PHYSICS EDUCATION OF ENGINEERS IN TURKEY

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Abstract *– Physics is an indispensable ingredient in engineering curricula because technology is based on our knowledge of physical laws. A good training in physics also provides a solid base for lifelong learning. In this paper we review physics instruction at Turkish engineering schools, and in particular at the Eastern Mediterranean University. We discuss problems of teaching physics, such as commonsense misconceptions. The paper also discusses some of the problems encountered in teaching physics to students who have learned English as a second language, problems arising from the trend of internationalization at some universities, including Eastern Mediterranean University, where the medium of instruction is English. It also compares the state of physics in Turkish engineering schools, with that in some European and North American schools.*

Index Terms – Engineering education, internationalization, physics education, Turkish engineering schools.

INTRODUCTION

Physics and technology are two inseparable, complementary entities whose interrelationship is ever-growing. Today's advanced technology is used in the service of physics, e.g. to probe the heart of the material world. In turn, quantum physics, the physics of the microcosmos, is becoming indispensable in modern technology and its engineering applications.. In the words of Wenninger 'Basic research – science – creates new technologies and innovations – but also depends on innovation and the new technologies for scientific progress' [1].

The importance of physics in engineering education cannot be overestimated. Above all, physics provides the experience of participating in the scientific method at an early stage of engineering education. It is conceivable that in a not too distant future few engineers will be able to practice without some understanding of quantum physics. Moreover, as some engineers observe, "the engineer who acquires the level of knowledge possessed by a physicist, can assert himself not only in the research and development area, but also as a manager of intensive development of the production branch" [2].

In many distinguished engineering schools, the importance attached to physics is reflected in their curriculum [3] – [6]. However, there are some reports from some engineering schools that physics contact hours have been decreased [7], and that lately physics either has been treated "treated as a subject of low priority," [8] or is "becoming a simple tool for specific engineering courses" [9].

From the student point of view, physics has little or no relevance to engineering. What is more, the negative public image of physics as an abstract and difficult subject, helped by the 'old fashionedness of high school physics' [10] poses a serious problem to physics educators. A recent survey [7] revealed that among secondary school students in at least one national context, physics is last in the order of preferred subjects. This is probably true for most countries.

In the next section we will briefly review the state of physics instruction at Turkish engineering schools, in particular at the Eastern Mediterranean University (EMU), and compare it with that in North American and European schools, as exemplified by electrical engineering. We will then look at two problems of physics instruction: the – universal- problem of commonsense misconceptions, and the problems which have arisen from the internationalization of engineering education, related to teaching physics in a foreign language (English in our case).

PHYSICS AT EMU AND OTHER TURKISH ENGINEERING SCHOOLS

The Eastern Mediterranean University is the oldest and largest university in North Cyprus. In the academic year 2000 – 2001 it had over 14,000 students from over 60 countries (largely from North Cyprus and Turkey), creating an international and intellectually stimulating environment. The University has been developing rapidly in its aim to become one of the centers of learning in the Middle Eastern regions. The language of instruction in all courses (except in some courses offered by the School of Law) is English.

The School of Engineering was established in 1979 and has about 3,500 students studying in its five departments:

- Civil Engineering
- Computer Engineering
- Electrical and Electronic Engineering
- Industrial Engineering
- Mechanical Engineering

The objective of the School is "to produce well-qualified graduates who have received a modern education of the highest standard, who at the same time have a particular understanding of the needs and problems of the region" [11]. The normal duration of study for the

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Bachelor's degree is four years. All departments also have programs leading to the Master's and Ph.D. degrees.

All undergraduate engineering programs at EMU have two physics courses in their curriculum except the Electrical and Electronic Engineering program, which has three physics courses. Each course consists of 4 hours of lectures per week, supplemented by 1 hour per week of tutorial and laboratory work for 14 weeks. All lectures are taught by professors from the Physics Department, and tutorial/laboratory sessions are conducted by graduate teaching assistants.

Physics I offered in the fall semester of the freshmen year, is a calculus-based course primarily devoted to the study of mechanics at the level of Serway and Beichner [12]. Physics II is offered in the spring semester, and is mainly about thermodynamics and electromagnetism. Physics III is essentially a second-year modern physics course, which includes introductory quantum physics and its applications to solid state physics at the level of Beiser [13].

The total credit hours allocated for physics in some selected Turkish electrical engineering programs are shown in Table I. The mean number of credit hours for physics is 9.04 and this represents 5.74% of total time allocated for physics.

TABLE I
TIME ALLOCATED FOR PHYSICS AT SELECTED TURKISH UNIVERSITIES

University	Total credit hours	Physics credit hours	Physics % of total hrs.
Anadolu	160	10	6.3
Ankara	150	12	8.0
Baskent	146	7	4.8
Bilkent	127	11	8.7
Bogazici	149	12	8.1
Cukurova	161	8	5.0
Dicle	176	9	5.1
Dokuz Eylul	145.5	8	5.5
Firat	164	9	5.5
Gazi	173	8	4.6
Gaziantep	175	8	4.6
Hacettepe	145	10	6.9
Isik	155	11	7.1
Inonu	175	8	4.6
Kadir Has	154	8	5.2
Kahramanmaras S.I.	189	6	3.2
Karadeniz Technical	180	8	4.4
Koc	139	8	5.8
Middle East Technical	132	11	8.3
Mustafa Kemal	164	11	6.7
Sakarya	131	6	4.6
Uludag	180	10	6.3
Yeditepe	153	8	5.2
Yildiz Technical	160	10	6.3

GENERAL COMPARISONS

A recent study [14] on 66 North American electrical engineering curriculums has shown that the mean number of physics credit hours is 10.3. This is only slightly larger than the average of our sample of 24 Turkish engineering schools. While the majority of North American schools provided the basic science requirements as either "3 physics – 1 chemistry" or
"2 physics – 2 chemistry" courses, most Turkish schools offered "2 physics – 1 chemistry".

