

## SIMULATION

## MODELIAVIMAS

## Engineering Education and Engineering Practice: A Student Teacher Perspective

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### Introduction

Engineering education faces significant challenges as it seeks to meet the demands on both, the engineering profession and the engineering educator profession in the 21<sup>st</sup> century [1, 2]. Engineering educators are expected to search for new approaches to teaching and learning and to opt for new curricular pathways to address calls of change and challenging crossroads. Recommendations on the need to “re-engineer” engineering education have become increasingly widespread over the last years. That this re-engineering is closely related to the emerging profile of the engineer of the 21st century is not debated; nor is it debated that the said profile is largely determined by the state-of-the-art or, else, by the attributes of the profession in the real world – existing, perceived, pursued or simply desired. Following this line of thought, much of the rhetoric in the field has tended to emphasize the impact of both engineering students’ and engineering educators’ perceptions on engineering education and practice in the 21st century. The question, though, remains: If such perceptions are important, how more important would the perceptions of prospective engineering teachers be, ie. those of undergraduate engineering educators?

This paper presents the results of a qualitative and quantitative study of electrical and electronic engineering student teachers perceptions of (a) engineering education, and (b) professional engineering practice. The study was conducted in the School of Pedagogical & Technological Education (ASPETE) in Athens, Greece, which is the sole Higher Education School in Greece for the education and training of prospective engineering educators in the country.

### Literature Review

Engineering literature appears to focus mainly on devices and techniques that interest engineers, and only a few accounts exist on everyday engineering practice and on what this construct actually involves [3-5]. Almost all the papers in the literature that refer to engineering practice

aim to provide evidence for changing engineering education or evidence to support a particular set of engineering competencies. Engineering education, on the other hand, appears to be based on a number of implicit assumptions about engineering practice, eg. that engineering is a purely technical discipline based on scientific rationality [6]. It is also often discussed in connection to the widespread dissatisfaction with the “practical” skills of graduates in the workforce [4, 7], or in the light of the observed decline in the numbers of engineering students [8].

In this context, and against this backdrop, there have been several studies in newly emerged fields such as engineering pedagogy and didactics, engineering sociology, engineering philosophy, engineering management, systems engineering, financial engineering, engineering culture, engineering ethics, etc, dealing with engineering graduates expected or perceived attributes and required skills [4, 8-16].

While a number of studies in the above framework have attempted to identify and analyse engineering students’ and teachers’ perceptions on the above critical issues, most of this work has limited validity. This is because skills and attributes are often either pre-determined from anecdotal evidence rather than derived from systematic field observations [3] or borrowed from questionnaires tested in other culture-specific settings.

Given the relative scarcity of reliable information on the above issues, and, more importantly, the absence of studies regarding the perceived needs and expectations of prospective engineering educators, an understanding of engineering student teachers perceptions on the questions under discussion could give useful insights and guidance to educators and curriculum developers in the field.

### Methodology

As stated above, the present study was conducted in the School of Pedagogical & Technological Education (ASPETE), a Higher Education School comprising five undergraduate Departments for the preparation of

engineering educators in five disciplines (electrical, electronic, mechanical, civil & structural, and civil & construction). The degree offered is a four-year full time programme in which engineering and pedagogical courses are integrated to provide graduates for the engineering education in Greece. Data came from semi-structured interviews of selected informants across ASPETE's Departments of Electrical and Electronic Engineering Educators, and a questionnaire survey of a stratified random sample. The combination of the two formats was chosen as a means to allow a more in-depth exploration of the answers and to allow better categorization and interpretation of the findings. What is more, qualitative methodologies do not require a large and statistically representative sample, but rather a smaller sample selected to yield maximum diversity in responses [13].

During 2009, ten students from the above two Departments attending the compulsory subject "English for Specific Purposes" (ESP) were selected in order to provide a sample that was diverse with respect to gender (six of them were males and four females), school of provenance (7 came from General Lyceums and 3 from Technical & Vocational Lyceums), branch of engineering (electrical and electronic), academic semester (5 student teachers from the electrical and 5 from the electronic engineering dept. attending the above mentioned 14-week ESP course in the 3rd and 4th semester of their studies, respectively), and academic performance. No freshmen were included in the sample, since a large proportion of them tend to be uncertain about their long-term goals [9] and current perceptions of their study programme. With regard to academic performance, the participants represented a typical spread of abilities and skills. Interviews were between 45 and 60 minutes long. They were conducted with a written protocol, but allowed the interviewer to ask further questions based on the interviewees' responses. The interview protocol focused upon the two research points stated in the introduction and included the questions below, among others. Additional probes were used by the interviewer (author) to solicit information relevant to the original research questions.

