DEVELOPMENT AND IMPLEMENTATION OF A POSTGRADUATE COURSE ON RESEARCH METHODOLOGY FOR ENGINEERS AND SCIENTISTS

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EXTENDED ABSTRACT

With an overall aim to contribute to the ongoing discussion of improvements and reforms in doctoral programmes worldwide, the present paper focuses on the development and implementation issues of a postgraduate course administered by the Department of Civil Engineering of the Aristotle University of Thessaloniki in Greece. The course is compulsory for all doctoral students and also for the students of the MSc postgraduate programme “Environmental Protection and Sustainable Development” of the Department.

The main purpose of the course, which is provided during the last six academic years, is the familiarisation of the postgraduate students with the basic principles of research (objectives, means, methods, conduct and results) together with the development of appropriate relevant skills The principal objectives of the course are those that make the postgraduate students, after its successful completion, capable of: recognising the main features of science, engineering and technology, being familiar with the scientific methods of research, identifying the processes and the final approach to the design and implementation of a research project, accepting all ethical rules in conducting scientific research, carrying-out efficiently a literature survey, using terminology standards and glossaries and applying good practices in definition giving and term rendering, presenting the results of their research in oral and written form, and selecting and composing their material for presentation through slides and posters.

In the paper all issues mentioned above are discussed from the perspective of the two main categories of the course’s learning objectives/outcomes aiming at: (a) acquiring knowledge on critical research-related issues (knowledge outcomes), and (b) developing transferable and personal skills necessary in practicing research, but also for career development (skills outcomes). Particular points that are emphasised in the paper include the multilevel educational structure of the course, the contents of the lectures, and the requirements for assignments undertaken by the postgraduate students, which aim at building research competencies and developing communication skills. Finally, the fact that the course is provided to a class, which is composed of graduates originating from a wide spectrum of disciplines, is also examined. It is apparent that, due to this discipline-mix of the class, the synergies developed between civil engineers and graduates from other engineering and science fields, either by taking part in the classroom activities or in preparing the assignments, form an additional positive characteristic of the course.

KEYWORDS

Civil engineering, Postgraduate course, Research methodology, Skills development, Course assignments

1. INTRODUCTION

In the last decade doctoral studies in European universities have increasingly achieved recognition as a key part of a wider process aiming at the development of a knowledge society. Implementing a European mandate for a reform of doctoral programmes, the European University Association (EUA) initiated in 2003 a series of actions (i.e. various workshops, seminars and surveys) that at first led to a report (EUA, 2007) summarising recent achievements and challenges and proposing recommendations on the further development of basic principles for doctoral programmes. That report focused on three clusters of issues: (a) the quality of the programmes, (b) the role of higher education institutions, and (c) the public responsibility and the role of state. In a more recent brief review (EUA, 2010) a series of updated recommendations is proposed to serve as a set of guidelines for the diverse landscape of European doctoral schools and programmes.

Among the issues underlined in the above mentioned publications, of particular interest to the present paper are those of a proper supervision of doctoral candidates and of a better provision to them of specific knowledge and skills training. Both issues are the subject of many individual studies (e.g. Lee, 2008 and Hoffmann and Nagl, 2010), as well as of group reports, like those produced by members of two European Thematic Networks: (a) TREE, which covers all engineering disciplines (Avdelas, 2007), and (b) EUCEET, which focuses on civil engineering only (Boswell, 2006, Pantazidou, 2010).

The purpose of the present paper is to present an educational module that aims specifically at the preliminary provision of knowledge and skills training to doctoral candidates of the Department of Civil Engineering of the Aristotle University of Thessaloniki (AUTh) in Greece. Yet, in some parts of the paper, the importance of a good supervision, particularly in complementing the educational programme of the institution, is also highlighted. Doctoral studies in Greece follow a typical path of combining the provision of postgraduate education -at the early stage of a doctorate- and the production of research. Details regarding the structure of the Greek higher education system in civil engineering schools/departments, as well as its connection with career development and employment issues can be found in selective publications (e.g. Latinopoulos, 2004, Dritsos and Moseley, 2010 and Latinopoulos, 2010).

