EDUCATIONAL CURRICULA AND PROFESSIONAL OPPORTUNITIES FOR NAVAL ARCHITECTS AND MARINE ENGINEERS: THE CASE OF GREECE[1]

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Abstract

We review educational curricula and professional opportunities for students getting a degree in Naval Architecture and Marine Engineering (NAME) in Greece. The only university currently offering such a degree in Greece is the National Technical University of Athens (NTUA), and specifically its School of Naval Architecture and Marine Engineering. The School's graduates typically find employment in the shipping industry, and currently enjoy strong demand from prospective employers, almost zero unemployment, and the highest average salary of all NTUA engineering graduates. We take stock at the skills necessary to enter this segment of the labor market, the structure of the educational program, and ideas on how it may evolve in the future.

Key words: Education and Training; Naval Architecture and Marine Engineering, National Technical University of Athens.

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1. INTRODUCTION

The National Technical University of Athens (NTUA) is Greece's premier technological university. It was initially founded as an arts and crafts school in 1836, almost simultaneously with the foundation of the modern state of Greece. NTUA further evolved according to the standards of the Continental European education system for engineers, with a solid studies background and a regular 5-year programme duration.

Engineering graduates from NTUA have been the major scientific and professional drivers throughout the country's modern history. They have worked as engineers in public and private technical agencies and companies and they have been engaged in all major engineering endeavors in the country. In parallel, they adopted teaching and research positions at the Greek as well as the international academic community.

This great national contribution and the conquest of this distinguished position by NTUA are due to the high standards of its studies, the high average quality of faculty and students and the satisfactory level of the infrastructure.

Naval Architecture and Marine Engineering (NAME) at NTUA was founded by Government Decree on May 15, 1969, and the first students were admitted during academic year 1969-70. The initial educational unit was a Department within the School of Mechanical and Electrical Engineering. Professor Frangoulis, Rector of NTUA during the period 1969-70, was instrumental in the birth of NAME at NTUA.

Three faculty chairs were initially created: (a) Ship Theory, (b) Ship Design and Construction, and (c) Marine Engineering. Professors Loukakis, Antoniou and Ioannidis were respectively elected to these chairs. A Lecturer, two Teaching Assistants and a Laboratory Assistant assisted each Professor in his teaching and research work.

From its inception, NAME at NTUA was allocated a specified number of entrants, which during the first year of operation were only ten (10)[2]. In later years the numbers increased. In 1974 the NAME Department produced its first graduates, and in 1982 it became fully self-regulating and independent Department. With the gradual influx of new academic staff the teaching material has been substantially updated and revised, both from the point of view of subject content and also through the introduction of new courses. In 2001 the School was divided into four Divisions: Ship Design and Maritime Transport, Naval and Marine Hydrodynamics, Marine Structures, and Marine Engineering. In 2002, all Departments at NTUA, including NAME, were renamed as Schools.

[2] By coincidence, this author was a member of the initial batch of NAME entrants.

The School of NAME is now fully developed and currently employs 26 faculty members. Besides teaching, it is heavily involved in fundamental and applied research through externally funded research projects. The School is today the top School of NTUA in terms of research income per faculty member and is comparable to European and other foreign universities in terms of external research funding. Major milestones in establishing the necessary research infrastructure can be considered the commencement of activities of the Towing Tank in 1979, and the development of the infrastructure of the Laboratories of Marine Engineering, Shipbuilding Technology and Ship Design. Two additional Laboratories have been formally established in recent years, the Laboratory for Maritime Transport (headed by this author) and the Laboratory of Floating Structures and Anchoring Systems.

The rest of this paper is organized as follows. Section 2 describes the NAME educational programme at NTUA and section 3 discusses the professional placement of NAME graduates. Finally section 4 presents the paper's conclusions.

2. EDUCATIONAL CURRICULUM

According to the NTUA study programme, studies in the School of NAME last five (5) academic years. On substance, this makes the total study programme equivalent to a B.Sc. followed by a M.Sc., although official recognition of this has not yet been granted to NTUA by the Greek government[3]. Each academic year is split into two semesters: the fall semester (September-January) and the spring semester (February-June). Of the ten (10) semesters, the first nine (9) are dedicated to course study including laboratory exercises, while the 10^{th} semester is dedicated to the writing of the Diploma Thesis. However, it is common that theses start much earlier.

A separate Interdepartmental post-graduate programme in Marine Technology and Science and a doctoral programme are maintained within the School. The number of doctoral candidates currently in the School exceeds 70. The rest of the paper deals with the 5-year study programme, whose entrants consist of 60 students per year, who are admitted on a competitive basis after taking the National Exams.

