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Published in:
Mercator

Publication date:
2012

[Link back to DTU Orbit](#)

Citation (APA):

Andersen, I. M. V., Nielsen, U. D., & Lützen, M. (2012). The Maritime Engineering Education: meeting industry demands. Mercator, (Marts).

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THE MARITIME ENGINEERING EDUCATION

– meeting industry demands

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ENGLISH SUMMARY

This article describes the outcome of a survey initiated by the Danish Maritime Fund (DMF). The survey resulted in a report that describes the engineering competencies requested by the Danish maritime industry. This is of interest since the desired competencies have changed in the past one to two decades, where Denmark no longer has a considerable ship-building industry. Furthermore, the DMF initiated report concludes that the demand for maritime engineers in the industry is larger than the output. The report sets forth a series of recommendations to the industry as well as the universities to enable meeting the demand for maritime engineers in Denmark. The recommendations are outlined together with the work commenced at the Technical University of Denmark (DTU) and the University of Southern Denmark (SDU) to follow up on the recommendations in the report.

DANSK RESUMÉ

Denne artikel beskriver resultaterne af et udredningsarbejde igangsat af Den Danske Maritime Fond. Udredningsarbejdet udmundede i en rapport, der beskriver de ingeniørkompetencer, der efterspørges af den danske maritime industri i dag, hvor Danmark ikke længere har nogen betragtelig skibsbygningsaktivitet. Yderligere konkluderer rapporten, at efterspørgslen efter maritime ingeniører er større end det antal, der bliver uddannet fra universiteterne. Rapporten præsenterer en række anbefalinger til industrien og til universiteterne, der skal muliggøre, at behovet for maritime ingeniører mødes. Anbefalingerne er kort beskrevet sammen med det arbejde, der er igangsat på Danmarks Tekniske Universitet (DTU) og Syddansk Universitet (SDU) for at følge op på rapportens anbefalinger.

INTRODUCTION

Decades ago Denmark was a shipbuilding nation with numerous small and large yards – the largest and most well-known is probably the Odense Steel Shipyard in Lindø which produced state-of-the-art ships like the world's first double-hull supertanker, advanced frigates for the

Danish navy and some of the world's largest and most sophisticated container ships. Today, most merchant shipbuilding has moved to large yards in Asia (Cho and Porter 1986).

Denmark's maritime businesses have shown a magnificent adaptability to the globalisation of the maritime industry. Large fleets of container ships, bulk carriers and tankers are today operated by Danish shipowners. A major share of all two-stroke engines installed on board ships is designed in Denmark and produced on a license from Danish company MAN Diesel & Turbo. The consultancy business is thriving, and so is the oil and gas exploration industry. Furthermore, with the emergence of Emission Control Areas and rising environmental concern the Danish Green-Tech industry, including e.g. exhaust gas cleaning and offshore wind farms, is experiencing growth.

As the Danish maritime industry continues to grow despite difficult financial times, some important questions have recently been raised: Has the education of maritime engineers been as adaptive to the large global changes in the industry as the industry itself? Do the topics taught in universities correspond to the competencies the industry requests? To seek the answer The Danish Maritime Fund initiated the formation of a working group with the purpose of carrying out a survey investigating which engineering skills of new candidates are required by today's maritime industry.¹ The objective was to outline the contents of an updated maritime engineering education.

THE SURVEY AND ITS RESULTS – RECOMMENDATIONS

The survey involved interviews, meetings and workshops with participation of shipowners, classification societies, consultancies, authorities, the oil and gas industry, engine manufacturers, equipment manufacturers, schools and universities. The survey resulted in a report (Cerup-Simonsen et al. 2011) prepared for the Danish Maritime Fund by the Danish Academy of Technical Sciences (ATV). The work has been carried out by a working group formed by:

- Vice President Bo Cerup-Simonsen, A. P. Møller – Mærsk (chairman)
- CEO Anders Ørgård Hansen, OSK-ShipTech
- Consultant Esben Fiedler Røge, ATV
- PhD student Ingrid Marie Vincent Andersen, DTU
- Assistant professor Marie Lützen, SDU
- Head of Division Mogens Schrøder Bech, Danish Maritime Authority
- Senior Vice President Peter Tang-Jensen, American Bureau of Shipping
- Senior Vice President Thomas S. Knudsen, MAN Diesel & Turbo
- Associate professor Ulrik Dam Nielsen, DTU

