

University of West Hungary

Thesis of Ph.D Dissertation

**Develop practical education method in higher engineering
education for water quality protection subject
(Based on water quality assessment exercise of Aranyhegyi
stream)**

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Sopron

2012

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1. Objectives of the research

Goal of this dissertation is to explore problems related to environmental engineering education and to emphasize factors influencing the quality of future education. Awareness of these problems is crucial when the objective is to improve quality of the education and to engage more and more talented youth for professional environmental activities. Regarding existing global and regional environmental problems and considering nowadays' expectations for sustainability we can say that sustainable society can't exist without technical intelligentsia having high-level scientific knowledge and responsible attitude for the environment. Nowadays the expectations from higher education for sustainability are not only to provide high-level theoretical scientific knowledge, but also to develop skills, abilities and attitudes through competency-based education. Since the level of academic scientific training in Hungarian higher education is internationally proven, the task is to meet the other requirement by properly chosen pedagogical methods. It also assumes changing approach in environmental engineering education.

The main objective of this dissertation is to work-out and present such practical teaching methods that develop competencies expected from this type of training in environmental engineering BSc education by adopting activity-oriented pedagogical methods. This paper wishes to prove with help of an adequate example, that project method, besides professional education, provides opportunity for developing environmental engineer competencies by enlarging learning-teaching space and treating field exercise as organic part of the education. The efficiency of the project method has been proven. It can be easily integrated with traditional methods, so it can be an effective supplement to the presently used education methods.

The "*Load of impurities in low water streams*" project elaborated in the present dissertation, validated by environmental-pedagogical experiment and considered to be the main value of the study, can serve as model for the efficient teaching of water quality protection subject in environmental engineering education, and can give help for other educational institutions providing similar trainings. The detailed practical methodology helps the process of project planning and execution in teaching of other environmental elements or even complex environmental subjects. The

project scene – Aranyhegyi stream – being a low water stream can be an appropriate example for a water quality assessment process mirroring the expectations of the Water Framework Directive.

2. Hypotheses of the research

1. In environmental engineering education the number of academic lessons is fairly more than the number of practical ones. Due to this fact and the lack of activity-oriented methods in BSc education there is little opportunity for developing competencies expected and conceptualized by the Training and Output Requirements of the education.
2. The practice oriented activity methods are not prevailing at workshops in environmental engineering BSc education, due to lack of preconditions, the traditional, classical frontal pedagogical methods (lecture, explanation) are dominant.
3. The early interest boom in natural science and technical engineering careers, particularly in the environmental engineering education, has stopped and shows a descending trend since 2004. The reason of this is that the interest of students in natural sciences at their secondary school is influenced negatively by their teachers' training practices exaggerating theoretical elements and the lack of their practical knowledge and experience.
4. The situation of technical higher education is difficult, because the level of natural scientific knowledge of admitted students fall behind the expectations of the universities.
5. Water Framework Directive released in 2000 and declared by Hungary in 2001 conceptualizes concrete requirements for vocational training. Due to academic nature of the current education scheme, there is still much space for improvements. The ecological approach of Water Framework Directive does not prevail in teaching of special subjects.
6. Contamination assessment of low water streams in Hungary gets no sufficient attention, which leads to negligent problem phrasings and solutions.
7. By aiming responsible and environmental aware behaviour, the project method as the educational strategy of environmental

pedagogy is suitable for establishing competency-based environmental engineer education. It has the methods in its toolkit, that make practical teaching of water quality protection more efficient and interesting and they also make the students more motivated and receptive.

8. Activity-oriented methods enlarge the learning space and require new learning conditions. The most efficient learning conditions of nature and environment awareness behaviour are in the nature or physical environment itself, namely at the field exercise. The works done on the spot and the applied methods notably support complex thinking, capabilities for autonomic activities, gaining first hand experiences and help forming responsible behaviour.

3. Methods of research

➤ *Document analysis*

Based on the records of Ministry of National Resources the dissertation analyses the number of students since the launch of the BSc education in environmental engineering and from this information evaluates the interest of youth in environmental engineer career.

Based on the schedule of 11 higher-educational institutes providing environmental engineering BSc education, the author analyses the content of water quality protection subject and its lecture organization taking into account practical and academic lessons.