This programme has been drawn up in order to provide the students with the basic scientific knowledge in the disciplines of NAME. Additionally, it covers a wide spectrum of requirements that are important for the professional career of NAME graduates. Many of the courses include term projects, the most comprehensive one being that on Ship Design. Although the center of gravity of the curriculum consists of subjects with a comprehensive engineering content, courses in maritime economics, shipping finance, ports and intermodal transport, shipping logistics, and safety and environmental protection are also offered in the last two years of the programme.

[3] This, together with the recent European Court's decision that foreign B.Sc. degree holders, even if their study programmes are of 3 year duration, cannot be banned of degree recognition by the Greek state, has contributed to serious unrest at NTUA and other Greek universities, especially at those that have 5-year educational programmes. In the opinion of this author, the only way to resolve this would to split the current programme into two consecutive cycles, one yielding a B.Sc. (say, after 4 years) and one a M.Sc. degree (in 5 years). However, such a split would encounter fierce opposition by some circles.

Courses up to and including the 7th semester, plus three (3) 8th semester courses and one (1) 9th semester course are compulsory. The total number of compulsory courses each student is required to take are 51. With some exceptions, the bulk of NAME courses essentially begin at the 5th semester, lower semesters being mainly devoted to general subjects including mathematics, physics, mechanics, fluids, thermodynamics, materials, computers, other basic engineering courses, and even some economics and humanities courses. Foreign language courses are also part of the general subject requirements.

Table 1 below lists all of the compulsory courses that are taught by NAME faculty. This is a subset of all compulsory courses that a NAME student is required to take at NTUA. It is noted that the table includes some non-NAME courses which are taught to NAME students by NAME faculty (sometimes jointly with faculty from other Schools). These courses are listed by an asterisk (*).

Table 1: Compulsory courses taught by NAME faculty

Course	Semester
Introduction to Naval Architecture	1
Mechanical Engineering Drawing*	1
Introduction to Workshop Technology and Laboratory*	1
Mechanical Engineering Design Using Computers*	2
Ship Design	2
Hydrostatics and Ship Stability I	3
Science and Technology of Materials I and Laboratory (Metals)*	3
Electrical Circuitry and Electrical Engineering Technology*	3
Mechanics of Fluids*	4
Electrical Technology Applications and Laboratory for Marine Engineers and Naval Architects	4
Machine Elements (Strength of Machine Elements, Transmission, Gearing)*	4
Science and Technology of Materials II and Laboratory*	4
Principles of Naval and Marine Hydrodynamics	5
Ship Resistance and Propulsion	5
Ship Strength	5
Probability Theory and Statistics. Applications in the Marine Environment	
Introduction to Automatic Control*	5
CAD/CAM Systems for Ship Design and Construction	6
Hydrostatics and Ship Stability II	6
Ship Dynamics and Laboratory	6
Dynamics of Marine Structures	6
Dynamics and Vibrations of Ship Mechanical Systems	6
Ship Design and Outfitting I (Methodology of Ship Preliminary Study)	7

Ship Design Project I	7
Economics of Maritime Transport I	7
Ship Systems and Marine Auxiliary Machinery (Networks, Hydraulic Systems, Deck Machinery)	7
Marine Propulsion Plants	7
Dynamics and Vibrations of Machinery and Ship Shaft Systems	7
Shipbuilding Technology and Laboratory	7
Ship Design and Outfitting II	8
Economics of Maritime Transport II	8
Ship Energy Systems	8
Ship Structures Statics	9

Restricted electives are offered in the 8th and 9th semesters and are grouped into four Thematic Units as follows:

I) Marine Environment and Interaction with Ships and Floating Structures.
II) Study, Design and Manufacture of Ships and Floating Structures.
III) Marine Engineering and Ship Propulsion.
IV) Ship Operations and Maritime Transport Systems Management.

Table 2 below depicts the electives listed for each of these Thematic Units.