The report outlines the engineering competencies demanded by the industry and sets forth recommendations to the ways in which the industry could and should involve itself in the maritime engineering education. The report is based on 13 interviews with the Danish

¹ The Danish Maritime Fund was established in 2005 and provides financial support to initiatives and undertakings, which may serve to develop and promote the Danish maritime sector. For an overview of the grants of the Fund, please see the article by Carsten Melchior in the December 2011 issue of this journal.

maritime industry, University of Southern Denmark (SDU) and the Technical University of Denmark (DTU). Furthermore, a workshop with participation from about 60 stakeholders from classification societies, shipowners, consultancies, authorities and marine equipment manufacturer was held in November 2011.

The outcome of the interviews and the workshop was a description of the desired competencies of engineering graduates. Today, both classical and “new” competencies are requested by the Danish maritime industry: The core disciplines (stability, hydrostatics, propulsion, seakeeping, structural assessment of marine structures, fluid mechanics, etc.) within maritime engineering and naval architecture still form the foundation for any maritime engineer. On top of that part, the industry requests broader, multidisciplinary competencies such as operations management, optimisation and economy, performance management, risk analysis, and understanding of environmental issues, legislation and the global industry as a whole.

Shipbuilding has, for a large part, moved to Asia. Therefore, the classical “ship yard engineer” is no longer requested by the industry. Instead, ships are often designed in a joint venture between e.g. the shipowner, the yard, a classification society and perhaps a consultancy company. Typically, the ship is being built on a yard in Asia – assembled from steel and many components such as engines, pumps and parts designed and produced elsewhere in the world. A modern ship is a very complex structure of different components, systems and subsystems, which require engineers with a good, overall understanding of the ship as a system.

Today’s requested competency profile, as outlined in Cerup-Simonsen et al. 2011, of the well-qualified engineer is T-shaped. This means that the graduate possesses a broad multidisciplinary knowledge about the maritime industry, its structure and disciplines as the horizontal bar of the T. The vertical bar represents the ability to immerse oneself in highly specialised academic and technical fields. In other words, the horizontal bar represents the general competencies and the vertical bar represents specialised competencies. The desired ratio between the horizontal and the vertical competencies varies between the different stakeholders of the industry. The survey revealed that the classification societies, consultants, offshore industry and the equipment manufacturers tend to focus on the vertical, specialised skills, while the shipowners and the authorities prefer candidates with a broader, horizontal knowledge.

Innovation and continuous performance improvements take place during both the daily operation and through projects. The desired competencies can therefore be divided from this distinction, since different engineering competencies are required in order to undertake the daily operation and the projects. Basically, the survey indicated that the types of competencies can be divided into operational and project directed competencies as listed below:

Competencies for operation:

- Operation management.
- Operation optimisation.
- Operation economy.
- Performance management and performance monitoring.
- Operation of ships and offshore structures.
- Environmental management.

- Environmental reporting.
- Understanding of national and international environmental legislation.
- Sustainability and life cycle analysis.
- Creativity, innovation and change management.

Competencies for projects:

- Naval architecture.
- Stability, seakeeping and propulsion.
- Structural assessment of ships and marine structures.
- Fluid mechanics, hydrodynamics and CFD.
- Wave loads.
- Thermal energy systems, machinery and combustion engines.
- Combustion processes, combustion chemistry and air emissions.
- Material science (metals and composite materials).
- Statistics.
- Electric control and automation systems.
- Alternative marine fuels, particularly the use of liquefied natural gas.
- Understanding of complex machinery systems.
- Acoustics and vibrations.

The common opinion in the industry is that the very specific skills needed by the employer are added to the graduate's solid base of engineering fundamentals. However, it is desirable that the universities, to a larger extent than today, play a role in the continuous upgrading of qualifications of the employees. The added skills and specific knowledge could be based on different post-graduate courses.

Possible post-graduate courses:

- Commercial and strategic understanding of the drivers of decisions in the maritime business
- Environmental aspects in relation to ship and offshore operations
- Project management and economy
- Inter-cultural communication and understanding
- Negotiation techniques
- Sales and sales processes
- Updated knowledge about new technologies and their use

In the survey, several interviews including the workshop addressed the benefits (and to some extent a need) related to marine engineers on board ships taking land-based jobs in the maritime industry. The engineers who go ashore already possess a lot of practical knowledge. The possibilities for this group of people to go from their more practical education to an academic education should be improved.

