

Environmental monitoring and management - environmental engineering education at CUT Kraków, Poland

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ABSTRACT: The aim of this article is to describe the learning programme of environmental engineering, in particular, the environmental monitoring and environmental management courses in the Faculty of Environmental Engineering at Cracow University of Technology (CUT) in Kraków, Poland. The curriculum contents are given in the first part of the article. In the second part, the author describes the outcomes of education programmes including main objectives. The third part illustrates the educational cycle, including the real outcomes of the programme in relationship with the expected ones. By analysing the curriculum, the author attempts to explain the new approach to environmental monitoring and management adopted at CUT.

Keywords: Environmental monitoring, environmental management, environmental engineering education

INTRODUCTION

In the last 50 years, the public has grown increasingly aware and concerned about the environment. Environmental monitoring and management have become integrated into a wide range of community, professional, government, and in almost all university, programmes. Social change is required to enable people to deal with the environmental challenges threatening the human society and the global ecosystem. A new approach to environment monitoring and management that supports collective action and reflection directed towards improving the management of human and environmental interrelations as the social learning approach is necessary.

Environmental monitoring is a system that consists of measurements, assessments and forecasts concerning the environment and the system of collection, processing and dissemination of environmental information. The study includes monitoring air quality, inland waters, surface and groundwater (as well as internal waters and territorial sea waters), the quality of soil, noise, ionising radiation and electromagnetic fields. It also includes the state of natural resources, including forests, types and quantity of substances or energy in the air, water and soil, and production and waste management [1].

Environmental management is the management of the use, protection and shaping of the environment. In their formal form, environmental management systems have operated for more than fifteen years, since Regulation No 761/2001 of the European Parliament and of the Council was published in 1993, which allowed voluntary participation by organisations in the community eco-management and audit scheme (EMAS) [2].

In 1996, the International Organisation for Standardisation (ISO) published the ISO 14001 standard on Environmental Management Systems - specifications with guidance for use [3]. Thus, the environmental management system should be understood as a separate and properly structured part of reality that is associated with the management of the processes in use, protection and improvement of the natural environment in a country, region or community [4-6].

Engineering education is the activity of imparting knowledge and the principles related to the professional practice of engineering. The aim of this article is to describe the learning programme of environmental monitoring and environmental management courses in the Faculty of Environmental Engineering at Cracow University of Technology in Kraków, Poland.

THE CURRICULUM OF THE PROGRAMMES

The Faculty of Environmental Engineering has held a strong position in environmental engineering education for many years in Poland. Graduates receive a Master's degree in the field of environmental engineering in one of the three specialisations (hydraulic engineering and geoengineering; installations and heat and health equipment; sanitary engineering). Students acquire basic mathematics and technical knowledge, as well as skills that enable them to solve environmental problems by using technical, economic and legal tools.

The Master's degree programme in environmental engineering contains a typically Polish system division of several courses and lessons spread over three semesters (1.5 years). This article focuses on environmental monitoring, which is located in the programme in the first semester, and environmental management that is in the second semester. Environmental monitoring has been given 2 ECTS credits and environmental management has been given 3 ECTS credits (points defined in the European system of accumulation and transfer of credits as a measure of the average amount of work, which a student is required to achieve in regard to the intended learning outcomes).

The engineering curriculum plays a key role in the education process of professional engineers. One of the important aspects of engineering education is the curriculum, which poses many opportunities and challenges, and has to be based on a foundation of science and education principles. The curriculum of these two courses involve a number of ways and means, e.g. lectures, tasks panel, exercises, projects, multimedia presentations, work in groups and consultations.

The environmental monitoring course refers to many issues related to environmental monitoring in Poland. There are seven lectures in the course, each of which tackles a particular problem (Table 1).

Table 1: The curriculum content of environmental monitoring in the Faculty of Environmental Engineering at Cracow University of Technology, Kraków, Poland (translated by the author) [6].

