

Survey for Interdisciplinary Co-supervision on Bachelor Thesis in Nautical Science

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Abstract—As the development of emerging technologies is applied in the maritime industry and nautical operations, an interdisciplinary supervision approach is expected to be designed in this subject to enable students the ability to handle the issues brought by the fusion of industrial conventions and technological evolutions. This paper provides the profile of the participants and the subject in which the co-supervision is to be engaged. We investigate how interdisciplinary supervision and co-supervision can be implemented in the nautical science undergraduate program. The resources of both undergraduate education and maritime-related research at the Department of Ocean Operations and Civil Engineering at NTNU are taken as the principal for the fundamental subject. As expected, not only do the undergraduates are benefitted from the co-supervision, the researchers taking co-supervision responsibilities also promote their insights by absorbing the human-dominant expertise knowledge generated by the students. Through the paper, we propose a route map to explore the mechanism of co-supervision in this subject and the expected outcomes.

Index Terms—Interdisciplinary education; nautical science education; simulator-based training.

I. INTRODUCTION

The maritime industry has been playing an essential role in world trade and cargo transportation for centuries, while human navigators have been playing the dominant roles onboard in the ship maneuvering and guidance [1]. The technologies development has a significant influence on the relationship between human operators and the onboard machines, especially in recent years after many onboard decision tools emerge, such as the electronic chart display and information system (ECDIS) and automatic radar plotting aid (ARPA), and the technology explosion noticeably in artificial intelligence and machine learning, sensor fusion, and data mining, etc. In this trend, both the industry and academia expect the cultivation and education of the nautical science bachelor program to be adjusted to provide students with access to knowledge and possibly grasp the frontier of technological development. We take advantage of the Department of Ocean Operations and Civil Engineering (IHB) at NTNU, which has substantial maritime-related research

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resources and nautical-science education experience as the venue for this co-supervision investigation project. Such type of cooperation has existed in the department for a while, but not systematically organized [2] [3] [4]. So, this survey study is also a trigger of how to more efficiently and effectively proceed such cooperation to promote the bachelor theses' quality and data accessibility to researchers.

A. How is the project idea raised?

In recent years, the development of maritime autonomous surface ships (MASSs) has been getting more attention. At the same time, this also causes anxiety among the nautical science undergraduate — will the MASSs substitute the role of human navigators onboard in a foreseeable day? In this context, teaching the students the knowledge and development state of the frontier technologies is expected to help build a positive relationship between the human experts and machine intelligence. Since the students are engaged in the nautical science program, they should still be advised by supervisors from their own program. Researchers from the maritime-related field are expected to play an additional supervision role in doing a bachelor thesis.

On the other hand, researchers without input from the onboard expertise may produce research items wandering away from the contingent industrial demands and even deviating from the correct track and violating the industrial conventions. Synthetically, both parties will benefit from the cooperation of the interdisciplinary supervision.

Empirically speaking, this survey study is also inspired by previous cooperation between researchers and students with different backgrounds at IHB. The pleasant experience and significant outcome [5] drive us to systematically reflect on the process and figure out a referable paradigm regarding co-supervision.

B. What problems are to be addressed?

In this project, we investigate:

- how the co-supervision can be organized in the nautical science program;
- the expectation of the co-supervision;
- the possible outcomes of the implementation (how each party benefits from the cooperated co-supervision).

We organize students to take part in the survey by answering questionnaires to collect their profiles and opinions.

C. Who will participate?

As we expect, the implementation of the project involves the students and supervisors. By taking advantage of the resources at IHB NTNU, the nautical science bachelor program students are invited to participate in the project as the party of students being co-supervised in their final year; the researchers employed in the maritime technology group are invited to be nominated as the co-supervisor. The bachelor theses' themes and contents are discussed and determined between the two aforementioned and the nominated supervisor from the shipping and nautical sciences group. In this study, we carried out a questionnaire-based survey among the first-year students; interviews are organized with researcher representatives (potential supervisors) at IHB. We target to collect information and opinion from the first-year students because we expect the conclusion drawn from this survey study to direct us on designing bachelor thesis topics and ways of supervision implementation. This process is assumed to take an academic year to finalize; at that time, the students who take part in the survey study will be conducting bachelor theses/projects. In this way, the supervision design is a close-loop work.



Fig. 1. Nautical science bachelor student on ship-bridge simulator K-sim.

