

Reimagining Education at Sea: Challenges and Opportunities in Naval Architecture

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ABSTRACT

Naval Architecture, better understood as shipbuilding engineering, is a form of technology since the ancient time. The science of shipbuilding mainly involves with ship hull shape and structural design until the 19th century when machines begin to power ships. Today, the curriculum in authors' department still focuses largely on mathematics and mechanics. Students' motivation to learn is low and the discipline seems to be trailing behind the new wave of cyber-centred technology. To encourage naval architecture students to think creatively and act innovatively is very challenging because shipbuilding looks like a traditional heavy industry. To help the students to establish a good foundation for future development in the new digital oriented technology and to utilize them in shipbuilding industry, authors introduced new teaching approaches in courses of 'Engineering Software', 'Data Acquisition and Analysis' and 'Fundamental Maritime Engineering'. Students were introduced to software similar to the commercial software used in the trade. They gained hands-on experience and continue to build the capacity with the software. The tasks in the classes were intentionally designed to be a combination of achievable simple ones and real-world complex problems. Students were guided to learn and use digital tools in conjunction with fundamental science, they showed confidence in acquiring a more holistic understanding which combines large complicated physical objects (like ships) and cyber possibilities. For the shipbuilding industry to evolve with the 4th industrial revolution, engineers who can use new digital technology on cumbersome objects are needed. A task-based learning with carefully chosen software in universities can be helpful.

1 INTRODUCTION

Building boats and ships is a very old skill if we look back into human history. However, according to what Ferreiro and Hocker discussed in [1], French astronomer Pierre Boubuer was the one invented the field of Naval Architecture scientific knowledge in the 18th century in the mountain of Peru. Pierre Boubuer provided a complete set of principles governing naval architecture scientifically, or can also be understood as a combination of hydrostatics, hydrodynamics. He also defined stability by inventing the metacentre, which pave the ground for future study on characteristics and behaviours of ships. In the old time, master shipwrights who were capable of designing and managing the entire process of shipbuilding (usually the wooden ones), ran the secretive trade. Today, naval architecture programs around the world teach engineering and science of ships, the knowledge and skills for the design, construction, production and operation of marine vessels and systems. However, as ships become bigger and the scientific knowledge becomes more and more complex, it is really

difficult for undergraduate and master students to develop intuition and overall understanding of ships.

1.1 Typical naval architecture curricula

In Taiwan, the modern version of shipyard first appeared in 1918 when Japanese mining entrepreneur Kimura Kyutaro started ship repairing business in Keelung. The first naval architecture program (a 5-year program for middle school graduates) was established in 1959, first master programme was established in 1973. *Table 1* shows the naval architecture curriculum in author's department today, which is not very different from how it was 30 years ago.

Table 1. Sample Naval Architecture curriculum

Year	Math. & Mechanics	Engineering & Ships
1st	Calculus, Physics, Statics	Introduction to Naval Architecture, Computer Application, Drawing, Engineering Shop
2nd	Engineering Math., Material Mechanics, Dynamics	Lines & Calculation, Stability
3rd	Fluid Mechanics, Mechanics Experiments, Structures, Thermodynamics	System Dynamics, Resistance & Propulsion, Model Making
4th		Ship Design, Ship Structure Design

This curriculum focuses on building theoretical competency through teaching mechanics and mathematics in the first 2 years. There are basic shop courses and model making in the first year and third year. But design courses are reserved until later because the underlying belief is that, to design a complex system one should acquire theoretical capacity first. However, students have continued to reflect their frustration and anxiety about learning theorems and lack of “feeling” towards shipbuilding in and off class. Many have complained about the absence of hands-on experience and not being able to advance their shop skills.

1.2 Connecting with the cyber technology

A contracting example comes from design school. A design educator from Copenhagen Design School has commented in authors' previous work of designing a Science, Technology and Society (STS) program for engineering education to enhance inclusiveness and diversity, as in [2]. He provided the example which design school students have to engage in design and model making since the beginning of their study. Therefore, the practical skills were exercised every semester, enabling them to integrate what they have learned into the design as they go along the curriculum. Similarly, architecture education also requires students to make models to showcase their design of community and buildings, similar to design students.