Lectures		
No.	The subject matter and detailed description of thematic blocks	Hours
L1	The objectives and tasks of environmental monitoring, network structure and organisation.	2
L2	The scale and scope of research conducted within the framework of environmental monitoring and selected methods of statistical data interpretation.	3
L3	Standard and telemetry monitoring system hydrometeorological parameters on a national and local system, measurement methods, type of obtained information.	2
L4	Monitoring data for improving and optimising the water economy.	3
L5	Air monitoring, measuring stations, pollution level reports.	2
L6	The status of air pollution in the country and air protection programmes.	1
L7	The role and importance of continuous monitoring as an example of the Kraków area.	2
Exercises		
E1	Statistical analysis of the environmental monitoring results and their interpretation.	10
Projects		
P1	Radiation monitoring levels in the environment.	5
Total		30

At the beginning of the course, the objectives and tasks of environmental monitoring in Poland are presented. Further on, the scale and scope of research conducted within the framework of environmental monitoring is outlined. Standard and telemetry monitoring systems are discussed briefly, as well as hydrometeorological parameters of the national and local systems. Monitoring data for improving and optimising the water economy is explained.

Furthermore, air pollution is considered due to an increasing level of air pollution in Polish cities, especially, in Kraków. Two lectures refer to air monitoring, measuring stations, pollution level reports and the status of air pollution in the country, and to air protection programmes. The last issue highlights the role and importance of continuous monitoring of the Kraków area as an example.

The course includes also workshops and projects. During the workshops, students work on a statistical analysis of the environmental monitoring data and learn how to interpret results of the research. Students measure radiation monitoring levels in the environment as part of the projects.

The environmental management course, consisting of five lectures, introduces different ways of management (Table 2). Firstly, ethical and sociological aspects of environmental protection are presented, followed by economic and environmental legal aspects, and the construction of a modern environment management system and its evaluation. Secondly, enterprise management and sustainable development are shown. This lecture develops the issue of environmental protection in the spatial planning and the procedure for the design and facilities operation. The lecture also encompasses an institutional system of environmental control, environment permits use and integrated permits, ISO 14001 as the standard for ecological assessment [3].

The main point of this programme is environmental management systems, eco-management and audit scheme (EMAS), and the management of disasters and major accidents in enterprises [2].

Table 2: The curriculum content of environmental management in the Faculty of Environmental Engineering at Cracow University of Technology, Poland (translated by the author) [6].

Lectures		
No.	The subject matter and detailed description of thematic blocks	Hours
L1	Ethical and sociological aspects of environmental protection. Economic and environmental legal aspects. Construction of a modern environment management system and its evaluation.	2
L2	Management enterprise and the concept of sustainable development. Environmental protection in the spatial planning and the procedure for the design and facilities operation. Institutional system of environmental control, environment permits use and integrated permits, ISO 14001 as the standard of ecological assessment.	4
L3	Environmental management systems. Eco-management and audit scheme (EMAS). Management of defeats disasters and major accidents in enterprises. Organisational structures. The role of state and local administration.	4
L4	Environmental management in enterprises. Clean production as a philosophy and a strategy for protecting the environment. The certificate of clean production as an environmental voluntary commitment forms. Best available techniques (BAT). BAT as a goal of clean technologies implementation. Evaluation of the activities of pro-ecological enterprises.	3
L5	Financing of investments in environmental protection. The consequences of environmental protection violation requirements.	2
Projects		
P1	The choice of an environmental problem at the local level or in the company.	2
P2	Characteristics of the area and the type of business.	4
P3	Indication of the technical, economical and administrative methods of the environmental problem solution.	6
P4	Indication of available funding sources.	2
P5	Presentation and completion of the project.	1
Total		30

Likewise, the role of state and local administration is presented. Environmental management in enterprises is also introduced, as well as clean production as a philosophy and strategy for protecting the environment. Best available techniques (BAT) are clearly explained as a goal of clean technologies implementation. The last lecture describes financing of investments in environmental protection and the consequences of environmental protection violation requirements.