D. Objectives

The main objective of this project is to figure out a way to handle the problems aforementioned in Section I-B. After the project is done, we expect to find the answers to the following questions:

- what is the attitude towards the emerging technologies about the ship intelligence from the perspective of the nautical science students?
- what is the expectation from the supervisor (from the shipping and nautical science group, hereinafter denoted as supervisor-NS)?
- what is the expectation from the supervisor (from the marine technology group, hereinafter denoted as supervisor-MT)?
- does the interdisciplinary make the supervised students outperform themselves compared to their classmates?

- is there a possible way to make such co-supervision practice as long-term cooperation between the two groups?

E. Current State

Currently, the shipping and nautical science group is responsible for the nautical science bachelor thesis supervision. The group invites experts and professionals from industries to provide bachelor theses/projects' topics. Most of these theses topics emphasizes empirical practice and industrial conventions. This solution enhances the students' competence in the job market, while on the other hand, it almost shuts down the door for them to look into and reflect how frontier technologies will significantly influence their vocational career in the future.

While at the marine technology group side, a research topic is investigating the human factors in ship maneuvering and operations. It means substantial data recording and describing the behaviors, relevant responses of the vessels and traffic, either collected from real ships or ship-bridge simulators (Fig. 1), are demanded to serve as the basis for further analysis on the human factors and human-machine interactions. The data are generated efficiently and heavily almost every day at the practice from the nautical science students.

In summary, the marine technology group's machine intelligence algorithms and analysis methods can improve the students' capacity to understand their own behavior better and more profoundly, to make their intuitive and empirical knowledge more systematical and scientific. The data produced by the nautical science students will help the researchers conduct more comprehensive studies such that elaborated onboard decision support can be developed and deployed. However, the passageway between the two groups is currently not fully developed maturely and fluently.

The results and experience gained at the bachelor program level in running the pedagogical-research method in collaboration with maritime experts can contribute to the implementation extended to the master programs in robotics, machine learning, oceanography, and bathymetry, together with the partner institutions. It can be achieved by involving maritime experts in the development of master's courses, in accordance with their research and development requirements, and even financing these projects. In this respect, NTNU and MBNA plan to organize workshops with the Norwegian and Romanian business community to promote the new master's curriculum and explore the possibility of implementing interscholastic co-supervision based on a virtual e-campus platform.

II. BACKGROUND

A. Relevant Literature

There have been studies on interdisciplinary supervision in recent years, especially from when the emerging technologies blur the boundaries between different subjects at doctoral level [6] [7] [8], and master level [9], though the research subjects are different from the bachelor level,

TABLE I
CURRICULUM STRUCTURE

1st year	2nd year	3rd year
Compulsory: Mathematics 1N Mathematics 2N Applied navigation 1 Applied navigation 2 Theoretical navigation 1 Theoretical navigation 2 Practical navigation 1 Basic safety training Philosophicum Electro Mechanics and firmness	Compulsory: Maritime law Marine environment Applied navigation 3 Theoretical navigation 3 Ship engineering Heat and flow theory Load handling Operation and maintenance of ships	Compulsory: Maritime communication Navigation 4 Sustainable chartering and operation Maritime organization and management Operation of on-board computer networks Economics for engineers Advanced safety training Medical treatment Bachelor thesis Elective: Position and survey system Sustainable international trade and shipping economy Offshore operations Advanced coastal navigation

some experience still can be referred and transferred. Similar interdisciplinary supervision has been explored in several fields, especially in the applied subject such as clinical medicine [10] and engineering subjects [11]. In most of the research items, they emphasize a common point that the student expertise should be drawn, and by taking advantage of it to enable students to develop themselves and venture into unexplored fields, which may bring surprises to the supervisors and co-supervisors in return [12].

B. Supervisors' Experience

In principle, at least two supervisors are involved in a co-supervision project in nautical science. One is from the shipping and nautical science group, and another one is from the marine technology group.

The experience of each one:

- supervisor-NS: expert in ship maneuvering and operations with deck class certificates and onboard practice over the years, professional in nautical education, familiar with the maritime conventions;
- supervisor-MT: professional in machine intelligence algorithms, acquainted with statistics-based data analysis, familiar with the frontier of the latest developed techniques in the maritime scope, have insight and reflection into the relationship between human and machine/technology.