Based on the Nation-wide Public Education Board ad hoc committee's report dealing with the state of public education of Natural Sciences and the competency survey applied in public education (PISA 2006), the dissertation summarises data of existing or missing interests of students in natural sciences, taking part in public education. Using the survey of Katalin Radnóti (ELTE TTK) and Technical – Scientific Committee of Hungarian Rector Conference, the author analyses natural science preparedness of students entering into natural science and technical higher education. Moreover the results of physics test papers of engineering

students applying to and gaining admission to the examined universities in the 2011/12 academic year have been processed.

The author examines and evaluates the objectives and task definitions of Water Framework Directive and Watershed-area Management Plan serving as WFD realization, National Public Education Strategy (2010) and National Environment Protection Programme III., related to higher education.

➤ *Investigation by questionnaire*

By the help of questionnaires the author examines environmental engineer BSc students' previous scientific experiences, aspects of choosing a career, educational expectations and competencies that have been developed during training period.

➤ *Efficiency analysis with environmental-pedagogical experiment and attitude examination*

Water quality protection project that had been worked out during the research period was tested and validated with a two-group pedagogical experiment. Members of the two groups –experimental and a control group – were students from second and third year of environmental engineering BSc education, who had applied to the courses of Water Quality Protection and Wastewater Treatment subjects run by the university in 1st semester of 2011/12 academic year.

Objective of the dissertation was to prove efficiency of the project model where the project method itself served as an independent variable and students' competencies were the dependent variables in this pedagogical experiment. To assess changes in the dependent variables, personal interviews, observations and questionnaires were used. Survey of students' level of knowledge and the content analysis of student self-evaluation journal-book written during the project work were used for evaluation of the experimental project.

The experiment assessed the efficiency of project teaching and based on results the dissertation brings up conclusions and recommendations. In the course of the project the status assessment report of Aranyhegyi stream was prepared. This low water stream was used as a field spot with sampling points covering the stream from its source to its estuary. The result of

environmental experiment is the water quality map of this low water stream, which will help the comparative analysis of future investigations.

4. Results of the research

Based on experiences gathered and results achieved since the beginning of the environmental engineering gradual education, it is important to discover problems that might determine the future of this training in order to formulate proposals by exposing causes and effects, to achieve increase in the quality of this education. Dissertation emphasizes importance of problem conceptualisation and resolution, because fulfilling nowadays expectations regarding sustainability cannot miss the work of environmental engineers having multidisciplinary knowledge and complex-minded thinking based on responsible behaviour towards the environment and nature.

Results of the research point out that nowadays, while universities in environmental engineering education principally implement undoubtedly high academic education level for engineers with having also environmental knowledge, but the trainings miss pedagogical methods that aim attitude forming and development, and would evolve competencies required by human society, employers and – realizing this – by the students themselves.

The decreasing number of students applying for environmental engineering calls attention to the problems related to the education. Despite of the growing needs of the environmental industry for more general specialists, the number of graduated students decreases, in which fact the decline in population plays only a minor role. Analysis based on the number of applicants for environmental engineering education, the number of university applicants of the 1st place and on the number of applicants for technical education, proved the assumption that the interest in environmental engineering career decreases. The main cause of the decrease is that career seekers have insufficient scientific interest and preparedness, moreover the overwhelming majority of theoretical lectures are not attractive enough for youth; and employers do not employ graduated environmental engineers lacking competency, so they face serious problems to find a job. These factors all together result the decline of interest in this

type of education and the decrease in number of students taking part in environmental engineering studies.

Results of the questionnaire made within the framework of this research show that *the majority of students (66%) getting into the education do not have GCE from any natural scientific subjects*, therefore universities need to fill these gaps and organize refreshing courses and teach the formerly learnt knowledge again, which is the base for the education. In 2008, the National Public Education Board and Board of Rectors dealt with the problem of scientific education and conceptualised tasks necessary for moving forward in this area. It can be stated that *the secondary education has a direct effect on technical higher education*. The solution of this problem requires some reforms in the secondary scientific education, where –like in the investigated education – the main problem is the exaggerated theoretical teaching.

The majority of students attended a four-year secondary school and usually learned scientific subjects for two years with good and high grades. The differences between the grades of secondary school and the results of test papers of the refreshing courses after admission, show that *the secondary school good and high grades do not reflect the knowledge level expected by higher education institutes*.

According to the analysis of the subject syllabus of 11 institutions providing environmental engineering education, it can be stated that *despite of many documents (3rd National Environment Protection Programme, Water-shed Management Plan, Water Framework Directive) stressing the importance of practical training, theoretical teaching is still more emphasized*. There are some institutes where practical workshops are completely missing from the education programme and/or the number of academic lectures is usually multiple of the number of practical workshops. *Number of practical lessons is about 40% of the total number of lessons allocated to the subject*.