The educational module presented herein is a postgraduate course entitled “Introduction to Research Methodology” that is administered by the Department of Civil Engineering since the academic year 2005-2006. Within this sense, the type of the paper’s content is that of a case study, as it fully describes the educational approach adopted in designing, organising and implementing the course at hand. All that follows is a review and a discussion of relevant issues, as perceived and presented by the paper’s author who has been the instructor of the course along the above mentioned six-year period.

2. DESIGN AND ORGANIZATION OF THE COURSE

2.1 Aim and objectives

The postgraduate students, who enroll in the study programme of the Civil Engineering Department that leads to the doctorate degree (PhD candidates, referred hereafter as PhDs for brevity), have to attend four courses during the first year of their studies (two compulsory and two optional). The course “Introduction to Research Methodology” is one of the two compulsory courses, the second being “Applied Computer Science”. The two optional courses can be selected from a list of postgraduate courses that are taught in the MSc programmes of the Department. The overall aim of this part of the study programme is the acquisition of specific knowledge and the development of skills and competences necessary for conducting research in specialised scientific fields of civil engineering.

Within the above context the course “Introduction to Research Methodology” aims at the familiarisation of PhDs with the basic principles of research (objectives, means, methods, conduct and results), as well as at the development of various relevant skills and competences. As explained in more detail below, this aim is fulfilled through a multilevel educational process. Yet, the learning outcomes of this course, although necessary in this first cycle of studies, are not sufficient for the doctoral candidate, and, therefore, additional knowledge and skills should be acquired and developed along the whole time span of his studies, mainly through the guidance of his supervisor and by his own effort and self-education (Latinopoulos, 2010a).

2.2 Learning outcomes

The general educational target of the present course is directly related to specific learning outcomes, which refer exclusively to the conduct of research. These can be distinguished in two categories: (a) those concerned with the acquisition of specific knowledge and (b) those connected with the development of specific skills. The full list of learning outcomes is expanded immediately below.

Knowledge outcomes

The knowledge outcomes from the specific course include facts, concepts, principles, and theories that will be useful to the PhD student in practicing research in his academic environment and with particular emphasis in engineering issues. These outcomes are:

- knowledge of the basic concepts (science, research, knowledge) and their mutual relationships
- understanding the principles of ethical conduct of research (avoidance of plagiarism and generally of research misconduct, allocation of credit and authorship, etc.)
- apprehension of the research process and the relevant concepts (structure and design of a research project, types of novelty, the researcher’s role etc.)
- familiarisation with research activities in sciences and engineering (methodology, methods, techniques, appropriate application of technology etc.)
- recognition of the basic concepts, principles and sources of terminology with an emphasis on their proper use in practicing basic and technological research
- acquaintance with the ways and forms of communicating research results and with the relevant activities of a young researcher

Skills outcomes

From a wider spectrum of skills, which a young researcher should develop, the specific course aims at providing a particular subset needed in the first stage of a doctorate. After completing the course the doctoral candidate should be able to demonstrate the following skills, grouped in five thematic lists.

<u>(a) Research design and organisation</u>

- recognise and validate scientific/research problems
- comprehend and effectively employ appropriate research methods and techniques
- critically analyse and evaluate the findings of other researchers
- summarise, document and report, in relation with the progress of a research project

<u>(b) The research environment</u>

- understand the context in which research is conducted
- demonstrate awareness of issues related to research proper conduct and ethics
- understand the rights and responsibilities of researchers in various forms of research (basic, applied, funded)
- understand the processes of research results exploitation (academic /commercial)

(c) Research Management
- identify and be able to access bibliographical and other information sources
- effectively use information technology tools for database management and for recording and presenting data and relevant information

(d) Communicating research
- effectively use appropriate forms and levels of communication (progress reports, scientific papers, theses etc.)
- prepare and deliver oral presentations to diverse audiences (composed of specialists or non-specialists)
- prepare and use presentation material of high quality (slides and posters)

(e) Teamworking
- develop and maintain working relations with supervisors and colleagues
- understand personal behaviours and their impact on others in relation with teamworking and contributing to collective success

2.3 Educational methods and material

The course is taught in the Spring Term of every academic year. The whole educational process is structured into four main components, as described below.