- What is your current understanding of (a) engineering education in general, (b) of the engineering education study programme you are now attending?
- How do you perceive yourselves compared with graduates from other tertiary institutions in Greece?
- What are your plans after graduation? How will the Bs. degree "Electrical/Electronic Engineering Educator" fit into your goals?
- What are the challenges in your field? How prepared you feel you are/will be for the challenges in your field?
- What do you think engineers do in the workforce?
- What are the desirable skills, competencies, and attributes required of engineers in the 21st century?
- What are some of the attributes that one should have to be a global engineer?

A challenge for the author was to draw out detailed and/or elaborate descriptions of experiences and expectations, which brought out richer and more contextual data. It goes without saying that such "discussions" were not always easy to conduct in English; hence, they were sometimes conducted in the mother tongue, a solution especially welcomed by the teacher students who, more than often, were tempted to frame their perceptions using culture-bound words and schemas. A second challenge for the author was the departure from the majority of formal semi-structured interviews reported in the literature so far, where interviews are traditionally recorded and then transcribed. After some thought it was decided not to use any tape recorders, which proved to be conducive to the less reserved responses of the students and their more frank cooperation. A third challenge was the processing and reporting of the interview data, which was performed by the help of the student teachers themselves as a follow-up activity in the frame of the specific course. It was decided that this would encourage reflection on their own perceptions, and that it would turn the whole procedure into a valuable learning activity.

Interviews were combined with a questionnaire survey of a random stratified sample from the same Departments. Respondents were asked to rate aspects of engineering education and engineering practice according to their own perception of their importance, on a scale from 1 to 4 (1 = no importance, 2 = low importance, 3 = medium importance, 4 = high importance). Questions were grouped into themes, which made it easier to identify overall patterns in the responses.

## Research Findings

Findings were analyzed in three ways. First, applying the traditional techniques of quantifying the answers to the questionnaire questions. Second, grouping and analyzing themes emerging from the interviews, and, finally, comparing the two and investigating points of convergence or divergence between them. Combined results are summarized in Table 1 below. On the basis of the different demands between the two academic disciplines from which the sample was drawn (electrical and electronic), it was hypothesized that the two groups of student teachers would differ in their attitudes and assessments, over and beyond individual differences. An initial comparison of their responses, however, yielded non-significant differences; hence, the variable was ignored in subsequent analyses.

**Table 1.** Recurring patterns and themes

<b>Interdisciplinary/concurrent approach in engineering educators study programmes</b>	<b>85%</b>
Importance of technical knowledge and skills	100%
Importance of engineering pedagogy	85%
Importance of sciences	60%
Importance of financial skills	45%
Importance of management skills	60%
Importance of communication and other interpersonal skills	55%
Importance of environmental awareness skills	35%
Importance of life-long learning skills	80%

## Analysis of Patterns in Student Teacher Responses

Further processing and analysis of the above patterns revealed the following results:

A large number of patterns related to engineering teacher preparation. The majority of the cohorts (interviewees and questionnaire respondents) from the engineering education departments under discussion argued for an interdisciplinary approach in engineering educators study programmes, that is conceptualized around the following areas: (a) in-depth disciplinary-based knowledge, (b) the sciences, (c) the humanities, (d) pedagogy knowledge. The emphasis was on the enhancement of disciplinary knowledge through the concurrent development of a critical understanding of the different perspectives that each area represents, and on the concurrent rationale of the undergraduate programme offered by ASPETE [17]. This is consistent with the construct of engineering pedagogy that has emerged over the years as a particularly dynamic quest and request to the theoretical credentials of technical teacher education in general [1, 2, 18].

Technical knowledge and skills was also a recurring pattern in the cohorts' responses. All the cohorts rated technical knowledge as highly important to both engineering education and engineering practice, with relatively lower ratings given to pedagogical, management, financial, interpersonal, and other skills. The majority of them said they felt they were well prepared for the technical workforce with regard to technical knowledge, but not so well with regard to technical skills. Three of the interviewees asked for more hands-on learning and teaching experiences until the later stages of their degree, and for more plant visits and stronger industrial linking in the frame of their overall studies. They seemed to regard this kind of preparation as a separate issue from their technical knowledge preparation. One of them also felt lacking the technical background needed to work with engineers from other disciplines in multi-disciplinary teams.

Engineering pedagogy was the second highly rated pattern in the data under discussion. Respondents pointed towards nothing less than the need for engineering pedagogy curricula aiming at producing (a) professional engineering teachers and educators who have the knowledge, skills and commitment to teach to high national and international standards, and (b) to maintain standards of education and professional preparation for the teaching profession as a whole. This last point relates to perceived anxieties about the status of engineering teachers in general. Any separation or differentiation would reduce the status of engineering teaching as a promising career and might cause recruitment difficulties, they remarked.