Table 2: Thematic Units elective courses

Thematic Unit	Course	Semester
I	Elements of Design of Floating Structures	8
I	Ship Track Stability and Maneuverability	8
I	Computational Hydrodynamics and Laboratory	8
I	Stochastic Modeling and Forecasting of Marine Systems	8
I	Ships Seakeeping and Applications	8
I	Anchoring of Floating Structures	9
I	Hydrodynamic Design of Small Crafts	9
I	Roll Stability and Regulations Background	9
I	Wave Phenomena in the Sea Environment	9
I	Lifting Flows	9
II	Ship Design II	8
II	Analysis and Design of Vessels Using Composite Materials	8
II	Welding Engineering	8
II	Health and Safety in the Shipbuilding Industry	8
II	Ship Design for Safety and Environmental Protection	8
II	Virtual Reality and Applications to Ship Design	8
II	Computer-Aided Ship Design	9
II	Reliability of Marine Structures	9
II	Vibrations of Hull and Ship Construction Components	9
II	Computational Methods and Applications in Shipbuilding Construction	9

III	Marine Diesel Engines	8
III	Marine Engineering Laboratory I	8
III	Hydrodynamics of Modern Ship Propulsion Systems	8
III	Measurements of Natural Quantities with Emphasis to the Marine Environment	8
III	Marine Engineering Laboratory II	9
III	Analysis and Optimization of Energy Systems	9
III	Combustion	9
III	Noise and Vibration Technology in Naval Architecture And Marine Engineering	9
III	Special Ship Control Systems	9
IV	Elements of Finance- Special Topics in Ship Finance	8
IV	Sensors Technology- Diagnostics and Prognostics of Ship Equipment Failures	8
IV	Ports And Intermodal Transport	8
IV	Artificial and Computational Intelligence in Ship Design and Operation	8
IV	Risk Management and Assessment in Maritime Transport	8
IV	Operation and Maintenance of Ships and Fleets	9
IV	Inspection-Maintenance of Ship's Metal Structure	9
IV	Logistics in Maritime Transport	9
IV	Economics of Maritime Transport III: Safety and Environmental Analysis	9
IV	The Human factor- Introduction to Human Reliability in Maritime Transport	9

Electives from the above table are restricted, in the sense that students should choose at least two (2) courses from each Thematic Unit, and a total of ten (10) such courses overall from the table.

The rest of electives are split in three groups: Group A includes courses offered by the School of Applied Mathematics and Physical Sciences and the Schools of Chemical Engineering and Electrical Engineering. Group B includes courses offered by the School of Mechanical Engineering and, finally, Group C includes electives offered by the School of Naval Architecture and Marine Engineering, including one on practical training. Three (3) courses should be chosen from Group A, two (2) courses from Group B, and three (3) courses from Group C or from the list of courses offered under the Thematic Units set of electives. The total number of electives that are currently offered to the NAME student are 89, of which some 18 should be chosen.

More details of the entire curriculum can be found in the School's study guide, as described in NTUA-NAME (2008).

4. PROFESSIONAL DEVELOPMENT OF NAME GRADUATES

At the professional level, NTUA NAME graduates are engaged in any one or more of the following professional activities during the course of their career (numbers in parentheses are indicative percentages, as obtained from a recent survey):

- *Shipping and Ship Management Companies (23%)*. Sea-going engineer, marine superintendent, new construction and repairs surveyor, chartering, claims etc.
- *Marine & Technical Consultancies (22%)*. Self-employed or in collaboration with others. Consultancies usually offer services on such matters as technical advice, new designs, claims reports, estimates.
- *Public Sector (19%)*. Ministry of Mercantile Marine (Inspectorate of Merchant Ships, or other divisions), Ministry of National Defense (Navy), Hellenic Register of Shipping, Research Institutes, public sector companies (Public Petroleum Corporation, Marine Technology Development Company, etc), banks, insurance companies.
- *Classification Societies (9%)*. All major Classification Societies have offices within the Piraeus area and carry out plan approval and/or class inspections.
- *Technical Commercial Companies- shipping related (8%)*
- *Commercial companies –no-shipping related (6%)*
- *Shipyards (4%)*. Design, Management of New Constructions, Management of Repairs.
- *Other- including Academic Career (4%)*. Within higher education and technical education institutions in Greece and abroad.

NAME graduates of NTUA currently enjoy a strong demand from prospective employers, at least in Greece. In fact, they have the 2nd lowest mean time to land a job among engineers (2.4 months), and the lowest average unemployment rate among engineers (2.2%). Moreover, they have the 2nd highest declared mean income for a first job, and the 1st highest for older graduates.

Figure 1 below shows the salary distribution for NAME professionals (dark bars) as compared to other engineers (light bars). The figure is from Frangopoulos (2008) and its source is a recent survey on the professional settlement of NAME graduates of NTUA. It can be seen that NAME graduates are better off than the average engineer.

