

## COMPARING NAUTICAL BSc PROGRAMS BY QUALITY INDICATORS

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### 1. PROBLEM AND METHOD

Merchant marine officers compete internationally for their positions and the maritime universities shall provide them with an education appropriate for working in an international industry requiring personnel with relevant qualifications, competencies and skills. Consequently, there is a need to measure institutional performance and it may be inspiring for those measured if it gives information and trust. Firstly, applicants and future candidates would know where to apply and their employers would know which candidates to employ. Secondly, funding governments, donors and staff, are informed of areas needed to improve.

#### 1.1. Problem

The general problem when evaluating universities is to define and identify the institutional contribution to each candidate's competencies, skills and knowledge [2], or citing the STCW-code: Knowledge, understanding and proficiency (KUPs) as identified. Thus, top-grade students, including candidates intellectually above average, may learn whether or not enrolled in an institution providing an optimal learning environment, state-of-the-art facilities and excellent academic staff. Vice versa, the top institutions may lift below-average students to a level where they achieve the required competencies etc. and perform well within a profession.

Quality indicators suitable for measurement should give precise and easily understandable information with respect to which degree goals are met [3]. In addition, define and identify the institutional contribution with regard to achieving the goals and finally restrict the various stakeholders, like students and teaching staff, from manipulating the information given.

A particular problem when evaluating nautical BSc programs is that, despite the STCW-code, there is no international standard of measurement. Thus an exploratory method for comparison was made.

#### 1.2. Method

The study developed a set of quality indicators in order to compare the institutions chosen, of which eleven of the twelve offered BSc degrees in nautical sciences.

The European Credit Transfer and Accumulation System (ECTS) and its equivalent for non-European universities were chosen as an instrument for comparison. Because of differences in credits in Asia, Europe and Americas, the equivalents to ECTS have been manually transformed by counting each subject and each number of hours taught or lectured. These systems of credits are standards with two aspects. One is to award students credits for workload per subject and exams, consequently to make transfers between universities more efficient. The other is to have transparency and standards for planning, delivery and evaluation. [4]. In addition, various data were compared: Entry criteria, retention- and failure rate. Also, the structure and content of the study program in relation to STCW, like nautical/maritime subjects beyond the STCW requirements and complementary subjects, i.e. the universities have a variety of subjects they include. Thereafter, a comparison of simulators and laboratories, the academic staff, and whether the program include a final thesis or project.

### **1.3. Interview guide**

An interview guide was compiled in order to ensure a homogeneous data collection. The interview guide was based on the foregoing quality indicators [5].

### **1.4. Limitations**

A total of twelve institutions took part in the mapping: Four in Europe, two in Asia and two in the Americas, comparing the four Norwegian BSc-programs in nautical science at UiT, NTNU, WNU and USN. All represent maritime nations with their academic tradition and views regarding education and learning, combined with what they themselves state as modern ways of training and educating merchant officers at sea.

Our criteria for selection: A world-wide perspective and maritime industrialized nations. Four institutions were visited; two in Europe, one in Asia and one in North America. For these interviews were made based on the interview guide. The remaining institutions reported their data in writing, based on the same guide. Before finalizing the study it was distributed to those participating for validation. Some of the data reported in writing were insufficient for comparison, resulting in challenges during the data analyses. One method of measurement which was not included is candidates' performance after graduation i.e. career goals, earnings.

## **2. DATA AND SAMPLE**

There are two main models for structuring the curriculum of nautical BSc-programs containing the competencies in the STCW Code, or a combination of the two: 1) The "*sandwich model*" covers the competencies at the operational level, STCW A-II/1, subsequently the competencies at the management level, STCW A-II/2. 2) The "*integrated model*" covers both the operational and management level within the same subjects. 3) A combination of items 1 and 2 above. 4) Approved seagoing service in addition to the above.

### **2.1. Curriculum Structure**

**Table 1:** Curriculum structure Overview institutions A- Nor4

Institution	Model (see above)	Compulsory STCW subjects (ECTS or Equivalent)	Complementary subjects (ECTS or equivalent)	Nautical / beyond STCW requirements (ECTS or equivalent)	Thesis (ECTS or equivalent)	Sum ECTS or equivalent
<b>A</b>	2+4 (60ECTS)	101	49	15	15	240
<b>B 1*</b>	2+4 (60 ECTS)	97	33	50		240
<b>B2 *</b>	2	97	33	115		245
<b>C</b>	1+4 (60 ECTS)	105	20	35	20	240
<b>D</b>	2+4 (60 ECTS)	120	48	12	n/a	240
<b>E</b>	2	81	95***	0	N/A	176
<b>F ****</b>	2+4 (60 ECTS)	127,5	22,5	15	15	240
<b>G **</b>	1 + 4 (60 ECTS)	133	47	0	None	240
<b>H</b>	2+4 (60 ECTS)	103	30	35	12	240
<b>Nor1</b>	2	100	50		20	180
<b>Nor2</b>	2	112,5	35	17,5	15	180
<b>Nor3</b>	2	105	30	30	15	180
<b>Nor4</b>	2	127,5	15	22,5	15	180