C. Students' Background

Students being supervised in this project are third-year (final) bachelor students conducting and writing their bachelor theses. The students have finished most compulsory courses at the bachelor level (as listed in Table I), have attained sufficient knowledge in ship maneuvering, and can reflect and brief themselves after every trial on the ship and the simulators. The impact is on them (final-year students), but the questionnaire-based survey is carried out among the first-year students.

Their curriculum in Table I also reveals the fact that the program conspicuously emphasizes expertise development in

the navigation profession (applied/theoretical/practical navigation courses) and other relevant basic on-board technical knowledge (electro, load handling, operation, maintenance of ships, and so on). It is a lack of courses regarding the introduction of advanced and frontier technologies in the maritime domain. From our survey and continuing project, we are inclined to enable students in this program to be engaged in the development progress of MASS, and it also may contribute to reducing disputes on ethic and societal issues induced by MASS.

III. METHODOLOGY

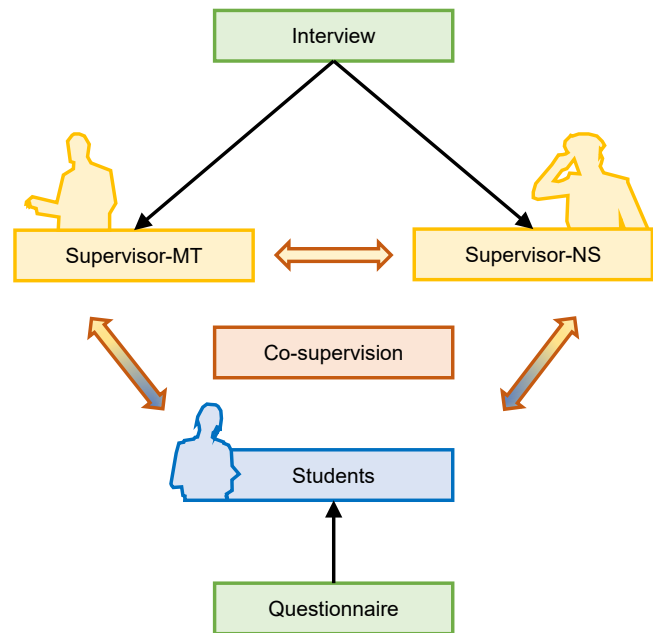


Fig. 2. The route map of pre-investigation.

As shown in Fig. 2, the main tools to be utilized in the project are:

TABLE II
QUESTIONNAIRE ON INTERDISCIPLINARY SUPERVISION OF BACHELOR THESIS/PROJECT

(Profile info including gender, grade, age)

- 1) How many years of experience in maritime do you have **excluding** the years with NTNU?
 0 1 2 3 Over 3 (_____)
 a) If not 0, which type of experience do you have?
 Not to reveal Experience: _____
- 2) Have you previously studied in the vocational schools (fagskole) before taking the bachelor program?
 Yes No
 a) If yes, in which profession have you studied in the vocational school (fagskole)?
 Maritime Other professions (_____)
- 3) Have you previously studied in other higher-education programs?
 Yes No
 a) If yes, what levels of higher education have you received before?
 Bachelor Master Doctor
 b) in which profession have you studied in the vocational school?
 Nautical science Other professions (_____)
- 4) You want to try to work on an interdisciplinary (combination of nautical science and another subject, denoted as Nautical+) topic to your bachelor thesis/project. (See Tips-3))
 1 2 3 4 5
 a) If positive, which professional topic do you want to combine nautical science study with?
 Computer/data science Psychology/Brain Hardware application Social science
 Others (_____)
 b) Can you explain briefly why you want to obtain knowledge/experience in the chosen field(s)?
- 5) You feel uncomfortable if English is used partly during supervision and communication.(See Tips-3))
 1 2 3 4 5
- 6) Can you clarify briefly what is your expectation on conducting a bachelor thesis/project? (or what do you want to obtain from it?)

- questionnaire: this is an easy approach that can gather information averagely from a group and form the fundamental database for the project. It helps us to have a general knowledge of the students' profile towards the co-supervision;
- interview: potential supervisors are invited for interviews to collect their opinion on conducting co-supervision works, including their willingness, expectation, the depth and difficulty level of theses/projects' topics, etc;
- practice of co-supervision: while the former two are completed, we have the chance to organize the co-supervision project between the two groups at IHB and invite students/researchers/lecturers to join in.

In this survey study, we implement the first two tools, questionnaires among students and interviews among potential supervisors. As for the practice of co-supervision, it is expected to be conducted after this survey study.