Educational method
The teaching and learning activities that are implemented in the educational process of the course are:

(a) Lectures (compulsory attendance in the classroom)
(b) Creative activity (team/co-operative activity in and outside the classroom)
(c) Active learning (undertaking and accomplishment of individual and group roles)
(d) Self-education (learning and skills development outside the classroom environment)

Assignments
All PhD attendants of the course should undertake and complete: (a) a general assignment (team-work), and (b) two specific assignments (personal work). The content, requirements and ways of implementation of these course assignments are described in detail in section 3.3.

Educational material
The educational material of the course is uploaded in the Blackboard e-education platform that is operated by the Central Library of Aristotle University of Thessaloniki. All course attendants have direct access to the following.

(a) The extensive PowerPoint presentations used in the classroom lectures
(b) A collection of informative material that accompanies all lectures issues
(c) Various guidelines and examples for the proper completion of the course assignments
(d) All completed assignments of the students

Students' evaluation
The criteria for the evaluation and assessment of the students are the following.

(a) The overall presence and activity in the classroom
(b) The contribution in the general (team-work) assignment
(c) The individual performance in the two specific assignments (personal work)

3. IMPLEMENTATION OF THE COURSE
3.1 Class participation and attendance

The class attending the course “Introduction to Research Methodology” is composed of two groups of postgraduate students. The first is the one already mentioned, i.e. the PhD candidates of the Department of Civil Engineering of AUTh, while the second consists of the students (hereafter referred as PostGrads for brevity) who attend the MsC course “Environmental Protection and Sustainable Development”, administered by the same Department (Latinopoulos, 2002). This joint teaching can be considered as an interesting educational form from various points of view. Maybe the most important aspect relates to students’ participation and can be assessed by two relevant characteristics. The fist concerns the class composition in terms of the proportions of the two subclasses populations, whereas the second reflects the wide spectrum of scientific disciplines from which class attendants have obtained their first degree. The latter is a distinctive mark of the interdisciplinary nature of the postgraduate programmes of the Department of Civil Engineering, while the former signals the likelihood of dominance of one subclass over the other, which could probably result in different patterns of reactions and behaviors in the classroom and/or in performing other activities.

Figure 1 shows the variation of class size and composition along the six years of the course’s implementation. In this period a total of 313 students attended the course (145 - 46% PhDs and 168 - 54% PostGrads). The annual attendance varied from 38 to 66 with an average of 52 students. These figures show that the whole class was manageable (in terms of size) and that the two subclasses were more or less equivalent (in terms of student composition). These two facts allowed a quite convenient handling of the human potential in all four components of the educational process.