All eight institutions (A-H) include sea practice in their 4 year study programs, and institution B also has an alternative replacing sea practice with theoretical studies in fourth year. Institution G's program only cover operational level, and E including 90 ECTS non-nautical elective subjects. F's compulsory STCW subjects (127,5) include complementary work.

Six out of eight non-Norwegian institutions prefer an integrated model teaching the students operational and management competence included within the various subjects, i.e. no distinction between subject levels stating X is operational and Y is management level.

Regarding the integration between operational and management level, University C says that: *“we used to be more integrated in the past and now concentrate on a sandwich structure of the program”*. This is interesting because this strong emphasis on step-by-step learning comes from an institution with a long academic tradition. This merely indicates that more than one model may achieve the same goals, and eventually it is up to the teaching staff and their personal preferences.

In addition to this choice of model, five of these eight institutions have integrated seagoing practice, leading to a Certificate of Competence (CoC). Surely, the first year starts with basics, but as institution F says in our interview: *“First period at sea is at the start of the second semester. When the students return, working with complex tasks on the simulator makes so much more sense, and their ability to reflect upon situations and their acknowledgement of the navigational skills required have increased”*. Thus, integration of practice is regarded to stimulate a high level of understanding and if combined with written and verbal analysis, the students may achieve the required academic standards and practical

skills. The combination of practice and simulation is a form of problem-based learning (PBL) and a well proven structure for professional educations [6]. The Norwegian institutions do not include approved seagoing service in their curriculum, thus they have no responsibility or formal exams related to the cadet period. The certification is purely a matter for the Norwegian Maritime Authority (NMA).

## 2.2. Volume of simulator training

**Table 2:** Volume of simulator training institutions A- Nor4

Institution	Number of semesters with STCW required simulator training	Simulator training beyond STCW requirements Type & Semesters	No. of students per full mission simulator	Total hrs. on navigational simulators	Total hrs. on other types of simulators or lab
<b>A</b>	<u>2 semesters:</u> 5 <sup>th</sup> semester ARPA and GMDSS simulator. 8 <sup>th</sup> semester ECDIS	Ship survey, Manoeuvring, Liquid Cargo handling i.e. Oil Tankers and Gas Carriers.	3	63	354, including laboratory training
<b>B</b>	<u>2 semesters:</u> 5 <sup>th</sup> sem. Navigational simulator 6 <sup>th</sup> semester, ECDIS, ARPA and GMDSS	Ship handling, Liquid Cargo handling in elective subjects	4, only used in elective subjects	142	Depends on subjects elected
<b>C</b>	<u>6 semesters</u>	Yes	1-2	204	80
<b>D</b>	<u>5 semesters</u>	Yes	2-3	224	84
<b>E</b>	<u>4 semesters</u> 4 <sup>th</sup> sem. Radar/ARPA 5 <sup>th</sup> sem. GMDSS 5 <sup>th</sup> & 6 <sup>th</sup> sem. ECDIS	Ship handling, Liquid Cargo handling	5	189	198
<b>F</b>	<u>8 semesters</u>	Yes	2-3	216	92
<b>G</b>	2 plus 1 3 <sup>rd</sup> & 4 <sup>th</sup> sem. and between semesters the 2 <sup>nd</sup> and 4 <sup>th</sup> year		4	157	
<b>H</b>	<u>4 semesters</u> 4 <sup>th</sup> sem. Radar/ARPA 5 <sup>th</sup> sem. ECDIS 5 <sup>th</sup> sem. GMDSS 7 <sup>th</sup> sem. LCHS and ERS (voluntary) 8 <sup>th</sup> sem. Ship handling / BTM. Offshore Navig.	Not identified in interview. Labs; radio (GMDSS), Navigational instruments, DP, etc.	3	200	120