A. Questionnaire

The designed questionnaire used in this survey study is given in Table II. We collect background information (gender, grade, age, and question 1)-3)) of participants and answers to several subjective questions (question 4)-6)) to know their opinions and preference towards interdisciplinary supervision on their theses work.

B. Interview

Interviews are organized with two supervisor-MT and two supervisor-NS from the department. Though there are no fixed questions during interviews, the talks are concentrated

on limited respects such as the expectation of the outcomes, what the students can obtain, how supervisors can promote themselves in the process, and organization.

IV. RESULTS & DISCUSSION

This section illustrates and discusses the results of questionnaires from students and interviews from supervisors separately. The results are presented from an overview angle and discussed generally.

A. Students' perspectives

We distributed 40 questionnaires and collected 21 of them back. Among 21 participants, there are one female and twenty male students, and six, nine, and five are located in the age group 18-21, 21-24, and 24-27 separately. One of the returned questionnaires is partially answered in some questions. The distribution process is with no bias and particular preference on participants.

As shown in Fig. 3, the blue dots are answers to Question 4, which show participants' interests in getting involved in the interdisciplinary supervision, and among the answers, no one chooses 5. Most participants keep a neutral attitude towards it, while five show a strong interest in it, and six are negative. The orange dots present the experience in maritime of corresponding participants, and the majority of their experiences in maritime includes able (AB) seaman, navy, Norwegian coast guard (kystvakten), light sailor (lettmatros), and on school/research boat. However, no trend can be concluded on the relevance between their interest in interdisciplinary supervision and their occupational background.

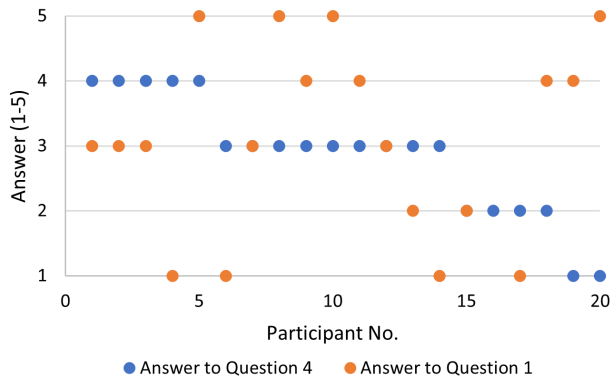


Fig. 3. Illustration of Answers to Question 1) and Question 4).

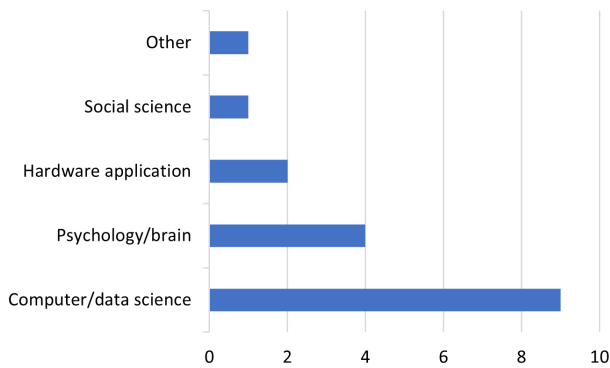


Fig. 4. Distribution of Answers to Question 4)-(a).

We regard the result of Question 4 as positive-neutral since we have 25 % percent of the participants interested in interdisciplinary supervision, and 45 % of them are standing in the middle, which implies that they can be influenced and attracted by further study introduction on this subject.

In answers to Question 4)-(a), as shown in Fig. 4, in which the subjects they prefer to combine with as Nautical+ are investigated, the result shows their dominant interest in computer/data science and the reasons they prefer to take an interdisciplinary bachelor thesis work in this combined field include (statements listed below has been revised on grammar and completion of sentence):

-They are very relevant to nautical studies, especially in the future.

-Computer/data seems to be a very big part of the profession, both onboard and on shore-based work.

-To obtain knowledge of how computers work if some should fail (onboard).

Coming after the computer/data science, psychonology/brain-related topics also attracts a certain number of participants. The reason why they are interested in it is quoted as below, which shows their responsibility and reliability in their occupation:

-In case of emergency situations and leading tough operations with many people included in the process.