In addition to the competency identification the survey was an eye opener for the industry as well as for the universities. It turned out that in the years of growth, the commercial and educational sides of the industry had not grown simultaneously. Quite contrarily, through the fat, successful years the output of maritime engineers from the universities declined, the maritime engineering education suffered reductions, lack of focus and was given a low priority. As a result the output of maritime engineers from the universities far from satisfies the current

need in the industry. This gives room for thought and, particularly, for action. In order to address the above issues the working group proposed the following recommendations for the future maritime engineering education:

1. The Danish maritime industry must be more visible at the educational institutions (high schools and universities) and in the public in general to attract more talented students to the maritime field of studies.
2. The maritime industry must engage itself in the early stages of the engineering education to influence the students and make them choose the maritime courses. This can be done through summer school placements, guest lectures, student projects, data, field trips, company visits, etc. The industry should contribute with cases to be used in the teaching of relevant courses at the universities.
3. The value chain between research, education and industry must be solid and with widespread interaction in all links. The competencies demanded by the industry (and described later in this report) must be reflected in the education.
4. The engineering education must constantly be updated to meet the industry's current and future demands. This must be done through continuously updating the courses offered at the universities and through tighter cooperation with the industry in the teaching and project work.
5. University research must support development, innovation and demonstration in the industry and enable research-based teaching.
6. Future engineers should have a T-shaped competence profile.
7. Education at the universities should be multidisciplinary and take place across different university departments and faculties and perhaps even across universities. The establishment of a coordinating maritime committee or a maritime centre could be a solution.
8. Further education of the maritime officers and engineers (the people that are initially educated to work on board ships) could be a source of engineers for land-based jobs in the future. The practical knowledge combined with technical and academic upgrading could be valuable for some stakeholders. A stronger link with the engineering educations is recommended.
9. The Danish maritime industry should prepare a catalogue of career opportunities, internships, summer placements, cases, projects and other relevant possibilities of cooperation between universities and the industry. Furthermore the universities should provide the students with a clearer overview of the maritime engineering modules at the universities.

The universities have responded with a number of initiatives to meet industry demands with respect to the number of graduates and their competencies. In return, the industry has responded with promises of more commitment to improving and continuously developing the education. This article outlines the initiatives set forth by DTU and SDU to ensure qualified and up-to-date maritime engineering candidates.

The initiatives at DTU constitute a reformed maritime education which, among other initiatives, implies updating of maritime courses, multidisciplinary collaboration between different departments and the use of a research vessel in the education of maritime engineering students.

SDU will analyse the possibilities of upgrading the skills of maritime engineers from a bachelor level to master or graduate degree. The valuable practical and operational experience, together with increased theoretical skills can create a good basis for land-based jobs in the maritime industry.

UPDATING THE MARITIME ENGINEERING EDUCATION AT DTU

DTU is committed to meeting the demands of the Danish maritime industry with regards to the new engineers' competencies, to facilitate better cooperation between industry and university, to make stronger cooperation across university departments and to make the maritime engineering education more visible and attractive to new students at the Technical University of Denmark. All of this will be achieved through an updated maritime engineering education offered by DTU Mechanical Engineering. The goal is to make an education based on courses given at DTU Mechanical Engineering as well as other relevant DTU departments, so that the combined curriculum matches the specifications above. Moreover, it will be strived for to make the maritime education more visible and attractive to present and future students.

To respond to the recommendations provided in Cerup-Simonsen et al. (2011) DTU Mechanical Engineering has already taken steps towards initiatives to update the maritime engineering education, enhance industry collaboration and, ultimately, attract more students. The work is in its very early stages yet, but in the following, the initiatives that DTU plans to undertake or has already initiated will be outlined.

The T-shaped engineer

Today, all maritime courses offered by the Technical University of Denmark are given at DTU Mechanical Engineering. In order to implement other engineering disciplines in the education of maritime engineers it is relevant to include courses from other departments in the maritime curriculum. This can be done by giving non-maritime courses a maritime touch and, if considered necessary and feasible, start up new courses at other departments such as DTU Transport and DTU Management Engineering. In order to meet the request for broader knowledge and a multidisciplinary profile, maritime content must be implemented in several courses across departments at DTU.