<b>Nor 1</b>	6 semesters	Not identified in interview. Labs; radio (GMDSS), Navigational instruments, Ship-hydrostatic lab,	2 -3	216	100 Have available research vessel 2- 3 days.
<b>Nor 2</b>	All six semesters have simulator training	Not identified in interview. Labs; radio (GMDSS), Navigational instruments, DP, Offshore ship handling	2	336	104
<b>Nor 3</b>	4 semesters	Not identified in interview. Labs; radio (GMDSS), Navigational instruments, DP, etc.	2 (1 in some) BRM: 3 per bridge + 2-3 observing	222	112
<b>Nor 4</b>	4 semesters	Not identified in interview. Use of simulators and labs such as radio (GMDSS), Navigational instrum. DP	2-4	226	124

Up-to-date equipment seems to be the standard for all 12 institutions with some variations. This gives them a platform for offering and developing modern adequate education. Also, most institutions have other simulators providing education and training within other areas than pure navigation and communications. The major difference is not in the variety of equipment, but how it is used. Some institutions introduce simulator training early in their programs, others later. Norwegian programs start early and the use of simulators seems to be well integrated throughout the three-year programs. This should be linked to the Norwegian role of developing the simulation of BRM, anchor handling and advanced offshore operations in close co-operation with the maritime industry. Here, problem based learning (PBL) shows its importance for nautical professional education, cfr. comments above.

There is a wide variation between chosen semesters and total hours in all; from 63 hours (institution A) to 334 hours (Nor 2). Institutions C, D, F, H and Nor 1, 3 and 4 have 200 hours or more. This must be seen together with other simulator and laboratory training as mentioned below, in order to get a holistic understanding of the learning outcome. Here we found again a huge variety ranging from 354 hours (institution A) to 80 hours (institution C). C, D, F, H and Nor 1-4 with more than 200 hours on navigational simulators have 80 to 124 hours on other types of simulators and laboratories. Institution E has an interesting model with a balance of 189 and 198 hours on navigational and other types of simulators respectively. Only institution F uses all eight semesters to teach compulsory STCW requirements; an observation here is that their integrated model seems to be stretched to its limits by maturing their students within the core element of the navigational skill and knowledge all through the program. However, the difference with institution C using six semesters and only 1-2 students or D and Nor 1-2 with five and six semesters respectively but in total more hours, may not be noticeable or viewed as significant. Nor 2 seems to emphasize simulator training giving their students 103 hours more than the average of compulsory simulator training.

### **3. DISCUSSION AND CONCLUSION**

#### **3.1. Curriculum structure and content**

We divide the main purposes of a BSc in Nautical Science in two. Firstly, to fulfil the requirements of STCW Reg-II/1 and Reg-II/2, as well as the requirements of STCW Code A-II/1 and II/2. Secondly to give relevant competencies beyond this and achieve an academic standard at BSc-level. The competencies in the STCW Code are typically structured in four ways: 1) Cover the competencies at the operational level, A-II/1, subsequently the competencies at the management level, A-II/2. The so-called “sandwich model”. 2) Cover both the operational and management level within the same subjects e.g. Meteorology. The so-called “integrated model”. 3) A combination of items 1 and 2 above. 4) Approved seagoing service in addition to one of the above.

Only institution G in the survey covers education limited to operational level, and only C and G have a sandwich model, teaching competencies at the operational level (STCW A-II/1) separated from competencies at the management level (STCW A-II/2). The others adopt an integrated model teaching operational and management competencies within same subject.

Five institutions have a 4-year BSc program including cadet training at operational level up to Certificate of Competence (CoC). Institution B has a particular variant in addition to the model with integrated training, where the sailing/cadet period is split between the first and second years of study and between the second and third years. The fourth year is purely theoretical with specialisation in seven different nautical / maritime subjects.

This integrated on board training is clearly different from the Norwegian model with its 3-year BSc program without any practical on board training up to CoC-level. Norway has chosen to assign responsibility for cadet training to private shipping companies after completion of a BSc program, without any form of final examination after the cadet period. However, there is documentation of on board training signed by an assessor with a particular training program as such and final approval from the NMA, and NMA has per date (2018) no objections to the system. However, reflecting upon the differences, we find solid arguments in favour of the integrated on board training during all four years of the BSc program:

When students return to the university after their seagoing practice, this training allows them to reflect on their experience together with their tutors and staff, thus the students have a systematic evaluation of skills and knowledge verifying that the average candidate acquires a thorough level of understanding and knowledge. This seems to be confirmed by our interviews and when asked about the effect of simulator training after a period on board, the tutors emphasised that students became more mature and understanding of training increased.