The course also includes projects, as did the previously-mentioned one. As part of the projects, students have to choose an environmental problem on the local or company level. They, then, have to characterise the area and the type of business and indicate the technical, economic and administrative methods of the environmental problem solution.

In each course, the student's workload is based on various forms of activities. Contact with an academic teacher is provided, including hours arising from the study plan and examinations. The course includes students' independent work hours. In this system, the total teaching load should be 150 class hours, including environmental monitoring: 15 hours of lectures, 10 hours of practical exercises, five hours of projects, 30 hours of student's own work; environmental management: 15 hours of lectures, 15 hours of projects, 60 hours of student's own work. The graduation requirement of the course consists of two assessments: oral presentation and project team work, as well as weighted average assessments received earlier, and a written examination.

Academics involved in those two teaching courses are highly qualified in their chosen field. Usually, the course is taught by 4-6 academic teachers [7]. The system aims to improve students' knowledge of, and ability in, the two core components of theory and practice. The principle is to improve basic skills with the specialised course to improve professional skills. It is useful for students to improve their overall engineering ability through practical engineering.

THE OUTCOMES OF THE EDUCATIONAL PROGRAMMES

The major objectives and outcomes of these courses are especially important for students who want to broaden their knowledge in the environmental engineering field. Graduates can, then, find employment in design offices and companies associated with implementing environmental engineering, as well as in units of state and local governments. It can also possibly be of interest to students who want to run their own business activity in that area.

The main aim of environmental monitoring is to provide knowledge on the theoretical basis of environmental monitoring, diagnosis and prognosis of environmental phenomena and processes. Theoretical knowledge will be enriched with practical problems arising in the design, implementation and maintenance of environmental monitoring

systems. Also, the objectives are broadening the knowledge of the essence, outline and the tasks of environmental monitoring in Poland, and allow familiarisation with the status of selected elements of the environment in Poland, based on the functioning of state monitoring.

The main aim of environmental management is to broaden the knowledge about systems and environmental management programmes in government units and formal procedures related to the management in environmental engineering.

Education programme involves an assessment of educational outcomes of the system, with some basic goals:

- a) The level of acquired knowledge;
- b) Necessary skills;
- c) Job requirements;
- d) Necessary professional customs and habits;
- e) Desirable attitudes, etc.

The desired educational outcomes define the content structure. It means that the subject is chosen on the basis of the environmental engineer. Bloom has suggested that there are six levels of cognitive domain, in order to help build a professional profile [8]. This provides scope for identifying the job specific knowledge, understanding and skills related to the environmental engineering profession. These are as follows: knowledge (remembering, memorising); understanding (interpreting, translating); application (problem-solving); analysis (the separation of a whole into its component parts); synthesis (creating or designing); and evaluation (resolving) [8].

The environmental monitoring education programme describes five main outcomes (Table 3). These are acquired knowledge, necessary skills and desirable attitudes such as: knowledge of the essence, outline and the tasks of environmental monitoring in Poland; knowledge of the monitoring network, their organisation and functioning; ability to assess the status of the environment in Poland due to the state monitoring; ability to interpret data coming from the monitoring network environment and cooperation in the group.

Table 3: Outcomes of education programme in the Faculty of Environmental Engineering at Cracow University of Technology, Poland (translated by the author) [7].

Environmental monitoring	Environmental management
Knowledge of the essence, outline and the tasks of environmental monitoring in Poland.	Knowledge of implementation mechanisms of the best available techniques.
Knowledge of the monitoring network, their organisation and functioning.	Knowledge of environmental management systems.
Ability to assess the status of the environment in Poland due to the state monitoring.	Development of plan aimed at fulfilling current environmental requirements.
Ability to interpret data coming from the monitoring network environment.	
Cooperation in the group.	

The environmental management education programme describes four main outcomes (Table 3), such as acquired knowledge and necessary professional customs and habits. During the course students can obtain the knowledge of implementation mechanisms of the best available techniques and knowledge of environmental management systems. They can also learn how to develop the plan aimed at fulfilling current environmental requirements and also cooperate within the group.