Results attained from the syllabus analysis of water quality protection subject show that there is no uniformed directive for the basic knowledge transfer, which prevents development of a holistic picture about environmental engineering education. Comparison of the content and the number of lessons of the subject was difficult, nevertheless it can be stated

that quite big differences exist between institutes regarding the number of lessons and content of teaching water quality protection, that belongs to professional core subjects. The problematical comparability of curriculums suggests that there is no unified conception about the subject teaching objectives, therefore it cannot be expected from employers to have a unified image about the knowledge and competencies of graduated students.

It's been concluded from the research that *conditions facilitating activity-oriented methods at practical workshops with low number of lessons are not given*. Group sizes are large (25-30 persons), number of lessons are restricted, usually placed in 2 x 45 minutes a week slots in the schedule, which is not enough to reach an outdoor field spot or to visit working plants and to execute measurements in the laboratory. *Without these opportunities mostly the frontal teaching methods appear in the education*. Students are not satisfied with this system (only 36% of them accept it) because the majority (89%) is looking for external professional workshops while 81% of them expect independently carried out project based training.

Water-shed Management Plan, that entered into force in 2010 by the 1127/21.05.2010 Government Resolution, expects such kind of training from the environmental engineering education, so that technically skilled specialists are to be released with modern scientific approach and knowledge. Among the tasks to be executed we can find the environmental pedagogy as the determinant pedagogical method of attitude forming. It cannot be satisfied within the framework of present educational strategy because *no efficient environmental pedagogy can be achieved due to the lack of practical workshops and field works*.

While traditional education's role is to communicate academic knowledge, the project based teaching takes a role of transferring applicable knowledge, this dissertation emphasises the importance of the second one in environmental engineering education. The results of "*Load of impurities in low water streams*" project realized as a two-group environmental-pedagogical experiment, prove that besides professional training, the project-based teaching method also helps to efficiently improve development of competencies. By the students internal motivation the ability of self-regulated learning is eventuated that helps to develop the ability of life-long learning, which is the precondition of sustainability.

The results of environmental attitude investigation made with the two-group experiment, show significant emotional and behavioural attitude difference between the project and the control group. It can be stated that *project work positively influences students' environmental awareness and responsible behaviour* therefore it satisfies the expectations.

The results reflect that environmental engineering students' environmental attitude is generally positive (51 environmental attitude points) and the statement that peoples' emotional attitude towards environment is significantly stronger than behavioural attitude is also found to be true, meaning people are more environmentally aware in their feelings than in their deeds. The investigation results have also proven the hypothesis that *project teaching with forming responsible and environmental awareness behaviour is applicable for establishing competency based environmental engineering education*. The results gathered from testing students' knowledge validate the increasing effects of project teaching on professional knowledge, which unequivocally come from underlying internal motivation and the willingness to learn.

The self-assessment work logs and achievements of students taking part in "*Load of impurities in low water streams*" project indicate that students have enjoyed the work, they have been motivated to learn and to reach their goals and their developing sense of achievement can stimulate them to mark out and to solve newer tasks. *The project work contributed to development of practical knowledge, ecological thinking and environmental awareness, ability for autonomic working and complex-minded thinking in a large extent. The cooperation in the group increased adaptiveness, tolerance and helpfulness that are expected by employers.*

The end-product of the project work, namely the *Ecological Map of Aranyhegyi stream* proved that state of the stream is *heavily polluted* according to the "one bad – all bad" principle of WFD. Due to anthropogenic impacts of the water-shed area particularly on the nutrient loading and oxygen balance the analysis showed the worst water quality, so it needs to be improved by increasing the efficiency of wastewater treatment in the future. The illegal effects that have been exposed during the stream investigation process (illegal wastewater hook up at two locations and illegal waste disposal at three points along the stream) also generate further water quality deterioration, but the resolution of these issues requires improvement in the inhabitants' environmental awareness.

According to the figures of the Water-shed Management Plan only 1031 streams have been included in the monitoring activity out of the 9800 low water streams in Hungary. The status assessment covers in the end 869 water bodies as a result of integration of smaller streams from the 1031 low water streams. The numbers show that the majority of low water streams (like Aranyhegyi stream) lack any kind of control, though their water quality unequivocally determine the quality of larger recipient rivers. The data of selected water bodies are incomplete, e.g. ecological status of 285 and chemical status of 814 water bodies are missing, so considering it as a whole the *status evaluation data of low water streams are incomplete in 94%*.