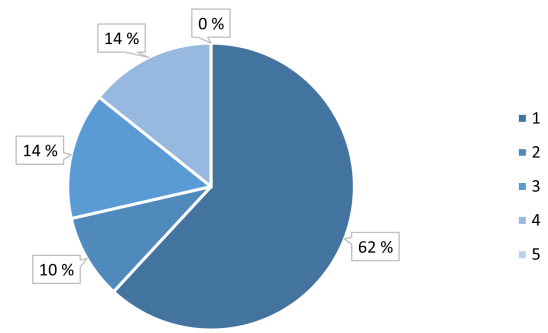


Fig. 5. Distribution of Answers to Question 5).

Some participants want to get involved in hardware-in-the-loop-related topics to gain more relevant experience. In the option *other*, the informant specifies the interest in mechanics.

Since researchers working at the department have a remarkably international background and the working language is English, we also propose Question 5) to see students' attitude on the supervision language, and the result is given in Fig. 5. It is found that most students (62 % - strongly disagree; 10 % - disagree) do not have a problem if the supervision is conducted in English communication. It suggests that more researchers at the department can be potential supervisor-MTs when the project is implemented.

In general, from the students' questionnaire results, we summarize a positive environment among the nautical science bachelor program students to be engaged in an interdisciplinary subject. The majority of them keep a neutral attitude, and some are positive. This result encourages us to put more effort into the project and figure out a way to lead the students to a more positive direction about the interdisciplinary supervision in the following years of their study.

B. Supervisor-NSs' perspectives

In this part, we organized interviews with two teachers at the nautical science group. One of them has conducted some cooperation in a simulator-based and onboard experiment with the marine technology group before, while another one is the coordinator in charge of the bachelor theses in nautical science.

According to Supervisor-NS 1:

...We are glad to invite researchers from the marine technology group to provide these topics and supervise our students... We have a lot of avant-garde experimental instruments such as the eye tracker, EEG sensor, and we also have a data transmission interface to realize real-time data export so that we can test any newly developed functions and solutions on navigation and guidance...

According to Supervisor-NS 2:

...interdisciplinary subjects are welcomed in our group, we have been inviting partners from the

industry to promote the practice... We have also carried out relevant studies in the frontier technology sector, such as virtual reality, and students will compare it with traditional solutions... We hope we can provide as a vast possibility to our students as possible...

From the interviewees' statement, we can conclude that teachers in the nautical science group are very open to creating possibilities for students with different occupational interests. When researchers at the marine technology group propose topics, they should comprehensively take students' interests, the capability of skills, and practicability of the topic to their career into consideration so that it can be a pragmatic complementary element to the current scope of bachelor theses in nautical science.

C. Supervisor-MTs' perspectives

In this part, similarly, we organized interviews with two researchers at the marine technology group. One of them is with senior experience in research topics in mechatronics, robotics, machine learning, and risk assessment, while another is an early-stage researcher involved in marine cybernetics and human factors.

According to Supervisor-MT 1:

...We have been kept in touch with colleagues in the nautical science group for research aims for a long time, and we always invite their students to test our new approaches and algorithm-based functions... How they can get involved in the analytical and statistical research is worth deep thinking, since they do not have a strong background in mathematics and physics...

According to Supervisor-MT 2:

...From my limited experience, data are critical for me to proceed in research... If there is a systematic organization of the interdisciplinary supervision, and their students are willing to be supervised by me to gain knowledge in our domain, I'd be appreciated it... I think it will be a win-win attempt...

From the interviewees' statements, we found that researchers in the marine technology group are also positive to consolidate such an arena between two groups. Moreover, when designing the topics, researchers should consider the students' background and grasp the topics in terms of depth and difficulty.

V. CONCLUSION

In this survey study, by implementing questionnaires among nautical-science students and interviews among potential supervisors, we conclude that there is a space to establish an interdisciplinary co-supervision in the nautical science bachelor program. The participated students in this study are in their first year, so we will continue to follow up about their attitudes towards the project, and we will attempt to organize seminars and lectures to enhance their interest in

getting involved in the project when they are about to conduct their theses work.

The method of learning through scientific research discussed in this study can be adapted for implementation in master and Ph.D. programs. Master and Ph.D. students are expected to use this learning method at a higher level, considering their multidisciplinary background and their professional experience gained in the labor market. The MAR-INTECH project is an excellent opportunity to implement this method together with other teaching/learning/assessment methods at the postgraduate level in oceanography and hydrography, underwater robotics, and machine learning in marine equipment.

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