Naval Architecture curriculum arrange design courses at the last year and most students would not be able to experience the completion of a ship design process. Also there is no requirements on making a model to realize the ship design. As a result, naval architecture students do not have the luxury of time to establish their intuition and many critical concepts about ships from diverse means of learning.

Kyu-Yeul Lee and colleagues had witnessed similar problems in Korea and they applied project-based and collaborative learning on 2 courses, “Planning Procedure of Naval Architecture & Ocean Engineering” and “Innovative Ship Design” as discussed in [3]. The students were encouraged to enter ship design contests and the results was positive in enhancing students’ design ability. They also stressed on the continue update of the subject to reflect latest issues in shipbuilding industry.

In author’s department, even though students’ frustration is obvious and their lack of incentive to learn is troublesome, little has been done to improve the situation. Therefore, without causing too much disturbances to the program curriculum, we want to provide students with opportunities to build conceptual understanding and practical skills at the same time in selected courses. This paper discussed our efforts to utilize the new tools of software, introduce key concepts of cyber technology and build students’ intuition about complex engineering systems.

2 MATH TOOLS FOR ENGINEERS

2.1 Cracking the math demon

For junior students, author offered this course “*Application of Engineering Software*” to bring them software-using experience without burdening them with programming or code writing. Several open source software packages were introduced to solve common engineering task.

2.2 “*Application of Engineering Software*”

Freemat and GNU Octave (the open source counterpart of Matlab) was introduced to solve simultaneous equations, inverse matrix, etc. Solvers like Fast Fourier Transform help students to see the relationship between time domain and frequency domain more easily. They also tried to solve ordinary differential equations without writing complicated codes and debugging. Students also learned how useful these software packages are in plotting equations for a quick understanding of the forms of the equations. It’s like a revisit to Engineering Mathematics without hand calculation. Students were surprised to learn that computer can help to solve equations and it’s more reliable than their hand calculation. After the course, they also expressed less anxiety towards using software because these software packages are more intuitive and responsive than programming languages.

3 CONNECTING WITH SONSORS AND DATA

3.1 Building the sensor system

Shipbuilding is a heavy industry concerning manufacturing large and complex objects. Measuring have long been a part of the shipbuilding industry, for example, measuring vibration caused by the main engines, temperature variations in the engine room, etc. Naval Architecture students are often foreign to the idea of acquiring

information with digital data and analysing them for specific purposes. Thus, they are not connecting the 4th industrial revolution or the concept of the Internet of Things when they learn about shipbuilding. However, both shipbuilding and shipping industry are fast in integrating the cyber technology into autonomous ships and better efficiency and security of seafaring.

3.2 “Data Acquisition and Processing”

To establish a foundation for students to bridge into the cyber technology for future shipbuilding, tactic experience with data acquisition and processing are really beneficial. [4] discusses how they uses digital tools of video, web TV, blog to promote learning and recording of the tactic knowledge. Similar effects can be achieved by even just having a little experience in seeing how data can be collected and analysed.

In the course “*Data Acquisition and Processing*” for senior students, we introduced automatic measuring using affordable Arduino sensors. Students tested infrared sensors, accelerometer and thermometer, etc. Some simple control loops were also applied in the tasks in the class. Students were amazed with how much micro sensors and controllers can do, and this fuelled their innovative thinking about ships and vessels at sea. Many of them went on to build autonomous vehicles to compete in handmade ship model contests.

4 REAL WORLD APPROACH

4.1 Tackle the big problem

In the course of “*Fundamental Maritime Engineering*” for master students, we focused on all the fundamental knowledge and aspects needed for developing an offshore wind farm, including oceanography, wave mechanics, geotechnical engineering and survey engineering. This is a fast-growing industry in the region and it involves very complex knowledge and engineering practices. We intended to provide students with a holistic overview from the very beginning when they started to learn about offshore wind farming. Therefore, we decided to introduce basic concept of various fields together. We also pointed out key issues which involves 2 or more given disciplines and asked them to work out how to communicate and collaborate with peers from different background.