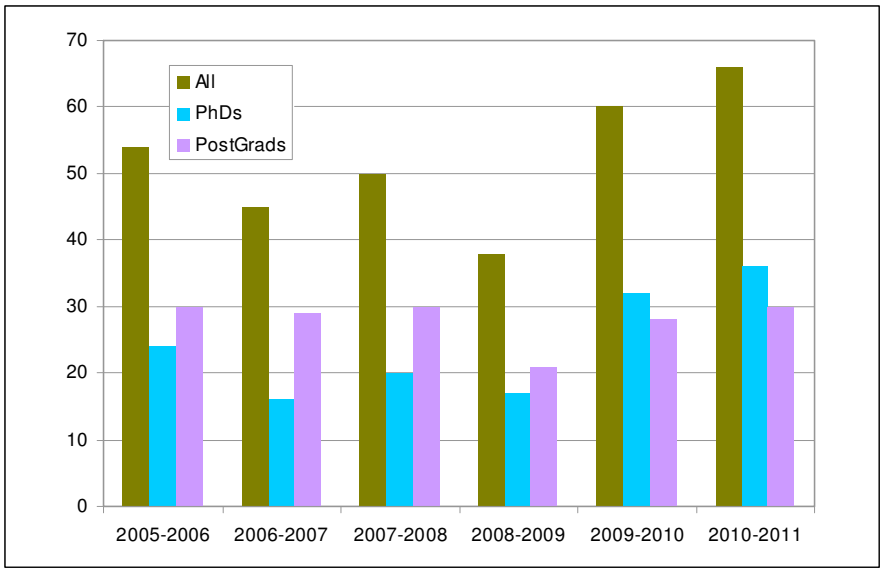

Figure 1: Variation in time of the class composition (number of PhDs, postgraduate students and total of attendants)

Admission to the two postgraduate programmes (i.e. for MSc and PhD students) is open to every candidate who holds any engineering specialisation but also to graduates from other disciplines, more or less relevant to the content of the two study programmes. Obviously, the demand from civil engineering graduates is higher and therefore there is a clear predominance of them over the rest engineers and scientists. This can be seen in figure 2,

where the composition of the course's class is presented in terms of these two groups of graduates. In average, two out of three course attendants are civil engineers. In the two subclasses the particular ratios are different, but still in favor of civil engineers: 4:1 in the PhDs group and 3:2 in the PostGrads one.

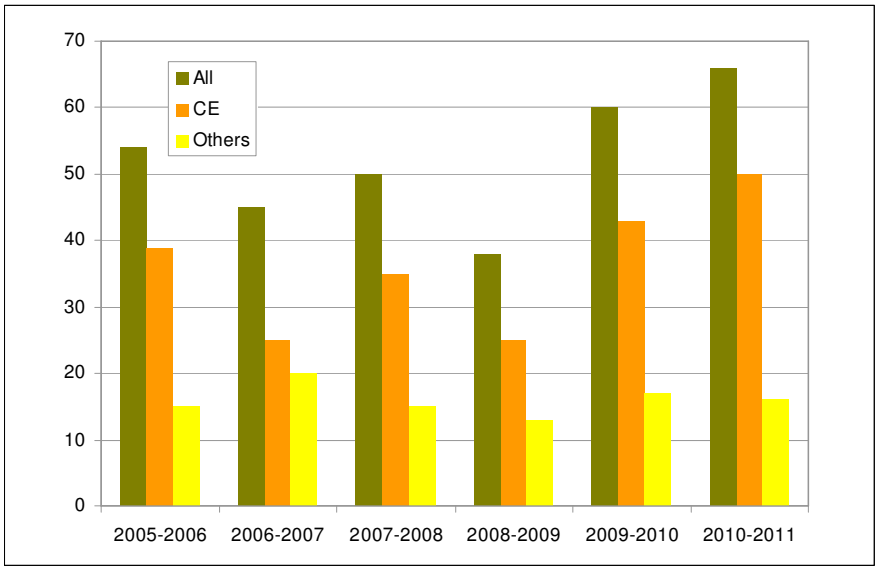

Figure 2: Variation in time of the class composition (number of civil engineers, graduates from other disciplines and total of attendants)

Of specific interest and therefore worth mentioning is the wide spectrum of graduates' disciplines other than civil engineering. From 96 non-civil engineers, who attended the course in all six years, 60% are engineers of seven other specialisations and 40% are scientists of 8 different disciplines. All these graduates hold the degrees listed in the following two groups.

a) Engineering specialisations: Planning and Regional Development Engineering (PE), Mechanical Engineering (ME), Rural and Surveying Engineering (RE), Chemical Engineering (CE), Environmental Engineering (EE), Architecture (AR) and Electrical Engineering (EL).

b) Other disciplines: Forestry (FO), Geology (GL), Environmental Studies (ES), Agriculture (AG), Marine Sciences (MS), Physics (PH), Biology (BI) and Law (LW).

In figure 3 the above mentioned data are shown in more detail, first for each subclass and then for the total of the class.