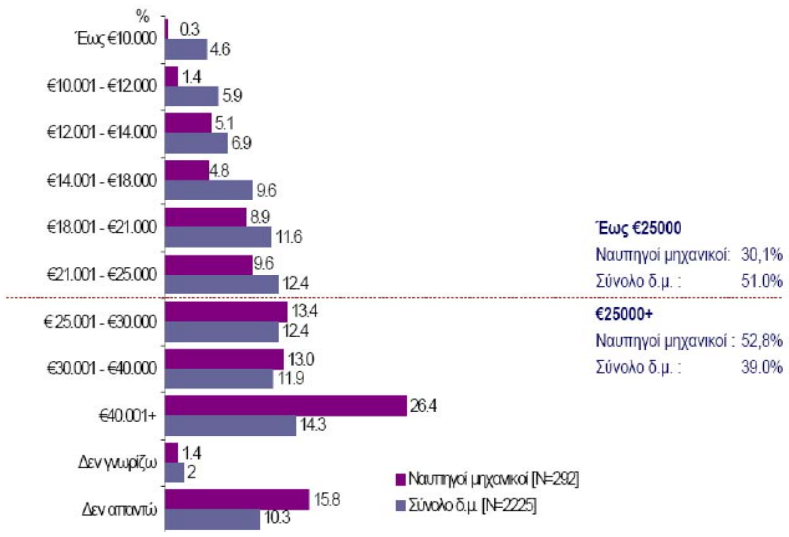

Fig. 1: NAME graduates salary distribution

Figure 2 shows in relative terms the salary evolution of NAME professionals, broken down by job category. The figure is taken from Hatzigrigoris (2007) and the source of this survey is a questionnaire undertaken by Kristen Navigation, to which some 143 NAME professionals responded.

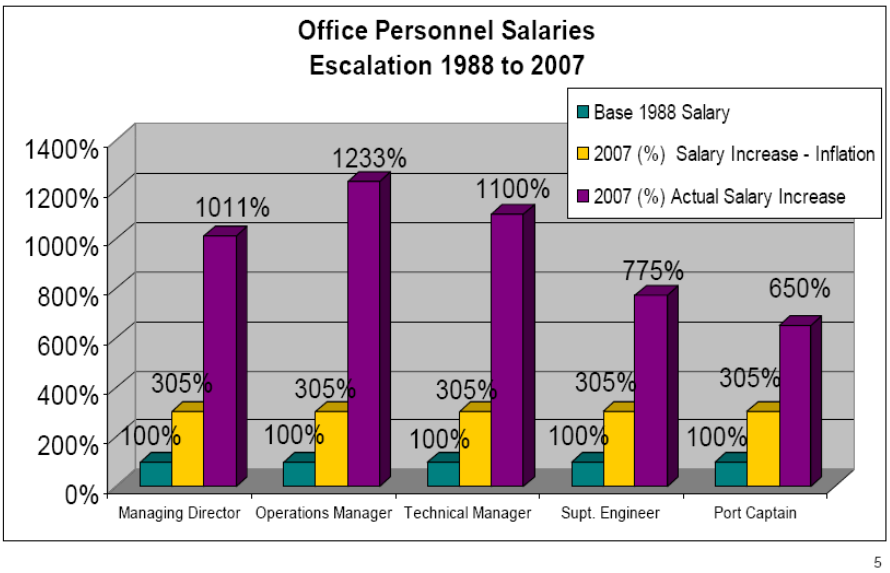

Fig. 2: Salary evolution

Figure 3 displays the level of job relevance to studies for the same set of respondents. Job relevance is observed to be on the high side.