4.2 Real world design tool

We introduced students to Q-Blade, from the very beginning¹. Q-Blade is an open source wind turbine software which allows users to design blades rapidly for a wind turbine and simulate its performance right away. It’s used for hands-on design and simulation. Students can produce the results of different design choices and turbine performance very easily. There are also online tutorials from which students can learn by themselves. They also reported feeling to be part of a bigger engineering community when they learned from the tutorials.

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4.3 Thinking of the real situation

The term project was to design a 1MW wind turbine. Students researched the local wind farm locations, wind profiles and other parameters to decide on the best design criteria. Fig 1. shows the example of one student's simulation of her wind turbine design.

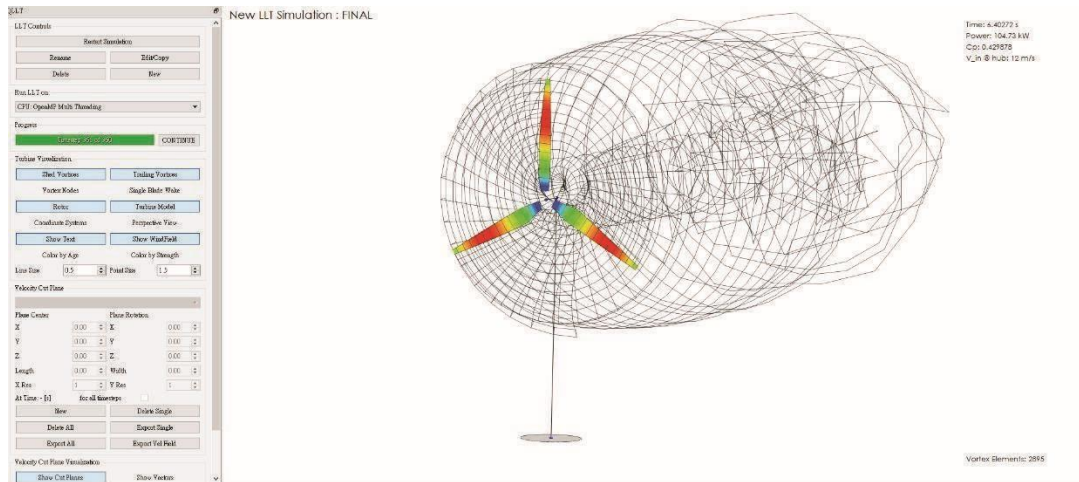


Fig 1. Student's term project of designing a 1 MW wind turbine

Many students expressed how good they felt after completing the design project. One of them wrote:

The final project is very challenging. I started with some basic review and a lot of trial and error approach, and I failed many times.

Therefore, I felt especially accomplished at the end. I took this course because I was curious about wind turbine. But I started to build up my interests about the wind power industry and I want to develop a career in it. I am very optimistic about it and I hope I can get certified and contribute to the growing industry.

This was very encouraging as we have seen students developing interests and selflearning capacity. Of course, further design details should be examined carefully when students were engaged in real situation.

5 SUMMARY AND ACKNOWLEDGMENTS

We intentionally incorporated many software packages on the shelves into our teaching contents. With the help of computer software packages, students obtained better understanding of theoretical and technologies learnt from textbooks and lectures. The use of open source software eliminates the difficulties of establishing conventional computer-aided teaching environment constructed by commercial software packages. We are excited to see the “dated and traditional” Naval Architecture curriculum in our department can come closer to the 4th industrial revolution. The real-world tasks and projects in the class facilitated active discussion between students and instructors. It also generated many new ideas about using cyber technology as an agent for building capacity in practical engineering. We hope to rejuvenate shipbuilding learning for contemporary higher education. It is certain more

work is needed for further investigation on course design and outcomes. However, this effort serves as an exciting and encouraging start.

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