3.2 Course schedule

The course's main activities take place along a period of 10 weeks in the Spring Term. On a specific day of each of these weeks there is either a lecture (given by the course instructor) or a students' activity taking place in the classroom. As shown in table 1 there are eight lectures and two students' activities. Each lecture deals with a single topic related to at least one specific knowledge or skill issue. In most lectures active participation of the attendants is highly encouraged. On the other hand, the two students' activities are fully undertaken by themselves and have the form of public events. These activities are directly related to the general assignment, as described in the following section.

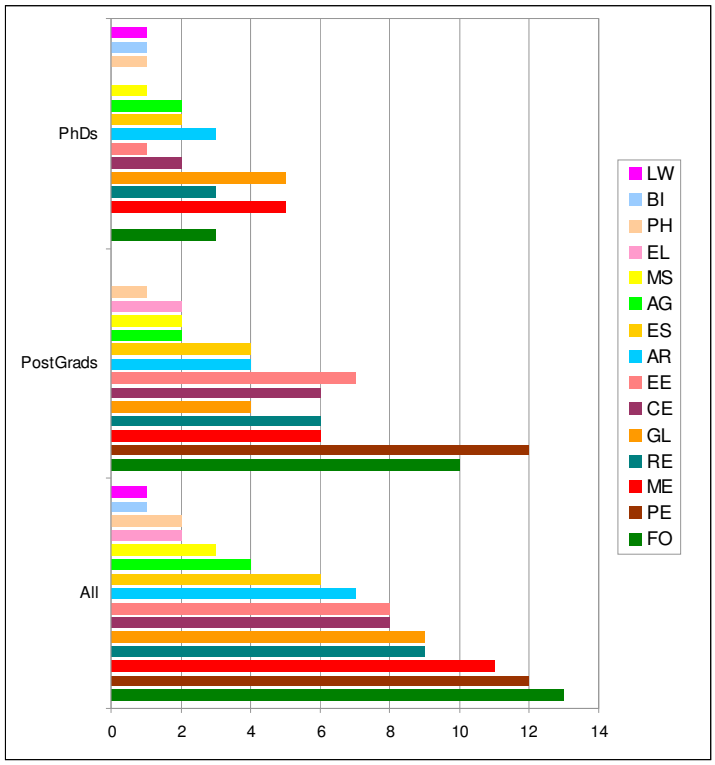

Figure 3: Disciplines of non-civil engineers attendants in all six years (of PhDs, PostGrads and total attendants)

Table 1: Outline of course lectures, activities and assignments

Week	Event / Topic	Student Assignment / Activity
1	**Lecture 1** Introduction – Basic concepts	
2	**Lecture 2** Research methodology and ethics	**General assignment**
3	**Lecture 3** Literature review and management	
4	**Lecture 4** Technical terminology	**Specific assignment A**
5	**Lecture 5** Quantitative research methods	
6	**Lecture 6** Oral presentations	
7	**Students activity 1** Oral presentations of paper critiques	Presentations and discussion of the critiques of journal papers
8	**Lecture 7** Posters and diagrams	
9	**Lecture 8** Scientific writing	**Specific assignment B**
10	**Students activity 2** Conference	Formal presentations (oral with PPTs) and poster presentations

3.3 Course assignments

The course assignments fall into two categories: team-work and individual work. They are all compulsory for the PhDs, while PostGrads have to take part only to the team-work, i.e. the general assignment. Details of the assignments are given immediately below.

General assignment
This assignment is undertaken by small teams composed of four or five students of the same or similar discipline. The successful completion of the assignment requires from each team to accomplish the following three separate tasks.