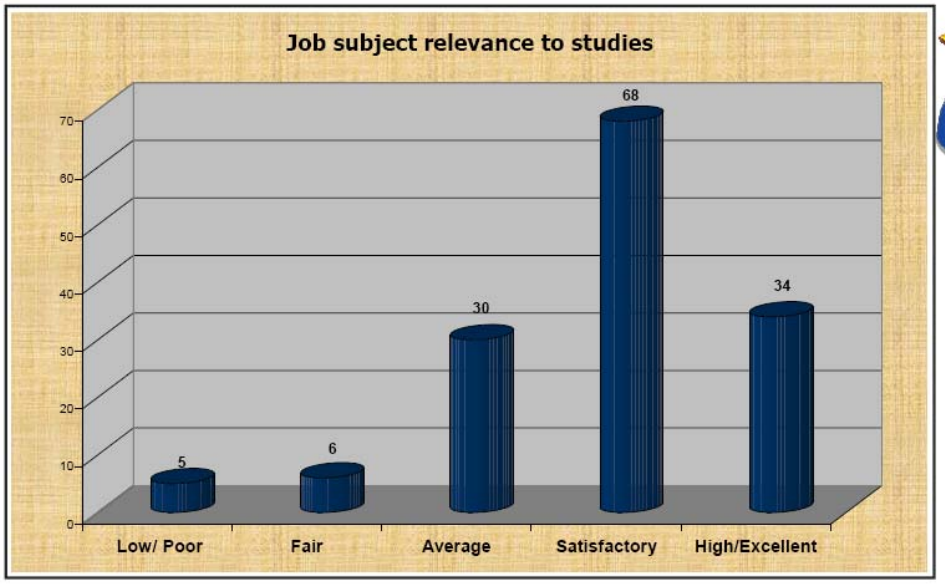

Fig. 3: Level of job relevance to studies

Again for the same set of respondents, Figure 4 shows salary satisfaction level, which is observed to be on the high side as well.

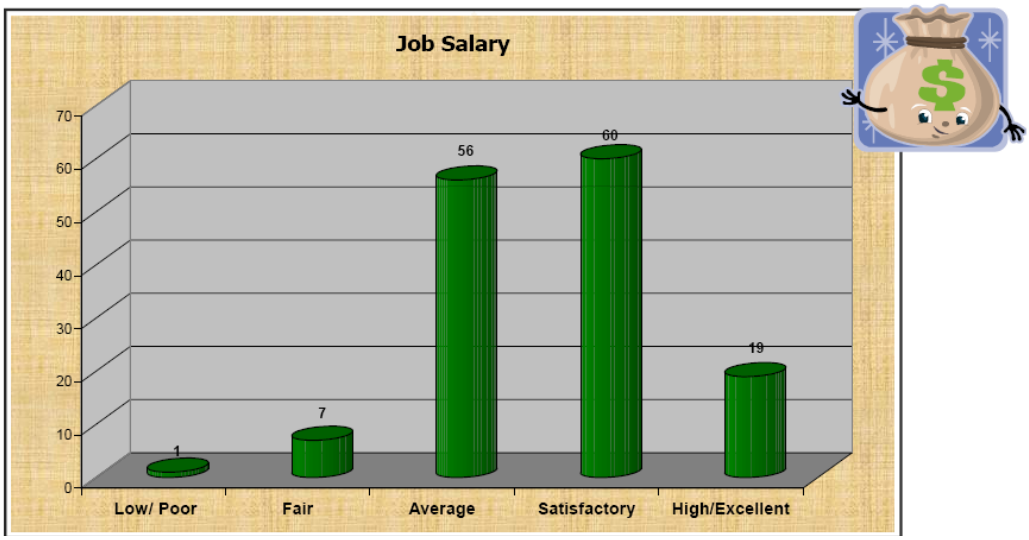

Fig. 4: Salary satisfaction level

In fact, this is also reflected in Figure 5, which is self explanatory.

Fig. 5: Job recommendation to others

5. CONCLUSIONS

It may be said that the educational curriculum of NAME at NTUA today bears as much resemblance to its counterpart when the activity started at NTUA close to 40 years ago, as that between a grown person and an infant. If the objective of this curriculum through the years has been to produce respected professionals who can provide technical service and leadership for the needs of the Greek shipping industry, one can definitely say that the experience thus far has been encouraging. Although the

opinion of this author is certainly subjective, it is speculated that the programme at NTUA must rank academically with the very best in Europe if not the world. This is true in an era when traditional NAME units seem to be shrinking or even eliminated from university programmes elsewhere, as exemplified with the recent case at MIT[4]. Ranking with the very best is also likely to be true with respect to the School's record of research, although this subject is outside the scope of this paper.

At the same time, it can certainly be said that room for improvement certainly exists, and caution is necessary as regards the future. The challenges ahead are numerous, and are connected with those that must be faced by any NAME professional within a rapidly changing maritime scene worldwide. Emphasis on areas like marine environmental protection and its various manifestations (for instance, ship air emissions) and on other non-traditional maritime areas is foreseen to shift the focus on the kinds of skills that will be in demand for Naval Architects and Marine Engineers worldwide, including those in Greece. This author believes that a student who is taught to be well-rounded so as to easily adapt to such a changing environment should be better equipped than a specialist who only knows a narrow topic very well. Similarly, the challenge for a comprehensive NAME curriculum would be not so much how to react to such an evolution of focus, but how to anticipate as best as possible future developments and be ready ahead of time with a comprehensive educational programme that would best serve the evolving needs of its graduates and of the industry.

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[4] The Department of Ocean Engineering ceased to exist as an independent MIT department in 2004, being merged with the Department of Mechanical Engineering.