In comparison, the Norwegian model has a disadvantage from not integrating theory and practice, both with regard to the practical skills learned at sea and the academic level. This could possibly be modified by increasing the level of simulator training as discussed below, cfr. 3.2. On the other hand, the BSc curriculum including seagoing practice and cadet training leading to CoC, requires either available training ships or a formalized and predictable

cooperation with ship operators: Professional education within nautical science requires huge investments and a long-term perspective. Thus, for Norwegian institutions to co-operate with the maritime industry and ship managers requires both an intake level in line with offered ship capacities and managers that commit to accepting a certain number of cadets on board. This is really a discussion on quality vs. cost effectiveness.

Another aspect regarding curriculum structure is the academic profile. How far beyond compulsory and complementary STCW subjects do the institutions take their candidates?

Eight of the institutions have a concentration of ECTS points around 100 dedicated to compulsory STCW subjects. Four institutions differ, E with 81, F and NOR 4 with 127.5, while G seems special with 133 ECTS equivalents covering only operational level. In other words, the majority seem in line. These subjects typically cover mathematics, physics, language, history, etc. There is a great variety among the institutions, from Nor 4 with 15 ECTS to E with 95 ECTS equivalents.

International trends of development are of importance for leading institutions, because they set the standards and interact with the maritime industry's global and national authorities' demands. The basis for nautical programs is stipulated by STCW, however, even though this standard has been developed over the years, it is an IMO convention based system legally setting minimum requirements, while particular industrial segments and/or national maritime authorities may demand even higher standards [7]. Within STCW a good example is Bridge Resource Management (BRM) training, developed by maritime universities for maritime purposes over the last three to four decades [8]. Today it is part of STCW's requirements [9]. In other words, we advocate that in order to develop new concepts and innovative solutions efficiently one cannot await new formal and legally binding regulations, but must actively seek a dynamic collaboration between maritime universities and the maritime industry.

A new challenge is the development of autonomous ships. Technical, operational and nautical management are core issues, together with legal and commercial challenges. How can universities offer their students both theoretical understanding and achieve the skills needed in future autonomous ship operations?

One practical challenge of including new learning into existing programs is that over the years the STCW minimum standard has increased by including new concepts, but old ones not necessarily discarded. Thus, leaving few hours available for new innovations and program profiling. Nevertheless, we do find good examples of profiling programs with in-depth specialisations; Institutions B, C and D all have clear profiling. The latter has marine transportation and marine operations giving in depth specialization within transport/ logistics/ commerce and technical operational subjects accordingly. This specialisation could be seen together with the final project or thesis and be a part of the program profile. NOR 1-4 may improve their profiles and to a greater degree give in depth knowledge of the latest trends of technical, commercial and legal demands for navigation and ship operation. One solution is to increase the collaboration among the institutions, nationally and internationally. Nationally, we see Centres of Excellence (CoE) in higher education. Norway has eight centres [10] and a new proposal is under way, one could argue that the NOR 1-4 should develop a nautical CoE.

### **3.2. Volume of simulator training**

The principal question from a Norwegian perspective is whether the disadvantage of non-integrated cadet practice is compensated for by increasing the level of simulator training. The Norwegian universities do have a higher number of training hours, but is the difference significant, and does the quality and type of training address the disadvantage in particular? The short answer is that as yet we do not know, and further studies are needed.

However, institution C, D, F have 204, 224 and 216 hours on navigational simulator respectively, and nor 1-4 with 216, 336, 222 and 226 hours, but only NOR 2 seems to have sufficient extra hours of training that may compensate to some degree. Combining the number of other simulators does not seem to change this overall picture. C, D, F have 284, 308 and 308 respectively, while NOR 1-4 have 316, 440, 334 and 350. Again, further studies are needed to know how to compensate for the disadvantage, or how to develop a Norwegian study model. A CoE in nautical studies is one way forward. Depending on capability of collaboration this can be developed combined for NOR 1-4 or by either one.

### **3.3. Conclusion**

Integrated on board training / cadet period through 4- year BSc programs is preferred by institutions with both a general high academic standard and long maritime tradition, including nautical BSc programs. This stands in contrast to the Norwegian BSc model with no integrated cadet period. Compared with their foreign counterparts, Norwegian institutions do have a high volume of simulator training. This gives a solid platform for further development. Further research may develop new concepts for navigators and more efficient use of simulators may shorten practice at sea, and we advocate integrating on board practices and PBL concepts through the study program. This to be seen in context with the development of autonomous technology and its consequences for shipping and nautical education.

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