(a) Paper critique
- Search in various literature sources and select a paper recently published in a peer-review journal with a content that falls within the scientific interests of the team members
- Critical analysis/evaluation of the paper in terms of: scientific content, structure and style of writing, completeness of literature review, methodology used, presentation and discussion of results and conclusions made
- Oral presentation in the classroom of the paper critique by a team representative (all teams presenting together in students activity 1 - see table 1) followed by discussion

(b) Paper presentation
- Reversed use of the paper: from an object of critique (as a third person's work) it is now considered to be the brainchild of the team members (hypothetically, as their own authored work)
- Preparation of a complete typical conference-type oral presentation supported by PowerPoint slides (following specific guidelines for authors)

(c) Poster preparation and presentation
- Preparation of a typical conference-type poster presentation of the same paper by following specific guidelines for authors

Oral and poster presentations are given during the second students' activity in the classroom which concludes the series of the 10-week activities. This event is a simulation of a real scientific conference, in which all students participate by sharing various roles: session chairpersons, speakers, poster presenters, discussants or audience members. Besides the development of various skills along the whole span of actions of the general assignment, every individual student has the additional benefit of extending and widening his personal knowledge, not only through the involvement in the study and presentation of a high quality research issue undertaken by his team, but through his participation as an audience member in the two students' activities, in which a large set of scientific issues, selected from a wide spectrum of disciplines, is presented and discussed.

Specific assignment A
This assignment is undertaken by every doctoral candidate individually and aims at his familiarisation with principles and sources of terminology and on their proper use in basic and technological research. Each student examines four different English terms selected from his team's paper, evaluates them as well as their definitions, and repeats the same process for the terms translated in Greek. A written report from this assignment should be delivered within a 10-day period.

Specific assignment B
The second personal assignment requires the preparation of a typical conference paper that should be written by every doctoral candidate on a topic relevant to his current

research activity. All students are provided with a set of instructions for authors (guidelines for paper preparation). The deadline for the paper's submission is two months after the end of the course classroom activities. The purpose of this assignment is twofold: (a) every doctoral candidate becomes familiar with the style, structure and presentation of research in a typical written form, and at the same time gets used to conform to relevant guidelines, and (b) he can correctly write a research paper in terms of content, literature review, presentation of methods and results, and conclusions. The fulfillment of the first issue is evaluated collectively by the course instructor, while that of the second one is evaluated individually by the supervisor of every PhD student.

4. CONCLUSIONS

Any appropriate analysis based on recent reports and scientific papers dealing with the doctoral studies in higher education institutions shows that this educational form is indeed a dynamically changing issue, as many universities have been or still are in the process of a kind of reform in the structure and/or content of their educational programmes related to doctoral studies. Doctoral education, aiming at specific (research-related) knowledge acquisition and skills development, is more or less a distinct training process for doctoral candidates considered as early stage researchers. From such analyses two main conclusions can be drawn regarding the current trends: (a) to many doctoral education is an individual journey and, therefore, at a significant degree, it is the outcome of the relationship of the candidate with his supervisor, or even better, of the apprenticeship of the former by the latter, and (b) due to the rapidly increasing rate of research outcomes and products, particularly in the technological sector, and also to multiple transformations of the society and its needs, there is an equally rising demand for extra educational provisions to doctoral candidates, in the forms of learning research-related issues and developing skills of a similar kind.

As result of the above, most universities in Europe and elsewhere have adopted doctoral programmes that are a combination of individual supervision and coursework of various types. The latter takes place usually in the first stage of the doctorates and may consist of compact (integrated) modules, a number of individual courses on different subjects, usually of a semester-long duration, or a series of short-duration seminars on specialised issues.

The doctoral programme of the Department of Civil Engineering of AUTh consists of four individual courses, among which the one presented in this paper is the most closely related to all aspects of practicing research. It is worth noting that this is one of the very few examples of coursework, not even in the country but also abroad, on research methodology specifically for engineering. Due to the more or less modular form of the course's teaching and learning process, it could be alternatively considered as equivalent to a set of inter-connected short seminars. In any case, the course is considered a successful enterprise, not only by the instructor or the members of the Department, but especially by the postgraduate students who attended it during the last six years.

Necessary at the first stage but not sufficient for the whole time span of doctoral studies, the educational programme of the Department of Civil Engineering of AUTh should be complemented by a research training that would be more specialised, student-oriented, and tailored to the needs of every individual doctoral student. Self-education and self-training are important ways of acquiring the additional expertise and skills, but the much more valuable training is on the very hands of each supervisor who should provide it to his apprentices adequately and in good time.

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