs of the University of Oldenburg

- Environmental modelling,
- Sustainability economics and management

can be studied by students with a Bachelor's degree in Computing Science or Business Informatics. The first one is offered in cooperation between the disciplines landscape ecology, marine environmental sciences, mathematics, national economics and computing science. It incorporates a short introduction to computing science for students from other disciplines who aim for an additional qualification in computing science. Students with a Bachelor degree in Computing Science can complete a project group module and a Master's thesis with a topic in Environmental Informatics.

The Master program 'Sustainability economics and management' is offered by the economics department and also imports Environmental Informatics courses.

So, the University of Oldenburg offers a wide range of possibilities for studies in the interdisciplinary field between computing science and environmental applications.

5. Conclusions

Carl von Ossietzky University of Oldenburg offers a very sound field for interdisciplinary studies in environmentally related topics, especially in topics related to natural sciences. Hence, our study program focuses not in the more traditional topics of Environmental Informatics but on ecological applications of computing science and is currently expanding to distributed energy management also. The specialisation 'Corporate Environmental Management Information Systems' in the study program 'Business Informatics' covers the applications of Environmental Informatics in business economics. Moreover, students with a Bachelor degree in Computing Science have a wide choice of Master study programs or specialisations related to environmental issues.

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