The importance of sciences in engineering education was touched upon by the interviewees in relation to the importance of problem-solving and analytical skills, the value of which they highlighted. Most of them attributed the development of such skills to fundamentals of mathematics and mathematical tools. One of them stated that the integration of common and/or similar science courses across engineering disciplines might facilitate cooperation in multi-disciplinary teams.

The importance of good financial and management skills in engineering practice was identified by several respondents. Three interviewees remarked that building a financial perspective into their studies would enable them to acquire a solid understanding of financial skills that would then help them to make cost-effective decisions reflecting and/or meeting the needs of their organization.

With regard to the construct of management, more than half of the interviewees stated that engineering management skills are crucial to the attainment of a leadership role, to the administration of large projects and budgets, and, above all, to the building and maintenance of good interpersonal relations. Not surprisingly, management skills were associated by them with communication and other interpersonal skills, including the ability to work in a team, to take initiatives and to make decisions. Three interviewees responded to the author's probe to discuss factors that may affect their ability to communicate effectively. In their opinion, such factors include self-esteem and self-confidence, good relations with their colleagues, strong technical knowledge, knowledge of communication techniques, good grasp of language, and fluency in at least one foreign language. An optional course in engineering communication, they said, might help them develop these skills. An interesting finding in this case was the observed deviation between this set of responses and the responses of two other interviewees who believed that these skills are mostly learned "on the job". Respondents were also divided on whether or not teamwork is a skill that can be taught at a strictly theoretical level. Half of them felt that more team-based assignments in their curriculum would have been more beneficial.

The issue of environmental awareness skills in engineering practice was particularly discussed by the four female interviewees who associated them with engineering ethics, and stated their commitment and "duty" to develop such skills in their future students. This is consistent with the literature that links environmental challenges in engineering with ethical issues [16].

Finally, the importance of life-long skills in engineering practice was highlighted by the vast majority of the respondents. One of them used the metaphor of "learning without barriers", that he then associated with the construct of "global engineering" and the attributes one should have to be a "global engineer". Among the key attributes identified in this case were broad range of work experience, flexibility to function effectively in different cultural and social settings, and, above all, to be open to new challenges and always welcome new learning opportunities.

## Conclusions

This paper examined electrical and electronic engineering student teachers perceptions regarding (a) engineering education, and (b) professional engineering practice. The results of a quantitative and qualitative study in the field were presented and analysed. Recurring patterns and themes in the interviewees responses seem to be reflective of the emphasis placed on the various aspects of their technical and pedagogical development in the

curriculum that is based on the principles and rationale of the concurrent model. Given the absence of studies regarding the perceived needs, expectations and goals of prospective engineering educators, an understanding of engineering student teachers perceptions on the above questions could give useful insights and guidance to educators and curriculum developers in the field. The findings presented in this paper can also be used as a starting point for further research.

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The paper presents the results of a qualitative and quantitative study of electrical and electronic engineering student teacher perceptions of (a) engineering education, and (b) engineering practice. The study was conducted in ASPETE, the sole HE School for the education and training of prospective engineering educators in Greece. Data came from semi-structured interviews of selected informants across ASPETE's Departments of Electrical and Electronic Engineering Educators, and a questionnaire survey of a stratified random sample. Given the relative scarcity of information on the issue, an understanding of such perceptions can provide useful insights for educators and curriculum developers. Bibl. 18, tabl. 1 (in English; abstracts in English, Russian and Lithuanian).

**M. M. Контонидою. Исследование опыта студента-преподавателя в учебном процессе // Электроника и электротехника. – Каунас: Технология, 2010. – № 6(102). – С. 167–170.**

Описываются опыты преподавателей при подготовке инженеров в электронной области. Исследование проведено в Греции по программе ASPETE опрос проведен случайно в виде анкеты и через компьютерную связь. Результаты положительные. Библ. 18, табл. 1 (на английском языке; рефераты на английском, русском и литовском яз.).

**M. M. Kantonidou. Studento-dėstytojo perspektyvos inžinerinio mokymo ir praktikos procese // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2010. – Nr. 6(102). – P. 167–170.**

Pristatyti elektros ir elektronikos inžinerijos krypties dėstytojų suvokimo rezultatai apie inžinerijos dėstymą ir praktiką. Tyrimas buvo vykdoma ASPETE, kur ruošiami būsimi inžinerijos dėstytojai. Duomenys buvo gauti interviu metu arba pateikiant klausimyną atsitiktinai atrinktiems žmonėms. Bibl. 18, lent. 1 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).