Based on the “*Load of impurities in low water streams*” *water quality protection project methodological guide*, that is considered to be the main value of this research, *similar project can be designed* and executed in the framework of other professional subjects in course of the training programme either in the secondary or higher education.

5. Thesis

1. Besides international cooperation and treaties, solution of environmental problems emerging on a global level also *makes necessary to form an engineer society that is responsible for nature and environment in its thinking*. Fulfilment of nowadays expectations of sustainability can be achieved only with engineers having multidisciplinary knowledge and complex-minded thinking.
2. In the environmental engineering BSc education strategy *the academic training is more emphasized*, the number of activity-oriented workshop lessons is low. The present educational strategy *does not fulfil* the tasks set for 2012 in the Water-shed Management Plan entered into force in 2010 as the realisation of Water Framework Directive (2000), concerning the *conditions of environmental education* to be achieved in the higher education institutes.
3. The project teaching as the strategy of environmental pedagogy helps expanding students’ professional knowledge, deepening their expertise and improving their general professional competencies. This method, relying on the internal motivation and considering the learning as a necessary tool for achieving results, helps to form self-regulated learning process.

4. The “*Load of impurities in low water streams*” project elaborated and validated in the framework of this dissertation, achieves the integration of subjects taught in environmental engineering education and facilitates the acquisition of multidisciplinary knowledge.
5. The water quality protection project, based on the methodological guide worked out in this dissertation *can be reproduced* and used for teaching any subjects connected to water quality protection in either secondary or higher education and for developing professional knowledge and competencies. Moreover, this methodology *can be adapted* for teaching other environmental engineering subjects by following the guideline. The worked out self-assessment work log, the questionnaire of environmental attitude examination and the system of aspects for the project closing assessment might give examples for similar exercises.
6. Design, implementation and assessment of status evaluation investigation of Aranyhegyi stream gives a *model* for further *low water streams water quality investigations*.

6. Proposals

- Concerning the primary professional core subjects, the institutes providing environmental engineering education should conceptualize the basic knowledge, requirements and the teaching objectives of the subject, so that employers could get a unified picture about the graduated students’ knowledge.
- Reforming secondary scientific education is as important as the environmental engineering education in order to increase the interest in career of environmental engineering. In both areas it is important to implement pedagogical methods based on experiments and autonomic activities instead of presently used, mostly frontal methods. The ecological approach expected by the Water Framework Directive and the Water-shed Management Plan, considering the contradiction between engineering and ecological sciences, requires application of activity-based teaching methods in the environmental engineering education. These methods can reduce the distance between the two areas and initiate

terms making an environmental engineer capable to operate as a connection between the two areas.

- In environmental engineering education it is extremely important for the students to get experience and practice during the training period from the exploration and resolution processes of complex problems taken from the real-life. It can't miss the direct connection with the environment and the nature, which are the most efficient mediums of improving responsible and environmentally conscious behaviour. It is important for the schedules of environmental engineering BSc education to accommodate field exercises as timetable commitments in order to ensure enough space and time for fulfilling external spot work. It also ensures the most efficient way of environmental pedagogy that is needed in higher education.
- Realization of project teaching needs some changes in environmental engineering BSc education curriculum. Instead of the average 2x45 minutes workshop lessons a week, the water quality project lessons should be prescribed in an accumulated number of lessons. In teaching water quality protection subject, *the lectures serve the communication of necessary academic knowledge and concepts. Besides lectures, practical knowledge can be acquired in the framework of project work.*
- Generally the *project work* (not only in case of water as an environmental element) *should be planned for two semesters* due to ecological aspects, this way giving opportunity to consider vegetation periods.
- Project leading teacher should set up a tutor (mentor) group, whose members should be representatives of suitable professions able to support students' project work with the greatest proficiency.
- *The fulfilment of the water quality protection projects in connection with field exercises might establish a domestic stream observer network.* Secondary and higher education institutes dealing with environment protection and water quality protection, choosing the nearest small stream can achieve the practice of water

assessment by a concrete example, while the gathered data can be sent to a central database where they will be available and comparable year over year by anyone. This way institutes could particularly contribute to decreasing deficiency detected in connection with the water quality status evaluations.

7. Publications

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