THE EDUCATIONAL CYCLE

In the educational cycle, the real outcomes (effects) of the discussed courses are positioned in references to the learning outcomes, objectives of the course, curriculum content, learning methods and forms, student's own work and evaluation methods (Figure 1). The figure illustrates the relationships between the beginning of the course and its end. All of these factors create the educational cycle at Cracow University of Technology.

The cycle's elements provide an excellent opportunity for further system development. The learning outcomes are knowledge, skills and social skills acquired in the educational process by the learners (students). Learning outcomes should be *verifiable* (observable, measurable) by the institution providing training (university). They give meaning to the educational cycle.

There are three important factors: knowledge - knowing and understanding; skills - communication, problem-solving, use of knowledge in practice; and competence - creativity and independence of action, identification and evaluation of important ethical, social and professional organisations and sense of responsibility. Learning outcomes are strictly related to the objectives of the course, which is a broad, general description of educational aims and expectations. They indicate what the teacher expects to achieve through the curriculum.

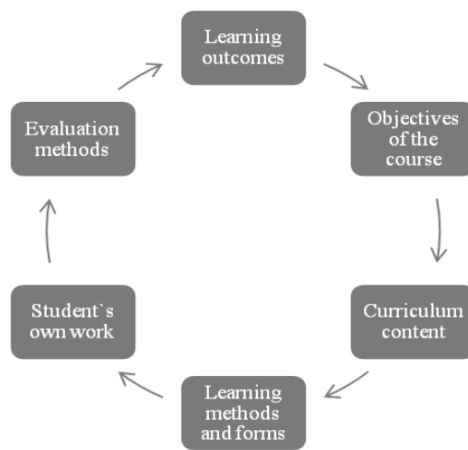


Figure 1: The educational cycle for environmental engineering and management in the Faculty of Environmental Engineering at Cracow University of Technology, Poland (by the author).

These objectives are usually extended from the teacher's point of view. Expected learning outcomes and objectives of the course can be described in the curriculum content. The curriculum content should take into account the needs and abilities of students for whom it is intended. Then, different learning methods and forms can be chosen e.g. lectures, tasks panel, exercises, projects, multimedia presentations, work in groups and consultations. At the end of the courses, the teacher evaluates the students' work and allocates marks to each. For these two courses, this is a weighted average of the oral examination, a group project and a written examination. The purpose of the university is the use of appropriate mechanisms (procedures) of assessment, as well as ruling out whether and how learning outcomes are achieved by students.

CONCLUSIONS

Since new legal documents relating to environmental monitoring and environmental management have been created, they have changed the approach to understanding these courses. Curriculum development in engineering education became an important issue for academic institutions. It occurred when the option of using three specialisations was created, and it allows students to choose different courses, which help them to broaden their knowledge in the environmental field and, as a result, find a good job. Students can find employment in design offices and companies associated with implementing environmental engineering, as well as in units of state and local government. Also, it should be of interest for students who want to run their own business activity in this area. Therefore, the Faculty of Environmental Engineering at Cracow University of Technology in Kraków, Poland still has a strong position in this field.

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BIOGRAPHY



Gabriela Zemelka is currently a PhD student at Cracow University of Technology in the Faculty of Environmental Engineering. She graduated as a Master of Environmental Protection from Jagiellonian University, and completed her postgraduate studies in analytical chemistry in industry and environmental protection at the AGH University of Science and Technology (Cracow, Poland), in 2013 and 2012, respectively. She has spent six months working in a laboratory and participating in a research project at Université Blaise Pascal in the Faculty of Chemistry in Clermont-Ferrand, France, before finishing her studies. As an aspiring scientist, she is interested in the determination of sources of suspended matter and sediment in the water reservoir catchments, which will enhance the knowledge of pollution of such environments. Her research leads to a description of the current reservoir contamination, and may support analyses and predictions of water quality and sedimentation processes, and also the creation of tools to manage catchments.

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