A major difference between Turkish and North American programs is in the number of total credit hour requirements for graduation. The mean number of credit hours of Turkish engineering schools is 157.6, while the corresponding figure at North American universities is 133.5 [15]. Thus, even though the time spent on physics is comparable, its share in the total time is 5.74% at Turkish schools as compared to 7.74% at North American schools. The corresponding figure for the EMU is 8.28%, third highest among Turkish universities (after Bilkent and Middle East Technical University).

For comparison with European engineering schools we refer to the extensive survey of the International Program Review – Electrical Engineering Committee [16]. According to this report, the mean time spent on physics expressed as a percentage of total hours in nine selected European schools is 8.1% (Leuven 12%, Delft 10%, ETH, Lund, and Twente 9%, Eindhoven, Chalmers, and Munich 6%).

PROBLEMS

In this section we will discuss two problems we encounter in teaching physics at EMU. One is universal and is about the commonsense misconceptions in physics; the other is specific to some Turkish universities which adopted a foreign language (English) as the medium of instruction.

Commonsense Misconceptions in Physics

In their much-cited work Halloun and Hestenes [17] have shown that prior to university instruction most students hold some commonsense misconceptions and beliefs related with events in our daily life which are in contradiction with Newtonian mechanics. The diagnostic tests such as Force Concept Inventory (FCI) developed by Hestenes, Wells and Swachkhamer [18] demonstrated the presence of misconceptions, and by applying the tests before and after instruction one could assess the effectiveness of the physics instruction.

The FCI has been implemented in many countries [19] – [23], always revealing that the commonsense misconceptions are deeply rooted and that conventional instruction produces little change in these beliefs. For more than a decade considerable research has been directed towards identifying students' misconceptions and improving physics instruction [24] – [29]. The Turkish high school curriculum is characteristically broad, and therefore, students' formation in physics is not particularly strong.

We first applied the Halloun-Hestenes mechanics diagnostic test [17] to our freshmen engineering students in 1988 [19]. The results of the pretest demonstrated the

presence of misconceptions and a low level understanding of Newtonian concepts. The gain at the end of one semester of conventional instruction was only 3.2%. When ten years later the test was repeated, the gain was increased to 12.9% [30], largely because of the instructors' increased awareness of misconceptions among the students.

Learning Physics in a Foreign Language

The role played by language in physics – a science that involves activities such as observations and synthesizing – which depends critically on spoken and written communication, is often underestimated [31]. If the ordinary language used for such communication is not the mother tongue, then communication may present a few problems, becoming less precise and sometimes inaccurate.

The trend of internationalization has led some Turkish universities (mostly private ones), including the EMU, to adopt English as the language of instruction. The primary motivations behind this choice are [32]:

- Better access to scientific and technical literature
- Better exchange of knowledge and culture
- To attract students and faculty members from abroad
- To prepare students who wish to pursue their studies at a foreign university
- To provide graduates better opportunities in an internationally-oriented job market

Those students who are admitted to EMU but whose English is not adequate for full-time study in an English language medium are required to study for one or two semesters at the English Preparatory School. Nevertheless, successful completion of the preparatory English course is not a guarantee of sufficiently high level of proficiency in English, and therefore, for some students, learning physics becomes much more difficult when they receive instruction in physics in English.

The effects of foreign language instruction on student performance have been the subject of several investigations [33] – [35]. Jochems [33] has studied the correlation between English proficiency and academic success, and concluded that for engineering programs, learning and teaching in a foreign language reduce the quality of education. He argues that a small lack of language proficiency may be compensated by higher mathematical ability and greater effort, but this becomes impossible in the case of a greater lack of language proficiency.

It is, however, not always easy to distinguish between student difficulties arising from lack of language proficiency and those from conceptual difficulties. Preliminary results from our research at EMU, suggest only a weak correlation between performance in physics and proficiency in English. This is supported by (subjective) observations of our instructors teaching freshmen physics.

CONCLUDING REMARKS

Physics is an indispensable ingredient of engineering curriculum. As Jelen [36] rightly argues, "physics in engineering education should not simply be in a position of a servant." Physics teaches exact thinking, and a good training in physics provides a solid base not only for the undergraduate curriculum but also for lifelong learning.

The expectation of Turkish industries from graduates to have the current know-how to solve immediate problems is reflected in the curricula of most traditional engineering schools, where there is a tendency to teach as many engineering courses as possible. This "multi-specialization" prevalent in the curriculum of most Turkish universities is usually achieved at the expense of basic science, and in particular humanities/social sciences courses [14]. In our experience we find it quite disturbing that many Turkish students carry the belief that physics has little or no relevance to engineering. In some countries, overspecialization (as opposed to multi-specialization) occurs, again at the expense of the basic sciences [37].

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