Visibility and attraction

The plan is to define study tracks for the students on BSc and MSc level in order to offer the students specific study tracks with maritime scope. Apart for making students' life easier well-defined study tracks at DTU would improve the visibility of the maritime engineering courses to the students, simplify the recruitment of engineering students to the maritime courses and ensure the education of engineers with a defined and complete set of relevant skills.

The intention is also to make a number of courses more "blue" by using maritime cases, data and projects in more general courses at DTU to make as many students as possible encounter the maritime industry as early as possible during their studies to become acquainted with the Danish maritime industry. By placing more courses at bachelor level it is the hope that more

students will take interest in the maritime field and choose an MSc within maritime engineering.

Industry collaboration

The industry has already given promises of more commitment to the education of maritime engineers. At DTU, industry collaboration will be sought to be increased in various ways including the following:

- Definition of bachelor's and master's theses in collaboration between DTU and the industry, which DTU, the student and the industry could benefit from.
- Use of specific cases, data and problems defined by the industry in the teaching.
- Company visits and guest lectures.
- Research collaboration.

DTU sincerely hopes that the industry follows up on the positive declarations given so far, which means a proactive behaviour in terms of setting up cases to be used in courses and theses as well as a realisation of the importance of university/industry collaboration.

ANALYSIS OF THE POSSIBILITY FOR UPGRADING ENGINEERS FROM A BACHELOR LEVEL TO A MASTER'S OR A POST-GRADUATE DEGREE

Today there is no maritime education at SDU, but as one of the main competencies at SDU is combining practical and theoretical knowledge, there is an obvious reason for starting an education programme for maritime engineers. The competency profile for the new candidates will primarily be within technical operation of ships and offshore structures. The valuable practical and operational experience that the students have obtained as engineers on board ships, together with increased theoretical skills, can create a good basis for land-based jobs in the maritime industry.

In continuation of the work carried out and described in Cerup-Simonsen et al. (2011), the Faculty of Engineering at The University of Southern Denmark has initiated an analysis to clarify the possibilities of upgrading engineers from a bachelor's to a post-graduate degree.

When leaving the school of marine engineering the engineers have obtained the title "Bachelor of Technology Management and Marine Engineering". This is not an academic degree but a professional bachelor's degree normally not fulfilling the admission requirements for the enrollment students at post-graduate level at a university. Therefore, it is necessary to have an educational programme tailored for these students.

The education programme is new, and as it has not been offered before an accreditation must be conducted. The purpose of the present analysis at SDU is to clarify whether there will be a basis for creating this new education.

The terms of reference for the analysis can generally be separated into the following:

- Is there a need for this type of graduate?
- Will it be possible to attract students to the new education?

- Does the university have an academic basis for supporting the education within teaching and research?
- How can the education programme be structured?

A working group of four participants, two from a school of engineering (Svendborg International Maritime Academy, SIMAC) and two from SDU has been established. The terms of reference was given to the group in February 2012. In May 2012 the group will deliver a report to ACE-Denmark (The Accreditation Institution), which will form the basis for the application for accreditation. If the Executive Board of the University of Southern Denmark finds that there is a basis for the new education, then an accreditation application will be submitted and finally, if the accreditation is positive, the new education can start in September 2014.

CONCLUSIONS

In order to ensure a continuous access to high quality maritime engineers it is necessary for both the universities and the industry in Denmark to engage deeply in the education of maritime specialists with the competencies requested by the industry. However, for the universities it is important to find the appropriate degree of specialisation in order to ensure that the skills of the graduates on the one hand match industry demands and on the other hand have sufficient substance to form the base of long-life learning and long-term value creation in the maritime industry.

The future of the maritime industry in Denmark depends on the number and quality of young candidates and therefor both universities and the industry must take responsibly in order to facilitate the education of world class engineers.

This article has outlined the initiatives planned or already started at DTU and SDU to accommodate a better and more attractive education of maritime engineers.

ACKNOWLEDGEMENT

The Danish Maritime Fund has supported the survey, which resulted in a report containing recommendations to the universities and the industry. Subsequently, the Fund has also given financial support for the initiation of the work towards accommodating the recommendations at DTU. The support from the Fund is much appreciated. Furthermore, the authors wish to sincerely thank Carsten Melchior from the Danish Maritime Fund for support and many fruitful discussions.

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